Human impact on the environment: A middle school project based learning unit development

Shannon Power
University of Northern Iowa

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Abstract
I chose to focus my creative component on the development and implementation of a Next Generation Science Standards (NGSS) aligned earth science unit for an 8th grade science course taught using Project Based Learning (PBL) and graded using Standards Referenced Grading (SRG) philosophies and a proficiency scale. The unit focused on the Performance Expectation MS-ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment* (NGSS, 2013e). This standard includes the Science and Engineering Practice (SEP) of constructing explanations and designing solutions, a Cross Cutting Concept (CCC) of cause and effect, and a Disciplinary Core Idea (DCI) of human impacts on Earth systems specifically how humans have altered the biosphere by damaging or destroying natural habitats and how when human population and per-capita consumption of natural resources increases, so do the negative impacts on the Earth unless activities and technologies involved are engineered otherwise. The Understanding by Design (UbD) method of backwards planning was utilized in the creation of the instructional unit. The 5E Learning Cycle instructional model and Storylines were used to develop and organize learning activities and the various assessments, including pre assessments, formative assessments and a summative assessment project. A pretest and posttest flowchart was used to determine student growth of sustainability concepts and a modified and abbreviated EQuIP rubric was utilized to evaluate the instructional units alignment with the NGSS and “Gold Standard” PBL criteria.
HUMAN IMPACT ON THE ENVIRONMENT: A MIDDLE SCHOOL PROJECT
BASED LEARNING UNIT DEVELOPMENT

An Abstract of a Non-Thesis
Submitted
In Partial Fulfillment
Of the Requirements for the Degree
Master of Arts in Science Education

Shannon Power
The University of Northern Iowa
July 2021
ABSTRACT

I chose to focus my creative component on the development and implementation of a Next Generation Science Standards (NGSS) aligned earth science unit for an 8th grade science course taught using Project Based Learning (PBL) and graded using Standards Referenced Grading (SRG) philosophies and a proficiency scale. The unit focused on the Performance Expectation MS-ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment* (NGSS, 2013e). This standard includes the Science and Engineering Practice (SEP) of constructing explanations and designing solutions, a Cross Cutting Concept (CCC) of cause and effect, and a Disciplinary Core Idea (DCI) of human impacts on Earth systems specifically how humans have altered the biosphere by damaging or destroying natural habitats and how when human population and per-capita consumption of natural resources increases, so do the negative impacts on the Earth unless activities and technologies involved are engineered otherwise. The Understanding by Design (UbD) method of backwards planning was utilized in the creation of the instructional unit. The 5E Learning Cycle instructional model and Storylines were used to develop and organize learning activities and the various assessments, including pre assessments, formative assessments and a summative assessment project. A pretest and posttest flowchart was used to determine student growth of sustainability concepts and a modified and abbreviated EQuIP rubric was utilized to evaluate the instructional units alignment with the NGSS and “Gold Standard” PBL criteria.
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This Study by: Shannon Power

Entitled: Human Impact on the Environment: A Middle School Project Based Learning Unit Development

Has been approved as meeting the non-thesis requirements for the Degree of Master of Arts in Science Education

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The completion of the Masters of Science Education program would not have been possible without the support of my family, friends, colleagues and the Science Education faculty at University of Northern Iowa. First, I would like to thank my husband Jared. I began this Masters program the week after we got married and have worked on it through every big life event since. Over the last few years, Jared has completed two Masters programs, we had our two children, Ollie and Lucy, and we have had many job changes. I have worked on classes during family vacations and worked on classes late into the night and on weekends, but Jared has always never stopped encouraging me and taking care of our little family. To him, I am forever grateful. I would also like to thank my co-workers at North High School and Southeast Polk Junior High. You have been ears to listen to my frustrations, brains to help me work through my struggles, and hearts to celebrate with as many of us have completed our own Masters programs. Additionally, I would like to thank my parents and my Gran. Each of you has instilled in me the desire to push myself to my limits and reach my greatest potential. I can always turn to you for good advice. Gran, your support has literally kept me in this program. I look forward to following in your footsteps as an educator and a person. Lastly, I would like to thank my advisor, Larry Escalada and my outside reader Kyle Gray. You have given me so much direction and I would not have completed this program without your help.

Thank you again to all the people in my life who have helped me reach my goal of receiving my Masters in Science Education from the University of Northern Iowa.
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CHAPTER 1- INTRODUCTION AND FRAMEWORK

For the final project in the creative component of the Science Education Master of Arts program at the University of Northern Iowa (UNI), I have chosen to develop a middle school earth science Project Based Learning (PBL) instructional unit for my eighth grade science classroom which focuses on teaching students how to monitor and minimize human impact on the environment, which is addressed in the Next Generation Science Standards (NGSS) (NGSS, 2013a). The purpose of this creative component is to create an instructional unit that addresses multiple outcomes that include:

- Helping students make connections between the standard content they learn in the classroom that is determined by the NGSS and how the things they learn in the classroom are seen and used in the world outside of the classroom.
- Helping students learn and present their materials in a different way, guided by PBL techniques and Standards Referenced Grading (SRG) which will be discussed later in Chapter 1 and Chapter 2.

The need that I attempted to address in the development of this instructional unit was:

- The lack of an authentic PBL instruction that aligns with the NGSS that uses Standards Referenced Grading.
- The lack of literature that exists on living sustainable lives directed to junior high school students.

Much of the information regarding sustainability and sustainable practices is geared towards adult readers, but as students become more aware of environmental issues, they need to have resources that help them understand ways to live more sustainably as well.
If individuals create sustainable habits earlier in life, there will be more people having a positive impact on the environment.

I teach at a junior high school that is made up of approximately 600 seventh and 600 eighth grade students that live in rural, suburban and urban settings in central Iowa. Due to the varied backgrounds of the students, it is important to make sure that each of the students has the opportunity to connect to content in a way that relates to them personally. In junior high, the students are given the opportunity to explore many different aspects of science education including instructional units that address life science, physical science, and earth science. In my building, the four eighth grade teachers form a Professional Learning Community (PLC). A PLC is a collaborative group of professionals in the building that use three driving questions to guide the work:

- What do we want each student to learn?
- How will we know when each student has learned it?
- How will we respond if the student has experienced difficulties in learning (DuFour, 2004)?

As a PLC, we use the same curriculum materials and assess students' progress using common assessments. Due to the PLC nature of my department, all of the 8th grade students in the district interacted with aspects of this project.

Prior to working in my current district as an 8th grade science teacher, I worked in a different district as a science academic interventionist and an Advanced Placement (AP) Environmental Science teacher. During my time as an interventionist, I worked in each of the 12 science classrooms in grades 9-12. It was my job to help students if they were
struggling with the content and it became clear to me that the classes where students struggled the most were the classes where students had a hard time personally connecting to the material. One reason science can be so challenging for students is because the new content they are learning can seem intimidating. The vocabulary is strange, the concepts are hard to visualize, and students have a very hard time seeing how the content they are learning in class impacts their lives outside of school. I spent a lot of time in classrooms with teachers who were experts in the content, but struggled to help the students make personal connections with the material. When I visited the classrooms of the teachers who took time to make real world connections with the students, I noticed that there was a much smaller need for intervention. By developing and implementing instructional units that connect students’ lives to the materials, a teacher can have science become a subject that can lose its intimidation and help students make a difference in the world.

**Connection to NGSS Content and Three Dimensions of Learning**

For a science teacher to develop an earth science instructional unit in the state of Iowa, it is important to identify the standards required to be addressed by all public school districts, grades K-12, by the Iowa Department of Education. To do this, teachers need to follow the standards set out by the Next Generation Science Standards (NGSS) through the Iowa Core. The Iowa Core is a set of common expectations that all students should reach for school districts around the state of Iowa (Iowa Department of Education, n.d.). These expectations, or standards, describe what students should know and should be able to do from kindergarten through twelfth grade in math, science, English language arts and social students, as well as 21st Century skills (Iowa Department of Education,
In 2015, the State Board determined that the NGSS were to be the science standards used for the Iowa Core (Iowa Department of Education, 2016). The NGSS standards are divided into three grade levels: Kindergarten-5th grade, 6th-8th grade, and 9th-12th grade. The Iowa Core has taken all of the NGSS standards within their given bands, and determined what specific standards should be taught to the specific grades. Schools have the ability to arrange these standards however they see fit, but it is intended that all students have access to all of the standards before they graduate from high school (Iowa Department of Education, 2016).

The Next Generation Science Standards are not built as a collection of content knowledge, but as a way to establish, extend and refine that knowledge. This way of arranging content has been identified as the Three Dimensions of Learning, which include Cross Cutting Concepts (CCCs), Science and Engineering Practices (SEPs) and the Disciplinary Core Ideas (DCIs) (NGSS, 2013c). Three Dimensional (3D) Learning is a term that refers to the three pillars that support each performance expectation/standard. In 3D learning, content is equally as important as Cross Cutting Concepts and Science and Engineering Practices (NGSS, 2013b). The Three Dimensions of the NGSS include:

- Cross Cutting Concepts which have applications across all fields of science (including things like identifying patterns, cause and effect, and system models);
- Science and Engineering Practices that help build student engagement in scientific inquiry and reason in a scientific content (including things like building models and asking questions);
Disciplinary Core Ideas, the academic content in which students need to be exposed.

This Three Dimensional type of learning helps students develop skills that will serve them throughout the rest of their lives by providing foundational knowledge for all (NGSS, 2013c).

In 2015, Iowa adopted the NGSS as the state science standards and my district started to implement these new standards that year. Lessons moved from being content that the teacher taught exclusively because they enjoyed teaching it to lessons and units developed using the 3D approach. By including all three of these Dimensions in their learning, students will be receiving a more comprehensive science education. Based on these Three Dimensions, I incorporate science content, as well as different science practices into my classroom. Some of the scientific practices include: developing explanations based on information from multiple sources of evidence; communicating results of their findings; and explaining cause and effect relationships. The use of the stated science practices aids science learning when Standards Referenced Grading (SRG) practices are used. SRG is a relatively new grading practice system which measures student’s proficiency on well-defined course objectives (Tomlinson and McTighe, 2013), which will be discussed later in this chapter, are a part of the need for this instructional unit.

Another beneficial aspect of the NGSS 3D learning was to help students build skills that allow them to address major challenges that confront today’s society as well as motivate and inspire a greater number of people to solve the world’s problems in the
future (NGSS, 2013c). Some of these potential problems include climate change, food and water shortages, and natural resource uses. This problem-solving aspect of learning is also enhanced by the use of 21st Century skills. When Iowa adopted the Iowa Core in 2015, they also included 21st Century skills, which are grade level standards for essential concepts that go beyond the content areas and help students to build skills that help prepare them to lead productive and satisfying lives (Iowa Department of Education, 2008). The instructional unit I developed addresses the skills identified in eighth grade employability skills by the Iowa Core. These skills include:

- Being able to communicate and work productively with others,
- Adapt and adjust to various roles and responsibility in an environment of change,
- Demonstrate leadership and social responsibility,
- Demonstrate initiative, self-direction, creativity and entrepreneurial thinking, and
- Demonstrating productivity and accountability while aspiring to meet high expectations (Iowa Department of Education, 2008).

To begin this process of solving real world problems in the future, I needed to identify the standard I was going to use. My instructional unit was based on the NGSS standard MS-ESS3-3: *Students who demonstrate understanding can apply scientific principles to design a method for monitoring and minimizing a human impact on the environment* (NGSS, 2013e). This standard includes the Science and Engineering Practice (SEP) of constructing explanations and designing solutions, a Cross Cutting Concept (CCC) of cause and effect, and a Disciplinary Core Idea (DCI) of human impacts on Earth systems specifically how humans have altered the biosphere by
damaging or destroying natural habitats and how when human population and per-capita consumption of natural resources increases, so do the negative impacts on the Earth unless activities and technologies involved are engineered otherwise (NGSS, 2013e). When developing lessons for the instructional unit, students' problem solving needed to be the central driving force of the lessons and students needed to see how their learning and skills can impact the real-world outside of the classroom. To address the three dimensions from the NGSS and solve real-world problems, I developed the unit using a teaching technique called Project Based Learning (PBL).

Earlier in my career, as an AP Environmental Science teacher, I learned about the teaching technique called Project Based Learning (PBL). In a video produced in 2009 by Edutopia, it explains that PBL is a way for students to actively explore real-world problems with real world solutions (Edutopia, 2009). In PBL, the project is at the center of the learning, not just something that happens at the end to prove that students have learned the content. Students move away from learning a specific topic on a specific day and move towards learning in-depth information when they are in a position to use that knowledge, explained Seymour Papert, a professor at the MIT Media Lab (Edutopia, 2009). My entire AP Environmental Science curriculum was created using PBL and, through that, I saw student engagement increase and noticed students who were not “typical AP” students were very successful. These students were able to see how the AP College Board content fit together and they were able to use that learned content to solve real world problems. Through PBL learning, students were able to tackle the guiding questions using many different ideas. Since the essential guiding questions of a unit are
broad, there is not just one way to solve the problem. By allowing students to have a voice and choice in the direction of their final product, the intimidation of having to get the single “right” answer is taken off the table. I believed that middle school students would greatly benefit from PBL learning. Since the students were given the opportunity to explore and solve problems their own way, they had the opportunity to become much more independent in their own learning, which is something junior high students benefit from.

One of the intended outcomes of the instructional unit is to help students make connections between the standard content they learn in the classroom, that is determined by the NGSS, and how the things they learn in the classroom are used in the world outside of the classroom. To make sure the purpose was accomplished, I used a checklist called the “Gold Standard” Project Design Element checklist, a collection of eight specific criteria (Buck Institute for Education, 2019) which will be discussed in detail in Chapter 2. Some of the criteria of the “Gold Standard” PBL include:

- being centered around a meaningful and open-ended question,
- having an authentic real-world or potential real-world application,
- allowing time for feedback and revision, and
- creating a public product that is presented to others.

The instructional unit was designed to help students learn and present their materials in a different way, guided by PBL techniques and Standards Referenced Grading (SRG), so the project will use proficiency scales and other standards referenced grading protocols. SRG are teaching and learning practices that my current district is moving towards.
implementing in the future and currently the 8th grade science department is pioneering this work at my school. Standards referenced grading (SRG) is a term used to explain that teaching, learning and grading are aligned to the learning standard (Des Moines Public Schools, 2019a). These standards are arranged into proficiency scales, a progression of learning goals with levels of difficulty, which are used to plan instruction and assessments (Marzano, 2015). SRG and proficiency scales both complement the Gold Standard PBL by using critique and revisions as key criteria components.

Using the proficiency scale (Marzano, 2015) as a guide, I will use a Backwards Design approach, utilizing the Understanding By Design (UbD) framework. This approach focuses the planning process and gives structure to guide curriculum development, create assessments and develop instruction (Wiggins and McTighe, 2012). Using the UbD framework, I will first identify the desired results of the unit which will be guided by the NGSS performance expectations, then determine the evidence I would need to collect to show the students have learned it. Lastly, I will identify the learning plan that students will follow to reach success on their assessments (Wiggins and McTighe, 2012). By planning the unit with the end goals in mind, the lessons created will help students learn how their classroom content connects to the world outside of the classroom.

Understanding by Design (UbD) and a 5E Learning Cycle instructional approach will be used to address the NGSS in the earth science unit. The 5E Learning Cycle utilizes different teaching strategies, provides connections among educational activities,
and helps teachers make decisions about interactions with students (Northern, 2019). This Learning Cycle is broken up into a 5 phase process defined by Northern as the following:

1. Engagement: Students’ prior knowledge activated, interests are piqued and the topic of study is introduced.
2. Exploration: Students participate in hands-on activities that help them make sense of concepts.
4. Elaboration: Students apply their knowledge to new situations.
5. Evaluation: Students demonstrate their understanding of the material which could be done in a variety of ways.

By following the 5E Learning Cycle, lessons can be designed so that students develop a full understanding of a lesson concept (Tonseenon, 2017) and teachers can provide opportunities for students to develop their 21st Century skills. In the instructional unit, the students will:

- Use hands-on and research techniques to learn about sustainable ideas,
- Identify the positives and negatives and cause and effect aspects of each of the ideas, and
- Explain how groups and ideas must work together to allow a community function to its fullest potential.

Once the aspects of the learning cycle have been completed, they will be arranged into the unit using storylines. Storylines are a visual representation of individual lessons or entire units that allow teachers to set clear paths of learning throughout the lessons. By
utilizing the learning cycle and storylining, students will be able to identify sustainable choices and the positives and negatives of the choices, and will build skills that can be used to make real world changes in their future.

I saw a need to develop this instructional unit to meet the NGSS standards and to help students see that their choices can have a huge impact on the environment. Too many people go through life without thinking about their impact on the environment. In a 2016 article written by Andrew Wu, a student at Yale University, he identified that only 4 percent of the worldwide market is devoted to environmentally friendly, or “green” products (Wu, 2016). He referenced a study by Lithuanian researchers that set out to identify the key factors that individuals used when determining whether to purchase or not purchase green products. They identified that the number one contributor in purchasing and using these products is knowledge and confidence in green products followed by convenience and price (Liobikiene, 2016). Regardless of students' plans after high school, they will be living in the “real world” and having the skills to make sustainable choices is important.

In addition to helping the students be successful in 8th grade science, this instructional unit will help students see that what they are learning in the science classroom can have a deep connection to their real-world, which is something I felt was missing in my school’s curriculum. At my school, the instructional units that had originally been developed taught lessons organized into individual ideas that were chunked in small pieces, rather than the pieces all flowing together to answer one central question. The sustainability instructional unit that I want to create would blend many real
world ideas together to answer the essential question of the unit. These real-world facts, including determining how much electricity or water students use, will help students identify the actual impact of their daily choices about living sustainably. By connecting classroom content to real world experiences, students can easily make sense of the academic challenges they encounter in the classroom.

So much information is available to us in the real world and it is important that we teach our students responsible decision-making practices. The decisions they make will have an impact on the real world and I am attempting to strengthen their skills in this area. Along those same lines, it is important for students to have 21st Century employability skills, namely in the areas of collaboration and communication. This instructional unit will allow for students to expand their skill set in those areas as well. Finally, the benefits of PBL and SRG in teaching and learning will help students implement these skills while viewing things through a science lens with the hopes that they will be able to translate these skills across different settings and situations as they progress through school and into life outside of the classroom.

For my creative component, the research questions I will investigate include the following:

- How does this instructional unit align with the PBL framework and the NGSS?
- How have my student’s ideas and knowledge of sustainability progressed throughout the instructional unit?
By answering these questions, it will allow me to further improve the current instructional unit and can serve as a template for me to create additional units that are aligned with the NGSS that incorporate PBL in the future.

As a science educator, I enjoy the fact that science can open people’s eyes to the world around them. Armed with knowledge, students can be productive members of society. My goal is to help students become people who ask questions and think about outcomes before they act. By developing a PBL earth science instructional unit for all 8th grade students in my school district, which is based on a middle school NGSS standard that addresses how humans can monitor and minimize their impact on the environment, I will be able to reach a large group of learners. Students will look at real-world problems and attempt to come up with real-world solutions. This sort of problem solving will be used in the classroom, but also will be something they will encounter in their lives moving forward.
CHAPTER 2- LITERATURE REVIEW

At this stage in my teaching career, I have found that students who have a personal connection to the content understand the content better. When students understand the content, they are able to think deeply about the topic and move past basic comprehension of the information and towards the ability to utilize their knowledge in new situations. This personal connection can be very hard to achieve, but I believe it is the teacher’s job to provide structures in their classroom that help students accomplish this personal type of understanding. My 8th grade earth science instructional unit is an important addition to science education literature because it will help junior high students learn about how humans impact the environment and will draw connections between their behaviors and that environmental impact. Very little information on personal sustainability that is directed towards and that is accessible for junior high school students is currently available. The development of this instructional unit addressed the needs that students need to learn about how humans impact the environment with an instructional approach that is relevant and engaging and that is aligned with the Next Generation Science Standards (NGSS). The instructional unit is also important because it utilizes the techniques of Project Based Learning (PBL) and Standards Referenced Grading (SRG) to achieve a relevant and engaging unit. The integration of the NGSS, PBL and SRG into instructional units and discussion of their combined impact on student learning is missing in current literature. Each component is backed by literature in this chapter. The following literature review will discuss research related to the following areas:
1. How constructivism provides the theoretical framework for the instructional unit in the classroom.

2. Connections and mapping to the Next Generation Science Standards (NGSS) and the Iowa Core’s 21st Century skills.

3. An overview of research-based teaching utilizing Project Based Learning (PBL) and a technique called the “Gold Standard” PBL.

4. An overview of Understanding by Design (UbD) that is used for a Backwards Design for classroom curriculum units and the 5E Learning Cycle and Storylines used to help sequence lessons to help students understand concepts.

5. An explanation of different types of assessments including pre-assessments, formative assessments and summative assessments.

6. An overview of the grading system called Standards Referenced Grading (SRG) which uses proficiency scales to guide planned instruction and assessment.

7. A detailed description of a rubric used to assess the quality of an instructional unit that is aligned in with the NGSS, called the EQuIP rubric.

**Theoretical Framework - Constructivism**

Constructivism is an educational theoretical framework that can be summarized as a way of looking at education where individuals construct their own knowledge by incorporating personal experiences (Central Michigan University, n.d.). Constructivist instruction tends to rely on social and exploratory experiences, sometimes without clearly-defined outcomes, often using critical thinking activities, peer review and/or collaborative projects (Central Michigan University, n.d.). Constructivism is naturally
problem-based learning that allows for new information to be combined with existing
information in order to adapt knowledge and make sense of experiences (McLeod, 2019).

Constructivist teaching methods are in contrast with traditional teaching methods
where knowledge is passed from teacher to student (McLeod, 2019). The teacher’s
primary role is to create a collaborative problem-solving environment where students
become actively involved in their own learning and teachers act as a facilitator, rather
than the instructor (McLeod, 2019). To do this, teachers must scaffold activities and
learning experiences so students are able to make sense of the new information (McLeod,
2019).

Next Generation Science Standards (NGSS)

The Next Generation Science Standards (NGSS) was created through a
collaborative effort between twenty-six lead states, the National Research Council, the
National Science Teachers Association and the American Association for the
Advancement of Science. As partners, they developed the K-12 Framework for Science
Education (NGSS, 2013a). This framework was developed using the most current
research on science and science learning and identified the science that all students
should know once they completed high school. After going through two public drafts and
revisions, the NGSS was completed in April 2013 (NGSS, 2013a). Iowa adopted the
NGSS as their science standards and stated that there would be a full implementation in
K-12 science classrooms by 2019 (Iowa Department of Education, 2016). The science
standards reflected a change in science classroom expectations and teaching practices.
Through the NGSS, students move beyond memorizing potentially disconnected facts, to
viewing science as a holistic understanding of integrated and interrelated concepts that connect to scientific principles that can be viewed in real-world situations (Iowa Department of Education, 2016).

In the NGSS, each standard is written as a Performance Expectation (PE), rather than a list of what students should “know” or “understand”. As a result, the NGSS indicates what a student should be able to demonstrate in order to prove that they have met the standard (NGSS, 2013b). PEs allow for clear and specific learning targets for curriculum, instruction and assessment. The NGSS Performance Expectations are more complete when they are viewed along with the additional Three Dimensions of Learning. These Dimensions include Science and Engineering Practices (SEPs), Crosscutting Concepts (CCCs) and Disciplinary Core Ideas (DCIs). The following describes the Three Dimensions in detail:

1. Disciplinary Core Ideas (DCIs): DCIs were developed to focus science instruction and assessment on the most important aspects of science. They are grouped into four domains: physical sciences, life sciences, earth and space sciences, and engineering, technology and applications of science. To be considered a core idea, the idea must meet at least two of the four criteria (NGSS, 2013c):
   - “Have a broad importance across multiple sciences or engineering disciplines or be a key concept of a single discipline;
   - Provide a key tool for understanding or investigating more complex ideas and solving problems;
○ Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge; and

○ Be teachable and learnable over multiple grades at increasing levels of depth and sophistication.” (NGSS, 2013c)

2. Science and Engineering Practices (SEPs): Scientific practices are behaviors that scientists utilize as they investigate theories about the natural world. Engineering practices are skills that engineers use when designing and building models. These practices are not called “skills” because the researchers felt that it was important that the students knew the skill, but also knew when to use the specific skill. The focus on practices better explains what is meant by using “inquiry” in science and the range of practices it requires (NGSS, 2013c). The NGSS uses these SEPs to show students that science content has an impact on their everyday life.

3. Crosscutting Concepts (CCCs): The Third Dimension of the NGSS are CCCs. The CCCs are scientific ideas that have their own impact on all different domains of science. These include: patterns, similarities and diversity, cause and effect, scale, proportions and quantity, systems and system models, energy and matter, structure and function, and lastly, stability and change. These concepts allow students to make connections between the various science fields and allow them to make scientifically-based views of the world (NGSS, 2013c).

The NGSS was developed to enable teachers to offer all students instruction that teaches them to analyze and interpret data, use critical thinking to solve problems and to make
connections across all science disciplines (NGSS, 2013d). The NGSS allows students to see a clearer picture of how science connects to their real world by allowing the students to use the skills and knowledge of multiple disciplines to solve problems.

To make sure that all parts of the NGSS performance expectation are included in the instructional unit, teachers need to ‘unpack’ the standard. Unpacking the standards allows teachers to translate the SEPs, CCCs, and DCIs into multiple instructional sequences that develop a blueprint for designing an instructional unit (American Museum of Natural History, 2018). To unpack the standard, teachers need to determine what students need to know/understand about the topic to be able to reach the performance expectations (American Museum of Natural History, 2018). Using the evidence statements from the standard, teachers can identify the specific details that need to be covered in the unit to satisfy the Three Dimensions of Learning. If the standard is fully translated, it will be clear what science content will be covered (DCI), what Scientific Practices will need to be demonstrated (SEP), and what Cross Cutting Concepts (CCC) will need to be included for a student to reach the desired level of the performance expectation. My instructional unit will be centered around an NGSS standard and will, explicitly, have students work through the DCI specified content, demonstrate the SEP specified science practices, and make connections between the identified CCCs. The specific standard is MS-ESS3-3: Students who demonstrate understanding can apply scientific principles to design a method for monitoring and minimizing a human impact on the environment (NGSS, 2013e). This standard includes the Science and Engineering Practice (SEP) of constructing explanations and designing solutions, a Cross Cutting
Concept (CCC) of cause and effect, and a Disciplinary Core Idea (DCI) of human impacts on Earth systems, specifically, how humans have altered the biosphere by damaging or destroying natural habitats and how when human population and per-capita consumption of natural resources increases, so do the negative impacts on the Earth unless activities and technologies involved are engineered otherwise (NGSS, 2013e). The ideas put forth by constructivism align with the Three Dimensions of Learning of the NGSS. When students utilize the science and engineering practices, like constructing explanations from evidence or analyzing and interpreting data, they are taking information, making it their own, and giving structure to their own learning. This project is important because it adds to the literature regarding the connections between the NGSS and real-world situations. The NGSS helps students connect scientific principles that can be viewed in real-world situations (Iowa Department of Education, 2016), so by developing the instructional unit using the NGSS, students will be able to connect their classroom content to the outside world.

**The Iowa Core and 21st Century Skills**

The new global reality is becoming increasingly complex, so there is a need to build new 21st Century skills so students can be successful in this current reality. The challenge in preparing students for this reality comes from the fact that we do not know what the work of the future will be like or how technology will influence a variety of issues (Iowa Department of Education, 2009). Students will need to think critically, use facts to plan and work towards an end goal, be able to be self-reflective and use reason to question claims and judgements that will influence the future (Iowa Department of...
Education, 2009). The Framework for 21st Century Learning stated that schools need to move beyond the focus on basic competency in core subjects. To do this, 21st Century interdisciplinary themes must be woven into the core subjects. These 21st Century skills bridge the knowledge, skills and dispositions of students from the core academic areas to real life applications (Iowa Department of Education, 2009). In 2007, the Iowa Legislature established the Iowa 21st Century framework as:

1. Political Science-Civic literacy,
2. Employability skills,
3. Financial literacy,
4. Health literacy, and
5. Technology literacy.

A group of business and educational leaders formed a nonprofit educational foundation called The Institute for Tomorrow’s Workforce. These leaders stated that the educational system needs to prepare all learners for the 21st Century by being problem-solvers, change agents and effective team players (Iowa Department of Education, 2006a). Students in a learning environment that promotes 21st Century employability skills will have academic and social skills that empower them to be productive, caring and competent citizens (Iowa Department of Education, 2009). Integrating these skills across all curricular areas will allow students to transition from the classroom to their roles as citizens and workers in an unknown global market. By utilizing these skills, the quality of life as a citizen will be enhanced (Iowa Department of Education, 2009). In the instructional unit that was developed, students have to solve problems without one
specific solution, so they need to demonstrate initiative, self-direction, and creativity. The students worked in collaborative groups, where they worked together to meet a common goal, accept and provide feedback, and adapt and adjust to various roles. Student groups developed solutions that would work in a real-world situation to create their final product, which was communicated with a larger group. According to the constructivist theory, learners actively construct new knowledge based on personal experiences. Some of the experiences students can have result from social interaction and teamwork. Twenty First Century skills, like working collaboratively, directly align with this learning framework.

**Project Based Learning (PBL) Instruction and the Gold Standard PBL Criteria**

Project Based Learning (PBL) is an instructional model that helps students learn new knowledge and skills by investigating and responding to engaging and complex challenges (Coyne, Hollas, and Potter, 2016). PBL units are student driven, cross curricular in a way that draws on many different skills, focused around standards and allows students to problem solve to answer large overarching questions (Everette, 2015). PBL is a student-centered approach to learning that allows students to use their own knowledge and investigate materials that help them solve real-world problems. In a meta-analysis study of the effectiveness of PBL on students' academic achievement that looked at published results from over 12,000 students, which revealed that project-based learning had a medium to large effect on students' academic achievement compared to traditional instruction (Chen and Yang, 2019).

Teachers can use the “Gold Standard” Project Design Element checklist to create a PBL unit. The checklist was developed by Buck Institute of Education, an organization
that focuses on helping teachers incorporate PBL practices into their classrooms. The “Gold Standard” Project Design Element checklist (Buck Institute of Education, 2019) includes:

1. Key knowledge, understanding and success skills: The project is focused on teaching students with a focus on key knowledge and understanding derived from the standards, and success skills including critical thinking/problem solving, collaboration and self-management.

2. Challenge Problem or Question: The project is based on a meaningful problem to solve or a question to answer at the appropriate level of challenge for students, which is operationalized by an open-ended, engaging driving question.

3. Sustained Inquiry: The project involves an active, in-depth process over time, in which students generate questions, find and use resources, ask further questions and develop their own answers.

4. Authenticity: The project has a real-world context, uses real-world processes, tools and quality standards, makes a real impact, and/or in connected to students’ own concerns, interests and identities.

5. Student Voice and Choice: The project allows students to make some choices about the products they create, how they work and how they use their time, guided by the teacher and depending on their age and PBL experiences.

6. Reflection: The project provides opportunities for students to reflect on what and how they are learning and on the project’s design and implementation.
7. Critique and revision: The project includes processes for students to give and receive feedback on their work, in order to revise their ideas and products or conduct further inquiry.

8. Public Product: The project requires students to demonstrate what they have learned by creating a product that is presented or offered to people beyond the classroom.

An effective PBL instructional unit starts with the initial planning of the project. The project needs to be centered around a large standard or set of standards (Everette, 2015). If a standard is too narrow or has too specific of a focus, the teacher may have to combine multiple standards together. The project also needs to have one or more essential questions that captures the project’s focus, is easy to understand, and will provide a sense of challenge for the students (Everette, 2015). All of the activities should be focused on helping the students answer this essential question and when the students have combined all of the answers from their activities, they should be able to answer the essential question. If the essential question can be answered through a quick internet search, the question is not complex enough (Everette, 2015). My instructional unit utilizes the first four components of the “Gold Standard” PBL. The instructional unit is also based off of one standard from the NGSS and addresses three essential questions which drove all of the learning activities and assessments throughout the unit. The essential questions involved real-world issues, so their answers required the use of real-world processes and required students to ask additional questions and find/use resources to answer the essential questions.
While working through different activities throughout the instructional unit, students had the opportunity to work independently, collaboratively, and with their instructor. During this time, students developed and used their 21st Century skills including understanding and communicating ideas, working with others, and problem solving (Everette, 2015). Additional skills that the students needed to use were critical thinking, being self-reflective, and using facts and reasons to plan and question results (Iowa Department of Education, 2009) as they moved towards answering the essential questions of the PBL instructional unit. While completing their public product for the instructional unit, students worked together to answer the essential questions based on evidence they have collected.

PBL projects should contain some form of student voice and student choice, a component of the “Gold Standard” PBL. Being given a choice in the direction of their education is a motivating factor for students. For some students being given the opportunity to choose how to proceed is the “make or break” element and without it, a project can seem like another longer and harder assignment (Larmer, 2016b). Voice and choice can still be limited, just like in the real world, individuals work under specific constraints (Larmer, 2016b). Students might not be able to pick their group mates, but as a group, they can choose how to “spend” their budget on materials to build their product. Student voice and choice can help students focus on what they are interested in and decide how they want to present their findings (Larmer, 2016b). Students can choose if they want to create a website, create a newsletter, slideshow presentation or can come up with their own idea of how to present their information. If the teacher decides ahead of
time where student choice is appropriate within the project and by doing that aspect of project design, the teacher can make sure that all of the academic content is covered (Larmer, 2016b). Ultimately, if students use their 21st Century skills to answer the essential questions and are given the opportunity to choose some of the direction of the project, they will find ownership in PBL learning and it will help them achieve academic success. Students were able to choose their setting of their sustainable society, choose their own role within the society, and choose how to present their information, but the teachers developed the initial scenarios and roles and decided what information students needed to cover in their explanation of the sustainable society.

As students completed the instructional unit, they not only completed the assigned activities and exercises but they also completed various assessments including pre-assessments, formative assessments and summative assessments. Throughout the instructional unit, students provided peer-feedback to others, received feedback from teachers and reflected on their own work. This critique and revision process, as well as the reflection process, are part of the “Gold Standard” PBL. By evaluating their own work and giving/receiving feedback from others, students develop metacognitive skills and insights about their own work (Block, 2015). During work time, the teacher can circulate the room with specific questions in mind for their students, like “What is your main argument?” or “Why is that piece important?” or doing general check ins (Block, 2015). Teachers can also set times for peer review by teaching peer review protocols. Different types of this peer review feedback include the “Pluses and Deltas” protocol where students identify things they like about the work and things that could be changed,
or the “Specific Criteria” protocol where students are given a checklist to identify things that are present in their peers work (Larmer, 2016a). If the review process happens during the learning, students have time to revise their own thinking or revise their product. Students will be provided peer review opportunities using guiding protocols. One of the peer review opportunities was set to occur after the students have completed audits of their natural resource usage and how that impacted the environment. The review process was made up of a checklist for students to fill out to identify components that were present in their peers' work. After this peer-review, students could make edits on their assignments before submitting as a formative assessment, which received teacher feedback.

The addition of having outside experts be part of the process can be very helpful to the students when completing PBL. These experts can act as advisors and ask students deeper questions to prove their thinking and improve the product they are creating and can help students prepare for their final presentation by asking questions that exercise their critical thinking and help students anticipate questions that can be asked during the final product presentation (Larmer, 2015). Some of the outside experts my students could be given the opportunity to speak to could include employees at an electric company, a waste management company, or city planners.

PBL instructional units conclude with some sort of public product that the students create and present to an audience. Audience members could include classmates, school administrators, or even community members. When students present to someone other than their peers and their teachers, it leads them to do higher quality work (Larmer,
An additional reason to make student work public is because it can become “discussible” by other students, teachers, and school/community stakeholders (Larmer, 2015). One example of these projects centered around restoring river rapid quality to the local river by tearing down and lowering dams. In the project, the students studied ecological effects on native and invasive plant species, considered public relation issues and proposed redesigns for the city council members. The students created models, websites, posters and maps to show the changes that were given to the council members (Larmer, 2015). A “big showcase” is not necessarily the end of each product, the public aspect can come from a few experts critiquing their work throughout the process (Larmer, 2015). With the public products developed or the ideas proposed by experts, students are able to see that their learning was done for a purpose and can have a positive impact on their community. Students designed a sustainable community that will be presented to classmates, teachers, and community stakeholders. They chose how to present this information (ex: creating a PowerPoint, generating a website, designing a pamphlet, etc.) and during this presentation, the student groups answered essential questions driving the PBL instructional unit.

As discussed earlier, Project Based Learning (PBL) is a learning approach where students engage in real-world problem solving (Jumaat, Tasir, Halim and Ashari, 2017). PBL has an essential question(s) that drive the learning and the students' constructive investigations include inquisition, decision making, and resolution to help solve that problem (Jumaat, Tasir, Halim and Ashari, 2017). Constructivism suggests learners create knowledge based on the experiences they have encountered and many times that
experience comes from dealing with real-world problem solving (Jumaat, Tasir, Halim and Ashari, 2017). PBL is a student-centered approach that aligns with many of the constructivist ideas including having a broad question that may not have a clearly defined outcome, asking students to use knowledge they have gained from critical thinking activities to answer the essential question, to use peer and teacher review to help revise knowledge and are often completed with a summative collaborative project (Central Michigan University, n.d.). This project is an important addition to the literature because it provides guidance in how to create a PBL instructional unit that aligns with a NGSS standard, which is something that many PBL units fall short on. When students learn and present their learning using PBL techniques, they engage in real-world problem solving and independent critical thinking, which are skills that allow PBL to make a lasting impression on student learning (Chen and Yang, 2019).

**Understanding by Design (UbD)**

Understanding by Design (UbD) is an instructional design framework that aids teachers in the planning process and provides structure to guide curriculum, assessment and instruction (Wiggins and McTighe, 2012). UbD is ideal for a curriculum that is driven by the standards due to the fact that it helps teachers identify clear learning goals, create useful assessments and plan meaningful learning opportunities all through the use of Backwards Design (Authentic Education, 2015).

Traditionally, teachers relied on the textbook for unit planning, activities and accompanying assessments. As guidelines have changed and standards have become the guiding principles for science classrooms, the UbD Backwards Design process was
developed. The UbD framework is based on seven key tenets (Wiggins and McTighe, 2012):

1. Learning is enhanced when teachers think purposefully about curricular planning.
2. The UbD framework helps focus curriculum and teaching on the development and deepening of student understanding and transfer of learning.
3. Understanding is revealed when students autonomously make sense of and transfer their learning through authentic performance.
4. Effective curriculum is planned backwards from long-term, desired results through a three-stage process which will be discussed in greater detail following this list.
5. Teachers are coaches of understanding that the focus is on ensuring learning, not just assuming that what was taught was learned.
6. Regularly reviewing units and curriculum against design standards enhances curricular quality and effectiveness and provides engaging and professional discussions.
7. The UbD framework reflects a continual improvement approach to student achievement and teacher craft. Student performance informs the need for adjustments in curriculum and instruction so that student learning is maximized.

The seven tenets of UbD can be accomplished by using the three stages of Backwards Design (Wiggins and McTighe, 2012). The three stages are briefly described as:

- Stage 1- Identify desired results,
- Stage 2- Determine Assessment Evidence, and
Stage 3- Plan Learning Experiences and instruction

The first stage of Backward Design focuses around the questions: (1) What should students know, understand, and be able to do? And (2) What essential questions will be explored in-depth and provide a focus to all learning? (Wiggins and McTighe, 2012). To begin this stage, teachers will need to consider the goals, examine the standards and review the curriculum expectations and clarify the priorities of the unit, based on the long-term performance goals (Wiggins and McTighe, 2012). By identifying the desired results, educators will prioritize information and will focus on activities that will allow students to explore information that will help them reach the desired results. For example, the NGSS performance expectations are an ideal starting point for completing Stage 1 of identifying the desired results (Bybee, 2013).

The second stage of the UbD Backwards Design process is to develop assessments that will reflect on whether students have achieved the desired results laid out in Stage 1 (Wiggins and McTighe, 2012). The key questions that will help focus this stage include:

1. How will we know if students have achieved the desired results?
2. What will we accept as evidence of student understanding?
3. How will we evaluate students' performance in fair and consistent ways? (Wiggins and McTighe, 2012).

Considering the standard-centered (stage 1) assessments in advance helps focus the teaching on the big ideas, rather than just completing enjoyable activities. In these
assessments, students are asked to apply their learning to new and authentic situations to determine if they are able to transfer their learning (Wiggins and McTighe, 2012).

The third stage in the UbD process is to plan the learning experiences and instruction. The key questions that will help focus this final stage are: (1) What knowledge and skills will students need to perform effectively and achieve desired results? (2) What activities, sequences, and resources are best suited to accomplish our goals? (Wiggins and McTighe, 2012). During Stage 3, teachers plan the most appropriate lessons and learning activities to address the goals from Stage 1. Too often, teaching focuses primarily on the presentation of information and does not extend the lesson to help students make meaning of the learning (Wiggins and McTighe, 2012). In Stage 3, teachers develop lessons that require students to be given multiple opportunities to actively construct ideas and transfer them to new situations and to be given timely feedback on their performance and how to improve (Wiggins and McTighe, 2012).

The UbD design model was used to design the instructional unit for the creative component. First, the standard was identified and unpacked, next the pre-, formative, and summative assessments were developed and lastly the activities were created. By using the UbD framework, it made sure that all of the necessary components were included in the instructional unit. In stage 3 of the UbD design model, teachers must design activities that help students reach the goals indicated in stage 1. An effective way to do this is to sequence lessons so they scaffold the required learning. As stated earlier, constructivism allows for new information to be combined with existing information, so when lessons
are properly aligned and scaffolded, students can effectively relate prior experiences to ones they have later in their learning.

**Learning Cycle Model**

A Learning Cycle is an instructional model that provides an active learning experience for students (Duran and Duran, 2004) and it has been shown to be superior to the transmission model, where students are passive receivers of information (Bybee, 1997). Learning Cycles follow a constructivist approach because students are active participants in their own learning and they are constructing their own knowledge (Bybee, 1997) by explaining and investigating phenomena, using evidence to back up conclusions and designing experiments (Duran and Duran, 2004). A Learning Cycle is built on the foundation of inquiry, through which students build models, find patterns, and learn concepts (Duran and Duran, 2004). The 5E Learning Cycle model that consists of five cognitive stages of learning (Duran and Duran, 2004):

- **Engagement**: In this phase, teachers assess students prior knowledge and possible misconceptions through pre-assessments. The engagement phase is a student-centered motivational phase that attempts to create a desire for students to learn more about the upcoming content and a phenomenon could be introduced. The engagement phase is also when the instructional task is identified (Duran and Duran, 2004).

- **Exploration**: In the exploration phase, students make observations and explain in their own words without being told the answers. Teachers act as facilitators and
students are encouraged to apply Science Practices like questions, testing predictions and communicating with peers (Duran and Duran, 2004).

- **Explanation**: In the explanation phase, teachers help explain concepts using students’ prior experiences. In this phase, teachers provide an explanation or correct any misconceptions. Students are asked to connect their prior knowledge, including what they observed and found in the exploration, with new concepts to develop their understanding about a topic. Students must explain their ideas so that they can be refined or revised (Duran and Duran, 2004).

- **Elaboration**: The elaboration phase is where students apply their knowledge to new situations. The goal of this phase is to develop a deeper understanding of the concepts (Duran and Duran, 2004).

- **Evaluation**: The final phase of the 5E Learning Cycle is where students are assessed. Assessments can take many different forms including self-assessments, portfolios, concept maps, models, project presentations, quizzes or tests. Throughout the instructional unit, assessments should be viewed as an ongoing process, with teachers making observations of their students as they apply new skills and look for evidence that the students have modified their thinking (Duran and Duran, 2004).

Although the 5E Learning Cycle is described above as steps to follow, in reality, it acts more of a cycle that caters to the needs of students. Some students may need multiple exploration and explanation rotations before they are ready for the elaboration phase. Also, the evaluation phase happens throughout the instructional unit to determine
student’s understanding and proficiency in practices. The cycle is very flexible and
dynamic (Duran and Duran, 2004). The development of my Project Based Learning unit
followed the 5E Learning Cycle instructional approach to create a student-centered
learning experience for my students. Students’ interests were piqued through an
introductory activity, they completed hands-on activities to experience content, there was
direct instruction and investigation, students applied their knowledge to new situations
and concluded by demonstrating their understanding through a presentation.

**Storylines**

Storylines are a visual representation of individual lessons or entire units that
allow teachers to set clear paths of learning throughout the lessons. Storylines are used to
guide students through content and to make sure each piece of learning adds to the
developing explanation, model or designed solution (Northwestern University, 2019).
Students should be able to see how each new lesson helps them address the essential
questions of the unit. Teachers guide students through the unit by laying out material in a
logical progression so that questions students may generate through the learning will be
addressed in future lessons. Teachers have the responsibility of asking probing questions
to challenge their students to think deeply about the essential questions.

Storylines provide a coherent path towards building disciplinary core ideas and
cross cutting concepts, piece by piece, anchored in students' own experiences and
questions using and further developing their science and engineering practices
(Northwestern University, 2019). Using storylines, along with the 5E Learning Cycles,
helps students develop a deep understanding with real-world context because teachers are
able to be very intentional about directing students towards real-life experiences that align with essential questions identified in the instructional unit. This project is important because it adds to the literature in regards to addressing the lack of literature for junior high school students to understand sustainability in their own lives. Storylining allows teachers to ensure they provide relevant information in a logical order to help students understand the content. This instructional unit taught students about using natural resources sustainably, how to determine if their personal life choices are sustainable and how to create a more sustainable society. The project provides examples for teachers to use when developing instructional units regarding specific content.

Assessments

Pre-assessments

Every student has had experiences outside of the classroom, which causes many of them to have various ideas about different science topics. Some of these ideas are accurate, while others are not. Teachers frequently make assumptions about what students should know about a topic and begin their teaching at that point rather than identifying what students actually know (Keeley, 2008). In order to effectively uncover prior knowledge, a pre-assessment given at the beginning of an instructional unit serves to inform teachers of student understanding (Keeley, 2008).

Administering pre-assessments prior to teaching serves multiple purposes. These assessments can prompt students to start thinking about the topic and they can bring light to misconceptions students may have (Keeley, 2008). The pre-assessments can efficiently inform teachers of what students know and do not know, which allows teachers to tailor
instruction to meet the needs of every learner (Keeley and Tugel, 2009) and not waste
time reteaching things students have already proven they understand.

**Formative Assessments**

In the classroom, assessments are given for a variety of purposes. One type of
assessment is called formative assessment and these are assessments that are given during
the instructional unit to determine if students are learning the materials that have been
covered in class. Formative assessments are used to identify student understanding,
clarify what comes next in their learning, trigger and become an effective system of
intervention for struggling students, inform and improve the instructional practices of
individual teachers, help students track their own progress towards attainment of
standards, motivate student by building confidence in themselves and their learning, and
fuel continuous improvement (DuFour and Stiggins, 2009). Formative assessments are
most effective when incorporated into the classroom when the learning is happening
(DuFour and Stiggins, 2009) and changes can be made to help students who are
struggling to meet the standards. Research performed by Bloom found that student
achievement, motivation, and time on task were significantly higher in classes
characterized by formative assessment, even compared with students taught by the same
teacher without the formative assessment aspects (Bloom, 1984).

Oftentimes, these formative assessments are created by Professional Learning
Communities (PLC), a collaborative group of professionals in the building whose goal it
is to identify what students should learn, determine how they will know learning has
occurred and determine what to do if learning hasn’t occurred (DuFour, 2004). These
particular formative assessments are called Common Formative Assessments (CFA) because the same assessment is administered by all members of the PLC. The results of a CFA can help teachers identify the components of their instruction that are going well and what needs improvement due to struggling students (DuFour and Stiggins, 2009). The members of the PLC can offer timely intervention strategies to aid struggling students.

For students to gain ownership of the feedback they receive, the students need to know the initial learning target and how the activities they are doing in class relate to the target. Students also need to receive feedback on their CFAs that directly tie back to the learning target (Brookhart, Moss, and Long, 2008). The feedback needs to provide students with achievable steps towards improvement. By asking questions that make students think, rather than regurgitate information, students will learn that successful students need to ask questions and that when they think for themselves, they are able to regulate their own learning (Brookhart, Moss, and Long, 2008).

When students are actively involved in the assessment process, they can use the feedback from the assessments to better understand the topic (Keeley, 2008). If students realize that they are struggling with a particular topic, they are much more likely to pay attention to the topic (Pintrich, 2002). If students' preconceived ideas are revealed to be incorrect, through formative assessments, a door is opened which allows students to construct new ideas (Keeley, 2008). When students receive feedback on their formative assessments, they need to know that the results are to help inform them about how to do better next time and how they are able to act on that message (DuFour and Stiggins,
When students are involved in the record-keeping process, they are able to develop the conceptual understanding to communicate their achievement and improvement over time. These involvements have been linked to profound gains in student learning (Hattie and Timperley, 2007). Based on the formative assessment aspects of the assignments, teachers can decide when they want to formally assess their students. If a reasonable number of students are not showing proficiency towards the standard, the teacher can reteach until they are confident that most students will show proficiency (Scriffiny, 2008).

**Summative Assessments**

Summative assessments, like formative assessments, aid teachers in identifying what students do and do not know (Garrison and Ehringhaus, 2013). A summative assessment gauges where a student’s learning is in relation to the standard (Garrison and Ehringhaus, 2013). These assessments most often occur after the instruction and are often included in the students’ class grades (Garrison and Ehringhaus, 2013).

Designing high-quality summative assessments aligned to the NGSS is a challenge, due to the broad nature of the performance expectations. Examples of the testable NGSS tasks include:

- Developing and refining models,
- Generating and analyzing data,
- Constructing scientific explanations,
- Engaging in evidence-based argumentation, and
- Reflecting on their own understanding (National Research Council, 2014).
The nature of these assessment tasks steers students away from memorization and requires students to demonstrate knowledge and skills similar to how science and engineering is practiced in the real world (National Research Council, 2014).

Many assessments were developed and implemented throughout the instructional unit. Formative assessments included pre-assessments (to gauge students’ initial knowledge), informal conversations, and short CFA quizzes which helped guide the pacing and teaching of content. For the pre-assessment, students filled in a flowchart to show their initial understanding and connectedness of the content covered throughout the unit. The formative assessments align with the constructivist theory. Formative assessments are meant to measure student progress to see what knowledge they have built and they help teachers determine if students have been successful constructing that knowledge. If these assessments identify students are struggling to make the connections, teachers can step in and provide learners with additional learning opportunities.

The summative assessment was a Project Based Learning (PBL) project, where students were responsible for working with a team to develop a sustainable community. Using data collected and analyzed and the scientific information they learned throughout the unit, the students determined the most appropriate choices for their community and explained their reasoning. As indicated previously, PBL aligns with a constructivist mindset because students made connections between previously learned material and their new scenario.
Standards Referenced Grading (SRG) and Proficiency Scales

The instructional unit had many graded components which fell under formative and summative assessments. These assessments were viewed using proficiency scales and assessed using Standards Referenced Grading techniques.

Explaining Standards Referenced Grading

Standards Referenced Grading (SRG), also called Standards Based Grading (SBG) or Standards Based Learning (SBL), is a relatively new grading practice which measures student’s proficiency on well-defined course objectives (Tomlinson and McTighe, 2013). The major difference is that SRG uses 1-4 scores that replace traditional point-based grades. In traditional point-based grading systems, the A, B, C, D, or F, letter grade indicated a very vague description of what students know and giving points to items, like homework, had the potential to change a student’s grade drastically. A student could turn in all of their work but perform poorly on a test and would receive a decent grade, while another student who did not turn in their homework but performed well on the test may receive a lower grade (Scriffiny, 2008).

In a traditional grading system, teachers can assign grades for a variety of tasks including assignments, homework, quizzes and tests and can give points for bringing in Kleenex tissues or showing up on time for class. In a SRG system, many of those things are not assigned scores/grades. A middle school in Minnesota asked teachers to compare semester grades to the end-of-the-year test scores on state subject exams and they discovered that about 10 percent of the students who received A’s or B’s struggled with the exam, while 10 percent of the students who received C’s, D’s or F’s did better than
their B+ classmates (Tyre, 2010). These teachers realized that they were actually grading compliance (e.g. turning in homework, participating in class, and completing extra-credit assignments) rather than grading mastery on the course materials (Tyre, 2010). In SRG, students only receive grading scores for bodies of evidence that align to the standards, while all other assignments may be noted in the gradebook, and will not hurt a student’s grade (Tyre, 2010).

Many teachers who use SRG in their classrooms remove point totals away from assignments, but rather frame assignments as learning tools, opposed to formal assessment/grade-generating tools. In a SRG classroom, students don’t need to complete all of the assignments, but they do need to know that they are accountable for mastering the standard that each of the assignments is connected to (Scriffiny, 2008). When assignments are given, they are used for students to ask themselves, “Do I know this? Can I do this?” (Scriffiny, 2008). Teachers provide feedback to the students who have turned in their assignments, which helps the students determine if they have the skills necessary to show proficiency on the content (Scriffiny, 2008). When giving feedback, teachers can choose select questions to focus on and they are able to use those questions as a formative assessment that helps determine if students are understanding a topic.

SRG allows teachers to adjust their instruction based on the individual needs of each student. When the class takes the assessment, the results can help the teacher decide how to move forward in their instructional unit. If the whole class seemed to struggle, the teacher may decide to pause the content to do whole class reteaching. Or if only a handful of students were not able to show proficiency, the teacher may decide to do individual
re-teaching while the rest of the class moved on to a different task (Scriffiny, 2008). Once students show proficiency, they can be challenged to complete more complex tasks at higher levels of Bloom’s taxonomy or that seeks connections among different objectives (Scriffiny, 2008).

**Explaining Proficiency Scales**

In SRG for science, all content that is taught surrounds the standard laid out by the NGSS. This standard is broken down into levels of proficiency, called proficiency scales, and students receive a scaled score based on their level of proficiency. The following specific academic descriptors are the scores students at Des Moines Public Schools receive (DMPS, 2019a):

- **Level 4: Exceeding Standard** - In addition to exhibiting Level 3 performance, students demonstrate in-depth inferences and applications that go beyond the target.
- **Level 3: Meeting Standard** - Students demonstrate they have the ability to meet the grade-level standard. No major errors or omissions regarding any of the information and/or processes (simple or complex) that make up the target.
- **Level 2: Developing Towards Standard** - Students demonstrate basic foundational knowledge of the target, including recalling or recognizing vocabulary critical to the target. No major errors or omissions regarding simpler details and process, but there are major errors or omissions regarding the more complex ideas and processes.
● Level 1: Insufficient progress - Student performance reflects insufficient progress towards foundation skills and knowledge.
● Level 0: No evidence of student understanding in submitted work.
● Level M: No evidence - The student has not submitted evidence to show understanding of the standard.

When developing a topic-specific content scale, the descriptors above guide the planning. Levels 1 and 4 are specifically worded above, but Level 2 and Level 3 are worded specifically to the work of the topic but stay true to the spirit of the wording of the descriptors above. The wording of Level 3 comes directly from the performance expectations from the NGSS and the Level 2 skills are developed using the evidence statements from the standard (DMPS, 2019a).

When a student takes an assessment, they are scored using this 4-point scale (DMPS, 2019). Scores take on a learning and feedback component. When teachers and students operate using the 4-point scale, it becomes clear what students know and what they need to work on to reach proficiency (DMPS, 2019b). If a student receives a 2, a teacher can identify what level 2 skills they have mastered and can indicate the level 3 skills they have not yet mastered. If a student has not mastered the Level 3 skills, they are able to retake assessments to show they have mastered the content (Tyre, 2010) and students are not penalized for their earlier learning attempts (DMPS, 2019b). At the end of the semester, all of the scores that impact a student’s grade are representative of the most recent attempt of mastery, not an average of all the attempts to master the standard (DMPS, 2019b).
The developed instructional unit was based on MS-ESS3-3: *Students who demonstrate understanding can apply scientific principles to design a method for monitoring and minimizing a human impact on the environment* (NGSS, 2013e). Using the performance expectation and the evidence statements of the standard, a proficiency scale was developed. The teacher used the proficiency to score students on a 1-4 scale based on the knowledge that students proved they have mastered. If the student had not proven that they were proficient in the standard, they had the opportunity to prove they understand the material through a different way and the additional attempts were scored using the same scale. SRG monitors student progress in a way that allows for students to show growth any time they learn new materials. Using this grading practice, if a student experienced a new scenario that helped them learn the material, they would be able to prove that newly constructed knowledge. SRG encourages students to keep improving and be actively involved in their own learning. My graduate project is important because it adds to the literature regarding a PBL unit that uses SRG as a grading system. Because of the detailed nature of PBL, some projects use the NGSS as a starting spot to determine the content/theme of the project and that is it. Creating an instructional unit that utilizes SRG and proficiency scales to align a PBL product to the NGSS is creating something that is new and is missing in current academic literature.

**EQuIP Scoring Rubric**

The Educators Evaluating the Quality of Instructional Products (EQuIP) rubric was designed to measure the quality of lessons/units and their alignment with the Next Generation Science Standards (NGSS, 2016). The purpose of this rubric is to determine if
lessons/unit needs revisions, to provide criterion-based feedback for improvements, to identify model units/curriculum for other teachers to use, and to inform the development of future lessons and units (NGSS, 2016). To use rubric well, educators must have a good understanding of the NGSS performance expectations which includes the Three Dimensions of Learning [Science and Engineering Practices, Cross Cutting Concepts and Disciplinary Core Ideas] of learning discussed earlier in Chapter 2 (NGSS, 2016).

The original EQuIP rubric evaluates the instructional unit, or individual lessons, using three different categories: NGSS Three Dimensional Design, NGSS Instructional Supports and Monitoring NGSS Student Progress (NGSS, 2016). In the first category, NGSS Three Dimensional design, the unit is evaluated on a criteria that includes:

- Students’ ability to make sense of the phenomena, an observable event that can drive students inquiry, or designing solutions to problems,
- Students’ understanding the grade-appropriate elements of the SEPs, DCIs, and CCCs and ability to integrate the Three Dimensions,
- Unit coherence to determine if lessons fit together, and
- Connection of the current content to different science domains or math and English language arts (NGSS, 2016).

In the second category, NGSS instructional supports, the unit is evaluated on how well it:

- Engages students in authentic and meaningful scenarios that reflect scientific experiences in the real world,
- Provides students the opportunity to represent their ideas and to respond to feedback,
- Identifies and builds on student’s prior knowledge in all Three Dimensions of the NGSS,
- Uses scientifically accurate and grade-appropriate information, and
- Uses differentiated instruction, giving students multiple ways of taking in information, and is engaging (NGSS, 2016).

The third category, monitoring NGSS student progress, evaluates the unit by:
- Monitoring observable evidence of the students’ knowledge of the three dimensions,
- Providing formative assessment to evaluate learning,
- Providing rubrics or scoring guidelines to help students interpret success and help teachers to plan instructions and provide feedback,
- Assessing student proficiency in an unbiased way for all students,
- Identifying a coherent assessment system with pre, formative, summative and self-assessment, and
- Provides multiple opportunities to demonstrate their knowledge of the three dimensions of the NGSS (NGSS, 2016).

The criteria in all of the categories are measured by the amount and quality of the evidence presented and rated Extensive, Adequate, Inadequate or None (NGSS, 2016). Once each criterion is rated, a score is assigned to each category from 0-3 based on the number of adequate and extensive ratings (NGSS, 2016). The final step is to add together the scores from the three categories, for a possible score of 9. Units that receive a 6-7 are
considered high quality with room for improvement, which a score of 5 or less would signify a need for major revisions (NGSS, 2016).

Due to the large scale of full EQuIP rubric and the fact that sections including Project Based Learning and 21st Century Skills will be added, the instructional unit was scored using a rubric that has been adapted and revised from the original rubric called NGSS Instructional Materials Evaluation (Escalada, 2017) which has been used in secondary science methods and science courses for both preservice and inservice science teachers. The modified rubric provided a quick snapshot of the alignment with the NGSS that was appropriate for this project and evaluated the instructional materials that contained specific criteria in each section.

**Literature Review Conclusion**

Throughout this chapter, I have provided the foundational literature that has provided the theoretical foundations for the development and implementation of my instructional unit as well as the ability to gain insights for the revisions needed to improve student learning. This project is an important contribution to the literature as the development, implementation and analysis of this instructional unit provides guidance and insights to educators on how to engage students in learning about a topic that is important in a way that is relevant and meaningful. Instructional units that are developed using a PBL framework, guided by the NGSS and real-world problems, and are graded using a SRG proficiency scale is a way to make learning relevant and meaningful to students. The insights I have gained for the implementation and analysis of the
instructional unit are important because the development of the instructional unit that combines the various components is very rare.

Per the literature review, I have determined that the components included are very essential for developing, implementing and analyzing the instructional unit and the data collected. Using the Next Generation Science Standards (NGSS) is important in this project because Iowa adopted the NGSS as their science standards by 2019 Iowa Department of Education, 2016), so all current units in Iowa need to use the NGSS to drive the instruction. The NGSS moves students beyond memorization of disconnected facts to viewing science as interrelated contents that connect scientific principles to real-world situations (Iowa Department of Education, 2016) which is an important part of this project. 21st Century skills are skills that bridge knowledge and skills from the academic areas into real life applications (Iowa Department of Education, 2009). The students will be developing and utilizing these skills by working in collaborative groups to meet a common goal and develop a solution to a real-world situation. Project Based Learning (PBL) is one of the main components of the project. PBL units are student driven, focused around standards and allows students to problem solve to answer large overarching questions (Everette, 2015). PBL instruction needs to have a real-world context that can sustain student inquiry (Buck Institute of Education, 2019). It has been discussed that students that engage in PBL units have a greater academic achievement compared to students who complete traditional instruction (Chen and Yang, 2019) due to the connection with the essential driving questions and the process of sustained inquiry and reflection. One of the goals of this project is to have students make connections
between the academic content and their real-world experiences, and the integration of PBL provides these connections.

Including Understanding by Design is an important addition to the project because it helps teachers identify learning goals, create useful assessments and plan meaningful learning opportunities through Backwards Design (Authentic Education, 2015). By utilizing Backwards Design, I am able to focus on the standard and the essential questions of the unit before developing the assessments. By using this technique, I can make sure that my assessments include all parts of the standards and are guided by the essential questions of the unit. The last stage is the development of learning opportunities. By completing the learning opportunities stage last, the activities can be developed to meet the goals of the unit and help students make meaning of the learning (Wiggins and McTighe, 2012). Utilizing the 5E Learning Cycle Model to develop the instructional unit is beneficial because learning cycles provide an active learning experience for students (Duran and Duran, 2004). Active learning experiences have been shown to be superior to the model where students are passive receivers of information (Bybee, 1997). Using the 5Es (Engagement, Exploration, Explanation, Elaboration and Evaluation) while developing allowed me to design a unit that was not teacher driven and provided opportunities for students to explore the material and make connections to develop their understanding about various topics. The cycle was flexible and dynamic and followed the needs of the students (Duran and Duran, 2004) so I was able to provide explanations when needed and allowed students to elaborate on their knowledge when they showed they could apply their knowledge to new situations. Storylines are beneficial
to help organize the lessons throughout the unit. Storylines are used as a guide to make sure each piece of the learning helps answer the essential questions of the unit (Northwestern University, 2019). I used the storyline to identify how each lesson helped answer the essential question and how the lesson aligned with the NGSS. The storyline helped me identify gaps in unit development when it came to including the disciplinary core ideas, cross cutting concepts to further develop students’ science and engineering practices (Northwestern University, 2019).

The inclusion of Standards Referenced Grading (SRG) is a useful addition to the project because SRG practices align students' grades with students' proficiency on a well-defined set of objectives (Tomlinson and McTighe, 2013). I used the standard to create a proficiency scale, which allowed students to be aware of the objectives of the unit. By using SRG, students' grades are based on their evidence that aligns with the NGSS standard (Tyre, 2010). SRG allows for students to use feedback to relearn and reattempt to master the content (Tyre, 2010) and students’ grades are representative of the most recent attempt of mastery, not an average of all the attempts (DMPS, 2019b). Two major tenants of PBL learning is providing feedback for growth and alignment with the standard, so utilizing SRG proficiency scale to score student work, provide feedback and allow students to resubmit their work allows students to reflect on their learning and improve. Utilizing a modified and abbreviated EQuIP rubric was a significant addition to the project because the original EQuIP rubric was designed to measure the quality of the lessons/units and their alignment with the NGSS (NGSS, 2016) which was a major component of the instructional unit I designed. The EQuIP rubric, and the modified and
abbreviated version I used for the project, helped provide criterion-based feedback for improvements and inform the development of future lessons and units (NGSS, 2016). The modified and abbreviated EQuIP rubric that was used helped determine if the unit was aligned with the NGSS, but also it is aligned with the tenets of PBL and 21st Century Skills. It was beneficial to use this version of the EQuIP rubric because it provides a learning tool for other educators that set out to develop similar instructional units.

This instructional unit provided a way for students to learn to solve real-world problems using scientific practices, guided by the NGSS and Iowa Core’s 21st Century skills. Project Based Learning and Standards Referenced Grading brought meaning and guidance to student work. Developing the lessons and assessments using Backwards Design and the 5E Learning Cycle, as well as analyzing the unit using a modified and abbreviated EQuIP rubric, ensured that all required information was included and taught in a logical way to help students make sense of the content. The goal is for junior high school students to understand how to make sustainable choices in their lives and to lessen human impact on the environment. Utilizing the theoretical framework of constructivist learning, students are active participants in their own learning, not just receivers of information from their teachers. Through a constructivist mindset, students construct their own knowledge, so they are able to use scientific practices to solve real world problems. It is clear that the instructional unit and additional project components that are being developed is an important addition to the academic literature. By weaving together the various components of the NGSS, 21st Century skills, Project Based Learning, Standards Referenced Grading, backwards design using the 5E Learning Cycle instructional model
and modified EQuIP rubric; the instructional unit will allow students to develop skills and knowledge for them to develop ways for students to monitor and minimize human impact on the environment.
CHAPTER 3- PROJECT DESCRIPTION

Curriculum Development

As stated in Chapter 1, the 8th grade earth science sustainability instructional unit I created for the creative component is focused on the Next Generation Science Standard MS-ESS3-3 Earth and Human Activity: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* This standard includes the Science and Engineering Practice (SEP) of constructing explanations and designing solutions, a Cross Cutting Concept (CCC) of cause and effect, and a Disciplinary Core Idea (DCI) of human impacts on Earth systems specifically how humans have altered the biosphere by damaging or destroying natural habitats and how when human population and per-capita consumption of natural resources increases, so do the negative impacts on the Earth unless activities and technologies involved are engineered otherwise (NGSS, 2013e). My research questions for my creative component include the following:

- How does this instructional unit align with the PBL framework and the NGSS?
- How have my student’s ideas and knowledge of sustainability progressed throughout the instructional unit?

The methodology I used to develop an 8th grade earth science unit was the three stages of Backwards Design laid out by Understanding by Design: (Stage 1) identifying desired results, (Stage 2) determining assessment evidence, and (Stage 3) planning learning experiences and instruction (Wiggins and McTighe, 2011). This completed template can be found in APPENDIX A. After developing the instructional unit, I organized it using a 5E Learning Cycle instructional approach and storylines. With
the research questions in mind, during the implementation of the instructional unit I collected data to determine the impacts of the PBL unit and how well it aligned with the NGSS.

The instructional unit I developed took approximately 6 weeks to implement in my classroom with 45 minute class periods and began on the 4th of April, 2021. Every unit prior was developed by the 8th grade science Professional Learning Community (PLC) and followed the NGSS and scored using Standards Referenced Grading (SRG). My school district determined the sequence of the units throughout the year, with the first half of the year focusing on Physical Science (waves, force and motion, and thermal energy transfer) and the second half of the year focusing on Life Science and Earth Science (evidence of common ancestry, natural selection, water cycle, factors that affect climate and human impact on the environment). Throughout the year, students focused on building and utilizing models, making arguments from data, and other NGSS guided tasks. Units were developed using an unofficial Backwards design model. First, the NGSS standard is identified and broken down; next, the summative assessment is written; and last, the learning activities are aligned to the standard and the assessment. This instructional unit was the last unit of the 2020-2021 school year and the only unit that utilized PBL style learning. The reason this was the only PBL unit was because PBL was a new and challenging technique that took a lot of time and effort to do correctly. Most of the previous units were implemented during Covid-19 hybrid learning (in-person and online simultaneous learning), so our PLC focused on developing units that could be completed without immediate teacher guidance. The last few units of the school year
were implemented when students were all back to in-person learning, which leant itself to completing a PBL unit.

**Stage 1- Identifying Desired Results**

To begin the process of instructional unit development, I unpacked the Next Generation Science Standard to determine what students need to be able to demonstrate understanding of by the end of the unit. Once the standard is unpacked and the skills and concepts are determined, the proficiency scale and skills tracker, a document students will use to identify the skills they have mastered based on the proficiency scale, will be written. These pieces help the student understand what material they need to prove they understand by the end of the instructional unit. The planning of the first stage of Backwards Design can be observed in Figure 1. The Figure 1 template identifies the goals of the unit, what students will understand by the end of the unit, what students are able to do by the end of the unit and the essential questions that drive the unit.

**Figure 1- Stage 1 of the Backwards Design Template**

*Desired Results of the instructional unit*

<table>
<thead>
<tr>
<th>Stage 1 - Desired Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Established Goals:</strong></td>
</tr>
<tr>
<td>● <strong>MS-ESS3-3.</strong> Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment</td>
</tr>
<tr>
<td>○ <em>Clarification Statement:</em> Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible and designing and evaluating solutions that could reduce impact</td>
</tr>
<tr>
<td>○ <em>Examples of human impacts can include</em> water usage (such as withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or removal of wetlands), and pollution (such as of the air, water or land)</td>
</tr>
</tbody>
</table>
Understandings:
- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing extinction of species
- Changes to Earth’s environments can have different impacts (negative and positive) for different living things
- As human population and per-capita consumption of natural resources increase, so the the negative impacts on the Earth unless the activities and technologies involved are engineered otherwise

Essential Questions:
- Explain how the use of natural resources can impact the environment
- Explain, using cause and effect, how the sustainable society you designed using scientific evidence, has a lower impact on the environment than our current society.

Students will know . . .
- Positive and negative environmental aspects of particular human activities
- Positive and negative economic aspects of particular human activities
- How to determine if a solution is appropriate for a given scenario

Students will be able to . . .
- Use scientific information and principles to address the results of a particular human activity
- Incorporate technologies/solutions that can be used to minimize and monitor the negative effects on the environment
- Describe the criteria and constraints for the solution
- Describe how well each solution meets the criteria and constraints
- Identify limitations of the use of technologies/solutions for their solution

Note. The figure shows the template that was utilized in the construction of the instructional unit. This template came from Wiggins, G., & McTinge, J. *Understanding by Design* (2005, p.22).

After completing the proficiency scale, I determined the essential questions used to drive my instructional unit. For the instructional unit, the following essential questions were used to guide development, instruction and assessment:
1. Explain how the use of natural resources can impact the environment.

2. Explain, using cause and effect, how the sustainable society you designed using scientific evidence, has a lower impact on the environment than our current society.

Question #1 will be used to help students identify a method for monitoring human impact on the environment and Questions #2 will be used to help students explain how to minimize human impact on the environment. By developing a sustainable society using PBL, students designed a method to monitor and minimize human impact on the environment.

**Stage 2- Determining Assessment Evidence**

The next step in the instructional unit design process was to determine the acceptable evidence of student learning. The first assessment that needed to be designed was the summative assessment in which the project scenario and scoring guidelines need to be developed. The summative project would demonstrate if the students have achieved the level of performance expectations that are expected from the instructional unit. To do this, I created the project guidelines, example included in Figure 2 that identifies the questions that students need to answer about their sustainable society sector, and rubrics that assisted me in analyzing the students’ work. This summative project was used to determine the students’ overall understanding of the learning goals and measure their depth of knowledge on the overarching essential questions. Their performance on this summative project determined their proficiency on the standard.
**Human Impact: Create a Sustainable Society (Electricity Advisor)**

1. Description of the chosen settlement [use Sustainable Society Project Outline]

2. CURRENT SEP COMMUNITY: What are the top 3 “appliances” that need electricity in your home? [Use audit for top 3 appliances that use electricity]
   - __________________________________________
   - __________________________________________
   - __________________________________________

3. CURRENT SEP COMMUNITY: What was the electricity source we use now and why is it a problem? [Use audit “current electricity source”]
   - Our current way to produce electricity is __________________________
   - This is a problem because...

4. NEW SUSTAINABLE SOCIETY: What new electricity source will your town use to generate electricity? Why would your new electricity source be best suited for your chosen society? [Hint: does your settlement have rivers? Lots of open space? etc??]
   - My town is going to use __________________________ to generate electricity
   - This is going to be best for my chosen society because...

5. NEW SUSTAINABLE SOCIETY: Discussing your new electricity source: SHOW YOUR WORK
   a. How much electricity will your society need for **1 day**? [Use audit “calculation questions”]
   b. How much electricity will one (wind turbines/solar panels/dams/coal burning power plants) provide in **1 day**? [Use research provided]
   c. How many of the (wind turbines/solar panels/dams/coal burning power plants) will you need for your 700 home community in **1 day**? [Use your audit calculations for community energy “consumptions” AND the amount of electricity generated by 1 energy source *use sustainable society calculator, if needed*]
d. Discuss some costs (\$) associated with your chosen electricity source. (List like a receipt)
   
   **Hint:** People would pay installation and maintenance (in taxes) and would pay the electric company for their individual usage. (Use research provided)

6. NEW SUSTAINABLE SOCIETY: Is this new electricity source renewable or nonrenewable? How do you know?
   - My new energy source is RENEWABLE or NON-RENEWABLE (circle)
   - I know this because...

7. NEW SUSTAINABLE SOCIETY: Explain why your new electricity source is a sustainable solution for your community/environment? (Hint: include details about why these things are pros or cons)
   
   a. Environmental Pros [good for land, water, air, plants, animals, etc]
   b. Environmental Cons [bad for land, water, air, plants, animals, etc]
   c. Economic Pros [makes/saves me money]
   d. Economic Cons [costs me money]

Note. The questions are tailored to each of the different roles in the summative project (electricity advisor, transportation advisor and waste advisor)

After creating the project guidelines and the rubric, I then planned for the pre-assessment. The pre-assessment helped gauge what students already know about the topic of sustainability and how certain behaviors have an impact on the environment. The pre-assessment I used was a flowchart that mapped student ideas about how humans impact the environment and ways to minimize these impacts. The same flowchart was visited at the end of the unit to determine if students have gained knowledge and understanding throughout the unit. The flowchart, which includes the three sectors of the project (electricity, transportation and waste) and places for students to identify what resources we currently use, issues with that usage, ways to monitor our usage and ways to minimize that usage, can be seen in Figure 3.
Figure 3- Pre-Assessment Flowchart
*Students identify their knowledge about natural resources, negative impacts of resource usage, monitoring resource usage and minimizing resource usage*

Note. The pre-assessment flowchart was used at the beginning and end of the instructional unit.

Finally, I planned for formative assessments to gauge student understanding throughout the instructional unit. These formative assessments came in the form of check-in quizzes called common formative assessments (CFAs) and general project check-in questions for students to informally answer during the project completion portion of the instructional unit. Throughout the unit, I ended up using student assignments and informal formative assessments as well.
Stage 3- Planning Learning Experiences and Instruction

In the final stage of UbD Backwards Design, activities and their accompanying guides were created to allow students to practice skills. These activities were planned to allow students to reach an understanding of the NGSS performance expectations (Wiggins and McTighe, 2011). Following the 5E Learning Cycle instructional approach, activities were organized into five categories: engagement, exploration, explanation, elaboration and evaluation.

● **Engagement**: During this phase, students were:
  
  ○ Introduced to the NGSS performance expectations and the proficiency scale,
  
  ○ Provided a pre-assessment that determined their depth of knowledge for monitoring and minimizing human impact on the environment,
  
  ○ Introduced to the summative assessment project (Creating a sustainable society) which created a “need to know” for all of the information learned throughout the instructional unit, and
  
  ○ Asked to identify their carbon footprint which was the engaging personal tie-in to the instructional unit.

● **Exploration**: In the exploration phase, students explored content to generate their initial understanding. Students investigated, through research, hands-on experiences, and activities, topics including:
  
  ○ Natural Resources,
  
  ○ Renewable and Non-Renewable resources,
○ Tragedy of the Commons,

○ Greenhouse effect and global temperature change,

○ Personal and community use of natural resources in regards to generating electricity, transportation/fuel options and waste removal systems

(students will audit their usage), and

○ Positive and Negative impacts of electricity sources, transportation/fuel options and waste removal systems.

● **Explanation:** During the explanation phase, teachers who are part of my PLC, explicitly taught science content that helped students explain their experiences from the exploration phase. Prior to the completion of the explanation phase, students took two formative assessments (evaluation phase) so that the teachers could determine what ideas students had or what topics needed further clarification. If the formative assessments showed a need for correction or clarification, it is at this point in the instructional unit that teachers provided that instruction.

● **Elaboration:** Once students had demonstrated their understanding of the topics introduced in the exploration and explanation phases, students were given the opportunity to demonstrate their understanding within a new situation. In the instructional unit, the elaboration phase is when the summative project began. In the project, students had to apply their knowledge of the different topics to determine the most beneficial way to provide electricity, transportation, and waste removal for a community. During this phase, students worked in groups to discuss
their choices and provided peer-review. While working on their summative project, the students determined if they needed additional resources to help them construct a full understanding of the most sustainable choice for their community. If they determined they needed additional information, the students’ learning shifted back to the exploration phase.

- **Evaluation**: In the evaluation phase, assessments took many different forms including flowcharts, quizzes/common formative assessments (CFAs), peer-reviews, and project presentations. Assessments were viewed as an ongoing process that determined what content needed further explanation. The unit started (pre-assessment) and ended with student generated flowchart to determine students’ prior knowledge and their growth. CFAs (formative assessments) were given to determine if students understood the materials. The opportunity for peer-review (formative assessments) was utilized during activities in the exploration and elaboration phases. These peer-reviews helped students deepen their understanding of the concepts and strengthen their summative product. The summative assessment project assessed students independently to determine their understanding of the NGSS performance expectation. Details of the summative assessment project include:
  - **Overview**: The project will assess students' knowledge in the NGSS performance expectation (MS-ESS3-3: *Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment*). Students will form teams of three individuals who will work
together, but will each be responsible for their own portion of the project.

As a group, they can determine how they want to present their project (PowerPoint, website, pamphlet, etc) but everyone is responsible for demonstrating their own understanding.

○ **Scenario:** A natural disaster hit an area and forced all of the inhabitants to different places around the country. Each of the places will have descriptions of various natural resources. Every new community will have about 3000 people.

○ **Student task:** The student group will make up the city council, where each member of the group will be the sustainability leader for either electricity generation, transportation/fuel options and waste removal systems. The council member will use previously collected data from the audits, mentioned in exploration phase, to determine how much of the resource is needed [monitor human impact] and will determine the most sustainable option for each sector for their community [minimize human impact].

To develop lessons and determine the order they were taught, I used the 5E Learning Cycle instructional approach and created a storyline for the unit, which can be found in APPENDIX B. The storyline was used to make sure all of the learning activities followed the SEPs and CCCs identified by the NGSS and aligned to the essential questions of the unit. The storyline also has lesson level questions, activity descriptions, activity alignment with the SEPs and the CCCs as well as what students should have learned by the end of each lesson.
The following section includes the Unit Outline with the initial engagement, essential questions, assessments and activities clearly identified. The Backwards Design template, found in APPENDIX A, contains the desired results of the unit including the standard addressed, essential questions, and descriptors of what students need to know and be able to do by the end of the unit; descriptions of each formative assessment, descriptors of the summative assessment project and lists of content assessed; and descriptions of the learning plan and each activity, as well as a full set of the unit materials embedded into the template.

**Unit Outline including the 5E Learning Cycle terms**

*Full set of unit materials can be found in the Backwards Design Template, APPENDIX A*

**Initial Engagement: Carbon Footprint Calculator**
- Humans create a lot of Carbon Dioxide/Methane in our lives. Students will use an online carbon footprint calculator to assess how much carbon their lifestyle creates. Activity sets up a “Need to Know” for all the content in the unit.

**Essential Question #1: Explain how the use of natural resources can impact the environment**
- Pre-assessment Concept Map [Engage]
- Introduction of Summative Project: Create a Sustainable Society [Engage]
- Natural Resources
  - Part 1: Natural Resource and Moana (identifying examples of natural resources) [Explore/Explain]
  - Part 2: Natural Resources and Easter Island (overusing natural resources) [Explore]
- Renewable and Non-Renewable Resources
  - Breakout Room Activity (identifying renewable and nonrenewable electricity resources) [Explore/Explain]
- Tragedy of the Commons
  - Tragedy of the Commons and the Lorax (impact of overusing natural resources for personal gain) [Explore]
● Greenhouse Effect and Global Temperature Change
  ○ What is the Greenhouse Effect? (identifying the greenhouse effect) [Explore/Explain]
  ○ Graphing Carbon Dioxide over 50 years (impact of carbon dioxide on global temperature change) [Explore/Explain]

● Formative Assessment
  ○ CFA #1 [Evaluate]
  ○ Summative Assessment Check-in [Evaluate/Elaborate]

**Essential Questions #2: Explain, using cause and effect, how the sustainable society you designed using scientific evidence has a lower impact on the environment than our current society**

● Part 1: Electricity
  ○ Electricity Speed Dating (learn about different types of electricity generation) [Engage/Explain/Explore]
  ○ Electricity Audit (calculate personal amount of electricity usage and determine additional data) [Explore]

● Part 2: Transportation
  ○ Transportation Land game (learn about different vehicle and fuel options) [Explain/Explore]
  ○ Transportation Audit (calculate personal amount of gasoline usage and determine additional data) [Explore]

● Part 3: Waste
  ○ Waste Removal System Stations (learn about different waste removal systems and pros and cons of each option) [Explain/Explore]
  ○ Waste Audit (calculate personal amount of waste generation and determine additional data) [Explore]

● Formative Assessment
  ○ CFA #2 [Evaluate]
  ○ Audit Peer Review [Evaluate/Elaborate]

**Summative Assessment**

● Develop a Sustainable Society (develop a sustainable society, including a more sustainable way to generate electricity, transport people and deal with waste) [Evaluate]

The focus of the first part of the instructional unit was about how the use of natural resources impacts the environment. In this half, my goal was to give students the
opportunity to understand how using natural resources has a greater impact on the environment than just using up the resource. I also wanted to connect overusing resources and their impacts to stories and experiences they previously had, like calculating their personal carbon footprint or the story of the Lorax. I transitioned between the first and second half of the unit by having students take a CFA that covered the information from the first half of the unit. To determine the pacing of the unit, I collected student evidence from their formative assessments and submitted activity guides to determine if any time outside of the original experiences was needed to help students gain the needed knowledge.

In the second half of the instructional unit, the student’s goal was to explain how the sustainable society they developed had a lower impact on the environment than our current society. Since they had previously learned about renewable and nonrenewable electricity resources while working in the first part of the unit, I began the second part of the unit with the electricity content. After electricity, I moved on to learning about transportation systems and waste removal systems. In each of the sections, the students had a way to explore the material without direct teacher explanation. After they explored the content on a larger scale, they completed a personal audit of their resource usage. They used their personal usage information to extrapolate into the needs of a community. The summative assessment was used to develop and present their sustainable society. They developed the society based on individual group parameters, which are found in APPENDIX A. I also collected summative assessment projects to determine students’ proficiency level, based on the proficiency scale. At the end of the instructional unit, I
determined if it adequately addressed the goals of the unit for the students and the teacher.

**Addressing Research Questions**

Although all 4 members of my PLC (myself plus three additional members) used the lessons and the project I created, I was the only member of the PLC collecting data that aligned with my research questions. My instructional unit featured a pre-assessment, multiple formative assessments and a final summative assessment project. As stated in Chapter 1, the research questions I answered include:

- How does this instructional unit align with the PBL framework and the NGSS?
- How have my student’s ideas and knowledge of sustainability progressed throughout the instructional unit?

To determine how my student’s ideas and knowledge of sustainability progressed through the unit, I compared my students' flowchart that they initially made as a pre-assessment to the flowchart they created after they completed the summative assessment project. I looked for the addition of new material and if the students were able to make deeper connections between various ways humans impact the environment. When looking at the three categories of the flowchart, electricity needs, transportation needs and waste removal needs, I identified the number of correct answers on each flowchart. I then calculated the percentage of accuracy of each of the three categories. I analyzed this flowchart and compared how their overall answers changed, which was consistent with my Institutional Review Board (IRB) proposal. No student identifiers were recorded on the flow charts.
I used a modified and abbreviated EQuIP rubric to determine how well the instructional unit aligned with PBL and the NGSS. The sections of the modified and abbreviated EQuIP rubric are: (1) Alignment with NGSS, (2) Instructional Supports, (3) Monitoring Student Progress, (4) Alignment with “Gold Standard” PBL, (5) Inclusion of 21st Century skills and (6) Teacher Resources. Using a modified rubric, the instructional unit received a 0-4 score based on the quality of evidence for each of the criteria listed under each section (Escalada, 2017). The scores were averaged to determine the rating for each section: 4- Excellent, 3- Good, 2- Average, 1- Fair, 0- Unacceptable (Escalada, 2017). The modified and abbreviated EQuIP rubric was filled out one time by the 3 additional members of my PLC after the unit had concluded. Each teacher averaged the six section scores before turning the rubric back into me. As with the student work, there were no identifiers on the individual rubrics. Once submitted, I took all of the surveys, which included the individual average section scores, and averaged the overall section scores, as well as the scores for each item in every section. The average scores were used to determine how well the project aligned with PBL, the NGSS, and the additional sections listed above.

To determine who was participating in the study, I sent parents/guardians a consent form to return if they wished for their student not to participate. The consent form included that this study was confidential, voluntary and participating in the study had no direct impact on the student’s grades. Prior to analyzing specific pieces of student work, I followed the IRB guidelines, identified by University of Northern Iowa. I collected data only from students whose parents have indicated that they allow their
student to participate in the research study. Following my IRB protocol, the only indirect identifiers of student work was student grade level, as this instructional unit was developed for an 8th grade science curriculum. I held on to the unidentified documents until the data was collected and then the documents were destroyed.
CHAPTER 4- REFLECTION

As the creator of this 8th grade earth science instructional unit, I had many focuses in creating and analyzing this unit. Before developing the content, I realized a lack of Project Based Learning (PBL) instruction that aligns with the Next Generation Science Standards (NGSS) that also uses Standards Referenced Grading (SRG) as the grading technique existed in my instruction. I also saw the literature lacked curricular resources and a discussion of the impact on student learning that focused on sustainable lives directed towards junior high school students. The purpose of this creative component was to develop an instructional unit that:

- Helped students make connections between the standard content they learned in the classroom, determined by the Next Generation Science Standard (NGSS), and the world outside of the classroom.
- Helped students learn and present their materials in a different way, guided by Project Based Learning (PBL) techniques, 21st Century Skills and Standards Referenced Grading (SRG).

After completing the development, implementation and analysis of the instructional unit, the research questions I sought to answer through this non-thesis project were:

- How does this instructional unit align with the PBL framework and the NGSS?
- How have my student’s ideas and knowledge of sustainability progressed throughout the instructional unit?
Research Question 1: Instructional Unit Alignment with PBL and NGSS

Using the average scores assigned by the three additional members of my 8th grade Professional Learning Committee (PLC) on the abbreviated and modified EQuIP rubric, found in APPENDIX D, I was able to synthesize the scores and determine how well my instructional unit fared on a variety of components. The rubric scored the instructional units’ alignment with the NGSS, contained instructional supports for student success, provided ways to monitor student progress, aligned with the Gold Standard PBL criteria, helped students develop 21st century skills, and contained teacher resources. This EQuIP rubric also allowed me to determine areas where improvements should be made. Each section and item of the rubric was scored and averaged by three members of my 8th grade PLC, excluding me, after the unit had concluded. I did not complete the rubric for the unit because I wanted the scores to be objective and I felt that if I scored it, I would have had a hard time separating the intention of the components and the actual inclusion of the components. All portions of the rubric were scored between 4 and 0, with 4 meaning Excellent and a 0 meaning Unacceptable. In the analysis, I will show the scores of each section and item of the rubric and the calculated averages of each of the components, and I will be analyzing the items for each section of the modified EQuIP rubric.

Alignment with NGSS

The initial section on the EQuIP rubric addressed the instructional unit’s alignment with the NGSS and it received an average score of 3.42 out of 4 and can be reviewed in Figure 4. Alignment to the NGSS includes all three dimensions of the NGSS,
including the Science and Engineering Practices (SEPs), Disciplinary Core Ideas (DCIs), and Cross Cutting Concepts (CCCs) and alignment to a set of performance expectations.

**Figure 4- Abbreviated and Modified EQuIP Rubric: Section 1- ‘Alignment with NGSS’**

*This section is comprised of data collected from rubrics submitted by PLC members about the alignment of the instructional unit to the NGSS.*

<table>
<thead>
<tr>
<th>Alignment with NGSS</th>
<th>Submission #1</th>
<th>Submission #2</th>
<th>Submission #3</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides opportunities for students to use specific elements of Science and Engineering Practice(s) to make sense of phenomena or design solution.</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Provides opportunities for students to construct and use specific elements of Disciplinary Core Idea(s) to make sense of phenomena or design solutions.</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td>Student sense-making of phenomena or design solutions require student performance that integrate the SEPs, CCCs, and DCIs.</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3.33</td>
</tr>
<tr>
<td>Lessons fit together to target a set of performance expectations.</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td><strong>Average Section Score</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>3.42</strong></td>
</tr>
</tbody>
</table>

The rubric item “Lessons fit together to target a set of performance expectations” received the average highest score of 3.67 out of 4. All of the unit lessons and assessments were developed aligned to the Standards Referenced Grading proficiency scale, seen in in Figure 5, which was developed using the NGSS performance expectations for MS-ESS3-3: *Students who demonstrate understanding can apply scientific principles to design a method for monitoring and minimizing a human impact on the environment* (NGSS, 2013e).
The development of the proficiency scale was with the first portion of Backwards Design. Having the proficiency scale allowed me to align the activities to the scale by asking students to explain things like, “How could the citizens of Easter Island have avoided disaster?” to address ‘identify solutions to minimize human impact on the environment’ from the scale or “Identify why there has been an increase in CO2 production over the past 50 years.” to address ‘identify results from particular human activity’ from the scale.

The item ‘Provides opportunities for students to use specific elements of Science and Engineering Practices (SEP) to make sense of phenomena or design solutions’ received the lowest average score of a 3 out of 4. Although the SEP for this standard was ‘constructing explanations and designing solutions’ which is ultimately what the students needed to complete with their summative project, many students did not make the connection between the introduction engagement activity, Personal Carbon Footprint, and the solution they identified in their final project. I found that the engagement activity
should have been revisited multiple times throughout the unit so that students were reminded to connect the learning opportunities back to the outcome of making connections between classroom learning and real-world scenarios. Logical places to make connections between the Carbon Footprint activity and other parts of the unit would be:

- After the Moana activity, asking students to identify what natural resources are being used that contribute to their carbon footprint.

- After the renewable and nonrenewable resources activity, asking students to determine if the resources they used to contribute to their carbon footprint were renewable or non-renewable.

- After the CO2 graphing activity, asking students to connect their carbon footprint to the impacts of carbon dioxide on global temperature changes.

- Revisiting the carbon footprint data prior to beginning the portion of the unit that addresses *Essential Question #2: Explain, using cause and effect, how the sustainable society you designed using scientific evidence has a lower impact on the environment than our current society.* A major focus of the unit is the impact that greenhouse gases have on global temperature change and the outcomes of the temperature change, so connecting the carbon footprint data and the environmental impacts of the carbon dioxide in the atmosphere creates a need to design a way to have a lower impact on the environment.

After reviewing the scores assigned to Section 1 of the rubric, found in Figure 4, I realized that I focused more on the Disciplinary Core Ideas (DCIs) and less on the
Science and Engineering Practices (SEPs) and Cross Cutting Concepts (CCCs). While developing the instructional unit, I wanted to guarantee that the students understood the content and used the Project Based Learning (PBL) nature of the unit to address the ‘designing solutions’ SEP and ‘cause and effect’ CCC. When teaching this unit in the future, I will be more intentional about pointing out the SEPs and CCCs to the students throughout the unit, when they occur naturally in the content.

**Instructional Supports**

The second section of the EQuIP rubric addressed the Instructional Supports given to students throughout the unit. This section received an average of 3.8 out of 4 and can be reviewed in Figure 6. The ‘instructional supports’ section received the highest average score on the rubric. I believe this section scored highest because the instructional unit was developed as a Project Based Learning (PBL) unit. A major tenet of PBL is the authenticity of the instruction. The essential questions that guide the unit, and can be found in Storyline in APPENDIX B, are all based in real-life situations. The PBL scenario, developing a sustainable society, was based on real-world experience and gave students a purpose for the background learning. PBL learning requires students to have a deep understanding of the content, so students can explain the sustainable choices they made. To make sure students can have a deep understanding of the material, they need access to scientifically accurate and grade-appropriate information and the students need to be given opportunities to represent their ideas and respond to feedback that supports their learning. The scoring rubric addressed each part of the PBL instructional unit in the ‘instructional supports’ section, observed in Figure 6.
Figure 6- Abbreviated and Modified EQuIP Rubric: Section 2- ‘Instructional Supports’

This section is comprised of data collected from rubrics submitted by PLC members about the Instructional Supports provided in the instructional unit.

<table>
<thead>
<tr>
<th>Instructional Support</th>
<th>Submission #1</th>
<th>Submission #2</th>
<th>Submission #3</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engages students in authentic and meaningful scenarios that reflect the practice of</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>science and engineering as experiences in the real world and that provide students</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with a purpose.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develops deeper understanding of the practices, disciplinary core ideas, and cross</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.33</td>
</tr>
<tr>
<td>cutting concepts by identifying and building on students’ prior knowledge.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use scientifically accurate and grade-appropriate science information, phenomena and</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>representation to support student’s learning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provides opportunities for students to express, clarify, justify, interpret, and</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.33</td>
</tr>
<tr>
<td>represent their ideas and respond to peer teacher feedback orally and/or in written</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>form as appreciate to support student learning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provides guidance for teachers to support differentiated instruction in the classroom</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.33</td>
</tr>
<tr>
<td>so that every student’s need are addressed by the following: connecting instruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to student; providing appropriate modifications for students who are English Language</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>learners, have special needs of read well below the grade level; providing extra</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>support for students who are struggling; and providing extensions for students with</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high interest or who have already met the performance expectations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Section Score</td>
<td></td>
<td></td>
<td></td>
<td>3.8</td>
</tr>
</tbody>
</table>

The item that addressed having students engaged in authentic and meaningful scenarios that reflect the real world received an average of a 4 out of 4, which was one of the highest items in section 2. I worked very hard to develop a summative project that used only real data and requiring students to determine the pros and cons of each
situation (ex: using electric busses or wind turbines) so that students would understand that no choice they could make for their Sustainable Society could be absolutely perfect, just like in the real world. The additional item that received a 4 out of 4 average was regarding supporting students learning with scientifically accurate and grade-appropriate scientific information. Throughout the unit, I made sure to give students enough detailed information for them to accurately make decisions, rather than have students seek the information on their own. By providing this information, students were able to focus on using the information to make sustainable decisions, opposed to spending their time comparing different sources. An example of this was when I asked students to determine how their town would sustainably generate electricity, comparing the economic pros and cons to the environmental pros and cons. I provided students with the average electricity generated by multiple sources and the cost to install and maintain each source. Students still needed to determine how many of the electricity sources they would need (ex: number of wind turbines) and the cost and environmental impact to the town. By providing the grade appropriate support, students are able to deepen their understanding of the content in a real-world situation.

One of the items that received the lowest average score, 3.33 out of 4, was regarding differentiated instruction and additional support for struggling students and those who’s learning could be extended past the basic proficiency levels. Differentiated instruction was provided by each teacher in the PLC, but no materials were developed specifically for the different learners. In my classroom, when I saw a student struggling, I sat with them and worked through the materials with them (ex: calculating daily waste
If I did not initially see students struggling, but the work they submitted showed me that they have gaps in their learning, I left detailed feedback about how to fix their mistakes and had them resubmit materials in the future. I believe this personalized feedback was sufficient in helping students fill the gaps in their learning. The feedback the students received was directly connected to personal misconception or academic issues. Individual instruction allows students to get exactly what they need without having to use that time reviewing things they already understand. When I teach the unit again in future years, I plan on using an online Audit/Sustainable Society Calculator (found in APPENDIX A) that I created, to help students calculate their resource usage and extrapolate to the needs of the Sustainable Society they developed. This calculator allows students to enter their specific information and the online tool completes the math for them. The calculator is aligned with the questions found on the audit as well as the summative assessment project. It was developed after the unit was over, but included in the resources because I believe it will be a very beneficial tool.

**Monitoring Student Progress**

The third section of the EQuIP rubric addressed monitoring student progress throughout the unit and it received an average score of 3.6 out of 4. Figure 7 shows the data collected for the monitoring student progress section. Monitoring students’ progress happened throughout the unit based on classroom conversations and submission of students' work. Student’s work was monitored using answer keys for assignments and the common formative assessments and a rubric for the summative assessments, which can be found in APPENDIX A.
Figure 7- Abbreviated and Modified EQuIP Rubric: Section 3- ‘Monitoring Student Progress’

This section is comprised of data collected from rubrics submitted by PLC members about ways to monitor student progress throughout the instructional unit.

<table>
<thead>
<tr>
<th>Monitoring Student Progress</th>
<th>Submission #1</th>
<th>Submission #2</th>
<th>Submission #3</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Includes pre-, formative, summative, and self-assessment measures that assess student learning.</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3.33</td>
</tr>
<tr>
<td>Elicits direct, observable evidence of students’ performance of practices connected with their understanding of core ideas and crosscutting concepts.</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td>Formative Assessments of student learning are embedded throughout the instruction.</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3.33</td>
</tr>
<tr>
<td>Includes aligned rubrics and score guidelines that provide guidance for interpreting student performance to support teachers in planning instruction and providing ongoing feedback to students.</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3.67</td>
</tr>
<tr>
<td>Assessing student proficiency using methods, vocabulary, representations and examples that are accessible and unbiased for all students.</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Average Section Score: 3.6

The item that's average score was the highest, 4 out of 4, was “assessing student proficiency methods, vocabulary, representation and examples that are accessible and unbiased for all students.” The instructional unit was developed using examples of scenarios that students previously have had experiences with (e.g. the movie Moana to teach natural resources or Transportation Audits where they calculated the amount of gasoline they personally used), so students did not have to struggle with learning the background scenarios as well as the new academic content. An additional high scoring item (with an average score of 3.67 out of 4) was related to observing evidence of
students' understanding of core ideas and crosscutting concepts. When I looked at student’s submitted work, assignments or assessments, I was looking for their connections between cause and effect of different scenarios (e.g. increased use of fossil fuel causes global temperatures to increase due to increased greenhouse gases in the atmosphere) or explanations about how to minimize human impact on the environment and the effects of the new ideas. To monitor the student’s understanding, I directly asked questions on the assignments. An example of the direct questions I asked was on the CO2 graphing assignment. I asked students to (1) identify the pattern of CO2 production over the last 100 years, (2) describe the change in global temperatures, and (3) explain how the pattern in CO2 production causes the change in global temperature. By asking direct questions, I am able to interpret students' understanding of the core ideas. The last high scoring item, receiving an average score of 3.67 out of 4, identified the presence of aligned rubric and score guidelines that supported teachers planning in instruction. Before teaching the unit, I created the summative assessment where students worked in a group a 3, each with their own role, to create a sustainable society. I generated each set of expectations for the 3 roles based on the NGSS expectations and created a scoring guideline, found in APPENDIX A. When completing the project, students had access to the scoring guideline and were encouraged to check the quality of their work against the requirements of the project. Something I found interesting was that two of the members of the PLC gave this item a 4, while the other member gave it a 3. The PLC member indicated in the feedback section of the EQuIP rubric that they gave this item a 3 because
the summative assessment rubrics were only filled out by the teacher at the end, so there was no ‘ongoing feedback to students’ which was indicated in the rubric.

The item that received a 3.33 was regarding Formative Assessments being embedded throughout the instruction. I only planned for two formal formative assessments (Common Formative Assessment (CFA) #1 and CFA #2 found in APPENDIX A) and administered them as quizzes to the whole class. The CFA’s provided information at the half way part of the unit (after the Essential Question #1) and after the completion of the content in Essential Question #2. As students turned in their assignments, I provided guiding feedback, so the assignments acted as informal formative assessments. At this point in the school year, many students stopped turning in assignments because completing assignments did not have impacts on their grade, based on Standards Referenced Grading (SRG) protocols that have been set by my school. One of the protocols is that assignments act as practice and do not factor into the final grade received by the student. In the future, I plan on taking time to implement smaller “check in” quizzes to give my students feedback on fewer components and allowing me to identify misconceptions earlier in the unit.

Gold Standard Project Based Learning

The fourth section of the EQuIP rubric addressed the Gold Standard Project Based Learning. This section scored an average of 3.71 out of 4. The scores received in this section can be found in Figure 8. This section is the largest section on the modified and abbreviated EQuIP rubric because the quality of the Project Based Learning (PBL) aspect of this project was a main focus of the research questions for the creative component.
This section was one of the highest scoring sections on the rubric, which indicates to me that the instructional unit was very successful in creating a PBL unit.

*Figure 8- Abbreviated and Modified EQuIP Rubric: Section 4- ‘Gold Standard Project Based Learning’*

*This section is comprised of data collected from rubrics submitted by PLC members about the instructional units’ alignment to the Gold Standard PBL criteria.*

<table>
<thead>
<tr>
<th>Gold Standard Project Based Learning</th>
<th>Submission #1</th>
<th>Submission #2</th>
<th>Submission #3</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional unit is driven by standards and success skills including critical thinking/problem solving, collaboration and self-management.</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>The project is based on a meaningful open-ended and engaging driving question.</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td>The project is active where students generate questions, find and use resources, ask questions and develop their own answers.</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3.33</td>
</tr>
<tr>
<td>The project has a real-world context, uses real-world processes, makes a real impact and/or is connected to student’s own concerns, interests and identities.</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>The project allows students to make some choices about the product they create, how they do work and how they use their time, guided by the teacher.</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td>The project provides opportunities for students to reflection what and how they are learning, on the project’s design and implementation.</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>The project includes processes for students to give and receive feedback on their work in order to revise their ideas and products or conduct further inquiry.</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3.33</td>
</tr>
<tr>
<td>The project requires students to demonstrate what they learn by creating a product that is presented or offered to people beyond the classroom.</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td><strong>Average Section Score</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>3.71</strong></td>
</tr>
</tbody>
</table>
In the Gold Standard PBL section identified in Figure 8, three items scored an average of 4 out of 4. One item that scored highest, 4, addressed real-world context, using real-world processes and is connected to student’s concerns and interests. This result is very similar to the second section of the EQuIP rubric and it scored high because everything was developed with these components being a driving force of the development. Another item that averaged a 4 out of 4 addressed that the unit was driven by the standards and included critical thinking/problem solving, collaboration, and self-management. Throughout the instructional unit, students collaborated in groups to complete many of their tasks. The summative project required students to manage their time working collaboratively in a group and think critically about how to solve the problem of creating a sustainable society that would logically work for their given scenarios. Every group utilized different ways of developing a sustainable society, so it was evident that they were collaboratively problem solving, without my direct interference. The last item that scored a 4 out of 4 was in regards to providing opportunities for students to reflect on what they were learning as well as the project’s design and implementation. Throughout the summative project, I asked students to give informal feedback to their peers and for students to reflect on the feedback and make edits to their project if they felt the feedback was valuable. I feel like reflection, guided by feedback, strengthens the learner and the individual giving the feedback.

The mid-scoring items on the PBL section of the rubric scored an average of 3.67 out of 4. The items that received the 3.67 average were: (1) The project is based on a meaningful open-ended and engaging driving question, (2) The project allows students to
make some choices about the product they create, how they work and how they use their
time, guided by the teacher, and (3) The project requires students to demonstrate what
they learn by creating a product that is presented or offered to people beyond the
classroom. The three items spanned the length of the project with the first item being
about the project introduction, the second item is about the creation of the product, and
the third item is about the final presentation of the product. The project was created with
an open-ended driving question, but not all students found it to be engaging. I believe the
lack of engagement for some students was driven by the fact that they are only 13 and 14
years old, so do not have the life experience responsibilities to decide how sustainable
their household is and they rely on parent decisions. The students were given the freedom
to choose how they worked and used their time. I gave them the questions and scoring
guides they needed to use to show proficiency, but they had the option of choosing what
parts to focus on at a given time. The students were not able to determine the product
they created since the requirement was to present their society to the class, but they were
able to decide how they wanted to present this information (e.g. create a video or present
using electronic slides). Lastly, students had the opportunity to demonstrate what they
learned by creating a product that they presented, but they only had the opportunity to
present it in the classroom. In the future, I would like to have the students bring this
information home and present it to their household in hopes of making positive
sustainable changes in their real lives.

The lowest scoring items received an average of 3.33 out of 4. One of the items
that scored a 3.33 was “the project is active where students generate questions, find and
use resources, ask questions and develop their own answers.” I struggle to give 8th grade students the opportunity to ask questions and find their own answers because many students do not have the real-world background to understand information they discover on the internet (e.g. costs of a yearly electric bill based on personal usage is not $30,000 but that amount of money is foreign to students who don’t receive a paycheck or costs to use wind turbines in a town goes far beyond costs to purchase a turbine). I initially set out to let students grapple with the details of the project, but ultimately developed a resource for them with vetted sources of pros and cons of specific choices, average costs of resources, etc. Asking questions and finding answers is something I am confident they will be able to do in the future once they have more real-life experiences. The second item that had an average score of 3.33 was “the project includes processes for students to give and receive feedback on their work in order to revise their ideas and products or conduct further inquiry.” Students received feedback from me on their assignments and they received informal feedback from their peers throughout the project. Originally, I created a peer feedback form to help students give feedback to their peers while completing their audits and during the sustainable society development, but I did not end up using them during the implementation of the project. The main factor that went into the decision to not use the peer feedback form during the project was because of the time constraints we were experiencing as we approached the end of the school year. During the school year, the students had not spent much time giving formal feedback to their peers, so it would have taken additional time to explain formal feedback protocols to
provide productive feedback. I decided to give feedback to the students so they could quickly revise their ideas and products.

21st Century Skills

The fifth section of the EQuIP rubric was about 21st Century Skills and it received an average score of 3.58 out of 4, seen in Figure 9. Twenty First Century skills are a collection of skills that students will use in their lives after they leave school. These skills do not directly relate to the academic content, but help students become functional members of society. Three of the four items in this section received an average 3.67 out of 4. The items were: (1) Provides opportunities for students to creatively collaborate with others towards a common goal, (2) Provides opportunities for students to effectively communicate with a group while demonstrating productivity and accountability to the group, and (3) Provides opportunities for students to adapt to various roles responsibilities while demonstrating leadership and social responsibility. The summative project required students to work in a group of 3, each with a different role (electricity advisor, transportation advisor and waste advisor), to create a sustainable society based on a set of parameters that included specific settings for each separate society. Each student was responsible for their own role so they received their own grade on the project. If all 3 worked together, they had a much greater chance of creating a cohesive sustainable society.
Figure 9- Abbreviated and Modified EQuIP Rubric: Section 5- ‘21st Century Skills’
This section is comprised of data collected from rubrics submitted by PLC members about the instructional unit’s ability for students to develop their 21st Century skills.

<table>
<thead>
<tr>
<th>21st Century Skills</th>
<th>Submission #1</th>
<th>Submission #2</th>
<th>Submission #3</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides opportunities for students to creatively collaborate with others towards a common goal.</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td>Provides Opportunities for students to accept and provide feedback.</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3.33</td>
</tr>
<tr>
<td>Provides opportunities for students to effectively communicate with group while demonstrating productivity and accountability to the group.</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td>Provides opportunities for students to adapt to various roles and responsibilities while demonstrating leadership and social responsibility.</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.67</td>
</tr>
</tbody>
</table>

Average Section Score 3.58

The lowest average scoring item, 3.33 out of 4, was about providing opportunities for students to accept and provide feedback. Students received feedback on any assignment or CFA they submitted, as well as through personal conversations during work time. I initially developed peer-feedback forms and protocols for students to use throughout the instructional unit, but they did not get used because the unit was already extending past the original end date and the students were less engaged through the second half of the unit. In the future, I will have students provide each other feedback on their understanding of the Greenhouse Effect and the three project audits. I believe providing feedback is a valuable opportunity for students to check their own understanding on a topic, while checking a peer’s understanding.
Teacher Resources

The last section of the EQuIP rubric is about the resources provided to teachers and can be seen in Figure 10. This section received an average score of 3.67 out of 4. The four items scored in this section included: (1) materials and resources needed to plan and facilitate instructions are complete, (2) teaching guide(s) clearly organized, easy to follow, and easy to use, (3) teaching and learning strategies, information on how to use the resources, and solutions and answer to questions provided along with teacher support resources, and (4) utilizes various types of instructional technologies that reintegrated with the instructional materials. Each of the four items also received an average of 3.67 out of 4.

Figure 10- Abbreviated and Modified EQuIP Rubric: Section 6- ‘Teacher Resources’
This section is comprised of data collected from rubrics submitted by PLC members about the teacher resources provided in the instructional unit.

<table>
<thead>
<tr>
<th>Teacher Resources</th>
<th>Submission #1</th>
<th>Submission #2</th>
<th>Submission #3</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials and resources needed to plan and facilitate instruction are complete.</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td>Teaching guide(s) clearly organized, easy to follow, and easy to use.</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td>Teaching and learning strategies, information on how to use resources, and solutions and answer to questions provided along with teacher support resources.</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td>Utilizes various types of instructional technologies that are integrated with the instructional materials.</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average Section Score</td>
</tr>
</tbody>
</table>
Throughout the instructional unit, the learning activities had very detailed instructions, so although the instructional unit did not have specific teacher instructions and answer keys provided, the assignments were easy to follow for teaching and learning. The instructional unit was clearly organized, with the activities and assessments following a logical progression to build background knowledge for the activities that came later in the unit. Many different types of instructional strategies were included through this unit. Some of the instructional strategies included, direct instruction, video and content readings, games, graphing, written assessments and project presentations. The plan was not specifically identified for “teacher only” use, but as stated earlier, the activities had very detailed instructions and guiding conclusion questions, so the teaching guides were not initially needed for my implementation of the unit. A logical next step would be to create teacher guides and answer keys for teachers who would be teaching this instructional unit that are not part of my 8th grade science PLC. The individual instructional unit activity descriptions and the individual activity improvement guides can be found in APPENDIX C that act as a guide for teaching the unit.

Overall, based on the scores each section received by the 8th grade PLC members on the abbreviated EQuIP rubric, the instructional unit’s final average score was a 3.63 out of 4, which equated to a score closer to an ‘excellent’ rating (4) than a ‘good’ rating (3). I believe this was a very effective tool in determining if the unit aligned with the NGSS and PBL protocols. The rubric provided very detailed analysis to the instructional unit. Having the additional members of the PLC to anonymously complete the rubric, rather than myself, allowed the instructional unit to be scored on what was actually
provided and the overall unit, not what was intended (ex: the lack of peer feedback that existed during the rubric vs the intent for students to provide peer feedback to each other). If I were to use the abbreviated and modified EQuIP rubric in the future to address the same research questions (alignment with the NGSS and PBL protocols), I could remove the section that addresses 21st Century skills because that was no longer addressed in the research question. With a few changes to the instructional unit in the future including more time for student feedback and more frequent formative assessments to guide specific differentiation, the instructional unit will align even better with the PBL and NGSS framework.

**Research Question 2: Progressions of Student's Ideas and Knowledge of Sustainability Student Data Analysis**

The second research question I addressed was “How have my student’s ideas and knowledge of sustainability progressed throughout the instructional unit?” To determine if my student’s ideas of sustainability progressed throughout the unit, my students completed a flow chart at the beginning and end of the instructional unit as a pretest and posttest, which can be found in APPENDIX D. The flow chart was separated into sections that included electricity generation, a transportation system and a waste management system. Within each of the sections, students attempted to identify the natural resource being used, the negative environmental impact of using the natural resource, identifying a way to monitor the use of the resource and lastly indicating a way to minimize the negative impacts of the current way we use the resource. These four subsections align with the proficiency scale created for the NGSS standard MS-ESS3-3. To analyze the flowcharts, I removed all identifying factors, cut each flowchart into the 3
sections and sorted them into categories of 0 correct answers up to all 4 correct answers. I determined if the answers were correct by comparing the student responses to content they learned throughout the unit including:

- Natural resource used to generate electricity (coal), create fuel for the car (oil), or waste removal (land),

- Issues with the identified resource use including overproduction of greenhouse gases which lead to global temperature changes or identified pollution source (ex: air pollution or water pollution),

- Ways to monitor the resource use by identifying completing electricity, transportation and waste audits or by explaining how they completed the audits, and

- Ways to minimize the negative impact of using the source the student initially identified by limiting resource use or using a more sustainable renewable source.

The flow chart was not used as a formal grading tool to determine a student’s final grade, so I did not create an official key or grading rubric. Standards Referenced Grading puts an emphasis on grades being directly connected to the standard, so learning activities like assignments or pretests that do not address the entire standard should not be formally graded. An additional reason for the flow chart not to be used as a formal grading tool was because the summative project provided the evidence I used to determine the student’s grade. Using the flowchart allowed me to directly compare growth over the unit, so if I had used the summative project as the final graded piece, I would have had a difficult time comparing pretest and post-unit data, since they were different questions.
The instructional unit was developed as a PBL unit, so there were many potential correct answers to some of the questions answered on the flow chart as well as throughout the unit. One of the questions on the flow chart was “How could we minimize the negative impact of the resource use” where students could suggest using the current resource differently (e.g. reducing the use or creating laws that restrict usage) or using different resources for the same outcome (e.g. using solar power instead of coal power). The varied answers make it very challenging to create a rubric that is not vague in details.

After sorting the pretest and posttest flow charts into the different piles based on the number of correct answers students provided, I calculated the percentage of flowcharts in each category as seen in Figure 11, Figure 12, and Figure 14. Student examples of the flowchart can be found in APPENDIX E. While analyzing the data, I discovered that I had 106 pretest flow charts and 137 posttest flow charts. In an attempt to conserve paper on the day the students complete the pretest, I printed the daily activity on the back side, so multiple students kept the paper to keep in their notes. I did not discover the differences in submitted flow charts until I analyzed the data after the school year had concluded, which led me to comparing data in percentages of success, rather than number of students who successfully answered in section.

Electricity Generation

The first student data set I analyzed, Figure 11, showed the change in knowledge and understanding regarding electricity generation, the environmental impacts of electricity generation, and ways to be more environmentally sustainable regarding electricity generation. Before the unit began, 60% of the students knew very little about
how electricity was generated and the negative environmental impacts connected to electricity generation. Even the 20% students who initially got 3 or 4 answers correct were missing details in their answers. After the instructional unit, 74% of the students had 3 or 4 answers correct and only 12% of students had little to no knowledge about the electricity topics. The large increase in students who had 3 or 4 answers correct (20% to 74%) showed that many students had a good understanding of electricity concepts.

**Figure 11- Electricity Flow Chart Percentages**

Correct answer data collected from the students’ electricity section of the pretest and posttest flowchart

<table>
<thead>
<tr>
<th>Percentage of students with identified number of correct answers before instructional unit</th>
<th>Percentage of students with identified number of correct answers after instructional unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 answers correct</td>
<td>42 students- 39%</td>
</tr>
<tr>
<td>1 answer correct</td>
<td>22 students- 21%</td>
</tr>
<tr>
<td>2 answers correct</td>
<td>21 students- 20%</td>
</tr>
<tr>
<td>3 answers correct</td>
<td>15 students- 14%</td>
</tr>
<tr>
<td>4 answers correct</td>
<td>6 students- 6%</td>
</tr>
</tbody>
</table>

An example of one student’s initial answers to the question regarding a negative impact of using the natural resource (coal) to produce electricity was “air pollution”, which is a correct answer. But after completing the instructional unit, one student answered “Coal puts CO2 into the air which is a greenhouse gas. Greenhouse gases block heat from going back into space, so it causes the Earth to heat up (climate change)”. Although both answers were correct, it was clear that student’s gained knowledge improved through the unit. The differences in answers between the first attempt at the flow chart and the second
attempt showed that the students improved their ideas and knowledge throughout the unit.

**Transportation Systems**

The second student data set I analyzed, Figure 12, showed the change in knowledge and understanding regarding the current transportation system, the environmental impacts of the transportation system, and ways to be more environmentally sustainable regarding transportation. After the unit concluded, 84% of the students who completed the posttest answered 3 or 4 answers correctly, while only 20% of students were able to answer 3 or 4 answers correctly at the beginning of the unit. Just like in the Electricity section, the percentages of students who knew very little at the beginning of the unit opposed to the end of the unit, grew dramatically (2% after the unit opposed to 55% at the beginning of the unit).

**Figure 12- Transportation Flow Chart Percentages**

*Correct answer data collected from the students’ transportation section of the pretest and posttest flowchart*

<table>
<thead>
<tr>
<th>Correct answers</th>
<th>Percentage of students with identified number of correct answers before instructional unit</th>
<th>Percentage of students with identified number of correct answers after instructional unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 answers correct</td>
<td>36 students- 34%</td>
<td>1 student- 1%</td>
</tr>
<tr>
<td>1 answer correct</td>
<td>22 students- 21%</td>
<td>2 students- 1%</td>
</tr>
<tr>
<td>2 answers correct</td>
<td>26 students- 25%</td>
<td>19 students- 14%</td>
</tr>
<tr>
<td>3 answers correct</td>
<td>18 students- 17%</td>
<td>48 students- 35%</td>
</tr>
<tr>
<td>4 answers correct</td>
<td>4 students- 3%</td>
<td>67 students- 49%</td>
</tr>
</tbody>
</table>
The level of answers was also much more detailed at the end of the instructional unit. Prior to the unit, one student’s solution to minimize the impact of the resource use was to “not drive everywhere”, but at the end of the unit, answers were more like this student’s answer. “Use of electric cars and use of electricity from renewable resources, like solar power, to reduce the amount of CO2 in the atmosphere.” The “4 answer correct” category difference was the greatest for the transportation section (49%), comparing it to electricity (42%) and waste (24%).

To determine the benefits and drawbacks about different transportation systems, students learned about personal vehicles vs public transportation and gasoline vs biofuel vs electric vehicles. To learn details about these systems and the positive and negative aspects of each of the options, students played a board game and they were responsible for writing down facts from the game on a guided note sheet. The game was played between two students where one student would draw a game card and ask the other student the question on the game card. If the student got the answer correct, they moved forward on the board and if they got the answer wrong, they stayed in their current position on the game board. After every round, students were asked to fill out a note guide based on the game question card to collect the information regarding the specific transportation components. The game/note guide technique posed a few issues for some students. One issue came from students who cared more about winning the game opposed to taking notes on the content. Those students struggled when it came time to use their knowledge in their audit and the sustainable society project. Another issue happened due to the time constraint of the class period. If some groups played the game more slowly or
took notes more slowly than others, they were unable to get through all of the guided information. The third issue was regarding the details of the information that was provided on the card. An example of an original card asked students to name two benefits of biofuel and the answers provided stated “carbon neutral” and “produce less CO2”. Students misinterpreted that to mean biofuel produces no CO2, so the lesson after the game required me to clarify information to the class based on the content they learned the day prior. My students, 13 and 14 year olds, did not have the background knowledge to connect content provided on the cards to real-world transportation options. After my class reteach, I edited many of the game question cards to add details to help students have a deeper understanding of the information without needing to be directly guided by an additional lesson, as shown by the bolded descriptor words on the card in Figure 13.

**Figure 13- Transportation Game Card**  
*Example of a game question card edited to add details after initial lesson*

```
Q: Name 2 pros of using biofuel for transportation.
A:
- Renewable resource
- Carbon neutral [takes in the same CO2 to grow as amount of CO2 released when burned]
- Produce less CO2 when burnt [10x less than gasoline]
```

**Waste Systems**

The final student data set I analyzed, Figure 14, showed the change in knowledge and understanding regarding the current waste removal system, the environmental impacts of the waste removal system, and ways to be more environmentally sustainable
regarding waste removal. This section was the lowest scoring section of all 3 parts, both before and after the unit. Prior to the unit starting, 6% of the students were able to correctly answer 3 or 4 of the parts of the waste removal flowchart and by the end of the unit, 55% of the students were able to correctly answer 3 or 4 parts of the waste removal flow chart. The number of students who had little to no knowledge of what happens to waste after it was thrown away in the trash can/recycling bin went from 82% before the unit began and that number reduced to 18% at the end of the unit.

**Figure 14- Waste Flow Chart Percentages**

*Correct answer data collected from the students’ waste systems section of the pretest and posttest flowchart*

<table>
<thead>
<tr>
<th>Percentage of students with identified number of correct answers before instructional unit</th>
<th>Percentage of students with identified number of correct answers after instructional unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 answers correct</td>
<td>64 students- 60%</td>
</tr>
<tr>
<td>1 answer correct</td>
<td>23 students- 22%</td>
</tr>
<tr>
<td>2 answers correct</td>
<td>13 students- 12%</td>
</tr>
<tr>
<td>3 answers correct</td>
<td>5 students- 5%</td>
</tr>
<tr>
<td>4 answers correct</td>
<td>1 student- 1%</td>
</tr>
</tbody>
</table>

Students learned about different waste systems (ex: sanitary landfills, recycling, composting) and ways to divert waste from the landfill by completing 8 stations and filling out a guided note page. Similar to the transportation game, time limits that potentially acted as constraints for their learning. If students wrote slowly or were slower readers, there was a chance that they could miss out on material at a particular station,
since most people did not complete the work outside of class. Also, I did not do a recap of the material after the stations because I needed to take a few days off to stay home with one of my children and when I came back to school, the class needed to begin working on their summative project. The lack of recapping the material resulted in many students using the waste systems they already knew about (e.g. recycling) and not adding details, opposed to new options they were less familiar with (e.g. bottle bills) when creating sustainable waste management options. In the future, I would review the material with the students to help students dive deeper into waste management systems they are more unfamiliar with.

Students completed the flow chart in the last 2 weeks of school, and many of the students were increasingly unfocused. In the future, I would attempt to complete the unit a month earlier (beginning mid-March opposed to April) to help students maintain their focus and I would have the students complete the individual section of the flow chart after they completed each of the corresponding audits, rather than after the summative assessment. All of the students were required to develop a smaller sustainability plan for each of the three audits so the students' knowledge about sustainability would be in the forefront of their minds after completing the audits. For the summative assessment, one third of the students were responsible for creating a sustainable plan for electricity generation, one third of the students created a sustainable plan for the transportation system and the last third of the students created a sustainable plan for the waste removal system, so completing the flow chart after the summative project may require some
students to think far back through the process to information they were not using for their specific project.

Originally, I believed the unit would take approximately 5 weeks to complete from mid-March through April, but it took a little more than 6 weeks beginning in April through mid-May. One reason for the extension of time was because of COVID-19 and end of the year absences. Many students were gone for a variety of reasons, and most of them did not complete the in-class assignments while they were at home. Fortunately, we had time available to extend the unit so that everyone had the opportunity to work through the content. A pacing guide for the 6-week implementation is found in APPENDIX C.

Students' demonstration of the content determined the pacing of the unit. Based on the Common Formative Assessments (CFAs) and activity guides, I determined that after CFA #1, most students were ready to move on to the second portion of the unit because they indicated that they had a general understanding of materials including: natural resources, renewable and nonrenewable resources, Tragedy of the Commons, and the greenhouse effect. Those students who needed additional support received re-teaching during time outside of class. In the future, I plan on providing students with review tutorials (videos and readings) that they can access on their own time to strengthen their understanding of the materials. As stated earlier in Chapter 4, after the electricity and transportation portion of the second half of the unit, I discovered that I needed to do a full class re-teach to explain some of the details needed for deep understanding of the benefits and drawbacks of different electricity generation and transportation options.
During the instructional unit, I set out to analyze student work that students were submitting to better understand the quality of the curriculum. Examples of work that was submitted included: Identifying natural resources from the movie Moana, Graphing and analyzing changes of amounts of CO2 in the atmosphere, CFA #1 and #2, Electricity Audits, Transportation Audits, and Waste Audits. The activities that synthesized student learning, like the audits, were much more challenging than the single learning days, like Moana’s natural resources. Many students struggled in completing the audits because they had to synthesize information from many learning activities, found linked in APPENDIX A. Below is an example of the varied content students needed to synthesize to complete their electricity audit:

- Identify all appliances that used electricity in their home and calculate the amount of electricity each appliance used in 24 hours,
- Recall the non-renewable energy source used currently (coal- from Renewable and Nonrenewable Breakout Game activity) and the greenhouse gas that is generated by burning coal (CO2- from CO2 Graphing activity),
- Explain the impacts of CO2 in the atmosphere (global temperatures increasing- from CO2 Graphing activity),
- Identify a more sustainable electricity source (wind, solar, or hydropower- from Renewable and Nonrenewable Breakout Game activity), and
- Explain the positive and negative components of the new sustainable electricity source (from Electricity Online Dating activity).
In the future, I will take more time helping students through this work and providing them resources to more easily complete these tasks. One way to more easily complete the audits would be to give students access to a digital audit calculator that helps them calculate their resource use and can calculate the needs of their community. Another way to complete the audits would be to help students organize their content notes. Instead of having notes on separate sheets of paper, I will be creating note “packets” to stay organized.

Through the implementation of this unit, I learned that the students had never completed Project Based Learning science before. The idea that there are many correct answers to many different problems was challenging for students to grasp and address. Many students wanted there to be one correct answer and for me to tell them the answer. By incorporating additional PBL units throughout the year, students could have the ability to wrestle with this type of thinking earlier and maybe wouldn't have struggled so much throughout this unit. The lack of only one correct answer made a few students very resistant to trying to solve the open-ended question of “How do we develop a society that is more sustainable than our current society?” Once those students grasped the concept that there were multiple correct answers, they were less hesitant to be ‘wrong’. In other science classes and in previous units in my science class, many students are used to being told exactly what to write, how to think about scenarios and what to do to answer specific types of problems. In earlier units throughout the year, I taught the content and modeled how I would answer the questions. I would give time for students to work with their peers to come up with a solution, but ultimately, I would have the students compare their
answer to my “correct” answers. This approach led some students to wait for my guidance without attempting to do their own work first. In this unit and summative assessment, I required students to think for themselves and take ownership of their ideas. I asked guiding questions if I saw students missing details, but ultimately, they were independent. Independent work challenged some students because they were so used to me guiding their learning and when I asked them to complete the work without my direct help every step along the way, some students struggled. I overheard multiple students complaining to their peers that the sustainable society project was too much work and would rather take a test. Since this was the last unit of the year, students were used to the test taking format of previous units, but based on the conversations and academic arguments I overheard students having, I believe that Standards Referenced Grading (SRG) units that are aligned to Next Generation Science Standards (NGSS) standards provided a much deeper understanding of the material than traditional learning styles. The students that were saying that the unit was too much work were the same students who generally waited for me to guide their learning, so considering that those students were not used to working through complex tasks on their own, the unit may have been overwhelming. I do not believe this is an issue because this instructional unit was the last unit of the year and is a great unit to introduce the students to independent learning prior to entering high school.

During the implementation of the unit, I discovered that students lacked depth of understanding of many topics which required me to review and revisit topics as well as provide additional support materials. I explained to a group of students this unit
(compared to earlier units through the year) was like going to English class versus going to French class. Due to the varied nature of the units taught in 8th grade science, students would not directly interact with sustainability topics prior to the PBL instructional unit. They would probably come into the unit having some background in the content, like in English class, but I would ask them to dive deeper into the material opposed to introducing brand new materials and teaching them the basics, like in French class. Some observations that I made that needed clarification were:

- Students knew that driving gasoline powered cars created air pollution, but they didn’t initially understand the cars also produces CO2 which is a major contributor to climate change.

- Students knew that wind turbines or solar panels were a “clean” way to produce electricity, but they didn’t understand what was “clean” about them or how they generated electricity in the first place.

- Students knew there was a difference between throwing things away opposed to recycling them, but they didn’t understand what happened to the item once it was put in the specific bin.

Identifying these areas where students lack a full depth of knowledge will help me make sure I clarify the details when I teach this unit in the future. To help students arrange the details they need to develop a more comprehensive knowledge base about the information, I could create summary guides for students to fill out as I present the content.
The development of the instructional unit and the use of the data collection tools (Guided flow chart and the abbreviated EQuIP rubric) has allowed me to gain insights into what it takes to create a high-quality Project Based Learning unit that aligns with the NGSS. I learned about the ways to be intentional with my unit planning by using the Backwards Design template and the 5E Learning Cycle model as well as organizing the material by developing a storyline. These materials allowed me to make sure the unit and activities were three-dimensional and centered around the essential questions of the unit. The 5E Learning Cycle model was effective in helping me determine if my unit focused on a variety of learning strategies to help students connect deeply with the material. The instructional unit had many activities that fell into the “explore” portion of the Learning Cycle, where the students created new ideas, but very few activities in the “explain” or “evaluate” portion, where teachers helped increase new knowledge and students apply knowledge towards new situations. In the future, I need to focus more time on determining students' needs and explaining the content details if needed. The storyline was an effective organizational strategy that allowed me to organize each learning activity into essential questions and determine the information students should gain through each activity. The storyline kept me from adding unnecessary activities that did not align with the essential questions. In the future, I need to share these essential questions with the students to help create the need-to-know that guides their learning. By connecting each learning activity back to the essential question of the unit, students have the opportunity to connect every part of their learning to the end goals of the instructional unit.
The implementation of my unit, beginning with calculating students personal Carbon Footprints, showed me that students can be engaged with material they initially know very little about. To make the experience more relevant throughout the unit, I need to remember to address their findings when relevant. An example of times to revisit the carbon footprint would be after they learn about increased CO2 in the atmosphere which is leading to global temperature increase. The carbon footprint identifies the amount of CO2 each person is responsible for creating, so there is a natural correlation between the two activities. Another time to revisit the carbon footprint activity is before developing a sustainable society which would allow students to understand why a change to our current use of natural resources and greenhouse gases production is important. Being thoughtful about helping students make connections between activities will continue to help me grow as an educator as I wish to create more PBL instructional units aligned with the NGSS that have essential questions and overarching ideas that drive student learning. I will be able to take what I have learned through this project and work with the rest of my 8th grade science Professional Learning Community (PLC) and the rest of the district science department to develop additional PBL instructional units to engage student learning as they transition into high school. The processes used have also helped me learn to reach out to colleagues, seek assistance advisors and share created materials across curriculum contents so that those beyond my 8th grade science PLC can be impacted.
Impact on Science Education

The development, implementation, and analysis of my instructional unit has impacted how I approach curriculum development and has the ability to impact science education in the future. Throughout the development, implementation and analysis process, insights I gained through the process include:

- Students are much more likely to take ownership of their learning if they are given access the resources to help them make deep connections.
- If students are able to make real-life connections with the content they are learning, they are much more likely to dive deeper into the materials.
- If students are given the opportunity to engage in answering open-ended questions with multiple correct answers, they are willing to try and solve the questions without getting discouraged by attempting to come up with the one correct conclusion.

This project contributes to the Science Education community because it integrates NGSS aligned, Standards Referenced Grading (SRG), and Project Based Learning (PBL) in the developed instructional unit as well as discusses the impacts of such a unit on student learning. Very few projects that align all three components exist, so this project is a new addition to scientific literature. I have shared a model Project Based Learning instructional unit that aligns with the NGSS and can be scored using a Standards Referenced Grading proficiency scale which can be used as a template for other teachers’ unit development. The instructional unit provides science educators with a list of resources to help them create their own curriculum using multiple curricular development
resources. APPENDIX A contains the Backwards Design template with the 5E Learning Cycle components included. Hyperlinks have been provided to all instructional materials and can be used or modified for personal use. APPENDIX B contains a completed storyline which shows each of the lessons, each lesson connection to the CCC and SEP, an indication of what question drives the lesson, and a descriptor of what students should know at the end of each lesson. Educators, faculty members and graduate students can use this tool to help guide student progress throughout the instructional unit. APPENDIX C provides a timeline and instructional notes to help educators pace their teaching, as well as areas where they may have challenges while teaching the content. In APPENDIX D, examples of the student flowchart and abbreviated EQuIP rubric can be found. These tools can be used to determine how well an instructional unit is aligned with the guiding principles of Project Based learning and the NGSS and to show student growth throughout the unit. In APPENDIX E, examples of pretest and posttest student flow cards are included. These examples are representative of student work at the various achievement levels.

Implications for Classroom Practice

The development of the instructional unit allowed me to explore multiple techniques I had not used previously. If a colleague asked me what insights I gained through the unit, I would tell them about the different techniques including Project Based Learning, Backwards Design and storylining. Backwards Design helps develop units with the end goals in mind. Ultimately, the unit needs to align with the NGSS Performance Expectation, Cross Cutting Concepts and Science and Engineering practices. I would
advise my peers to develop a Standards Referenced Grading proficiency scale to drive the instruction. The next steps would be to identify a real-life scenario that aligns with standards and use that scenario to develop Project Based Learning essential questions and unit templates. Lastly, creating a storyline and connecting it to the 5E Learning Cycle allows teachers to be very intentional about connecting learning activities to the essential questions of the unit and the CCC and SEP aspects of three dimensional teaching. Before implementing the unit, I would suggest that educators review the unit using the abbreviated EQuIP rubric to identify any gaps in the unit and previously developed materials. If gaps are identified, attempting to fill them prior to teaching allows for a stronger instructional unit. I would also recommend my peers share the learning path with their students. If students understand the intention of how certain activities align with the end goal and how they will use the content they are learning in future lessons, they are more likely to engage with the material. After they have implemented the unit, I would recommend they reflect on their success and challenges and use this unit as a template for future NGSS aligned PBL units.

**Future Work**

In the future, I would like to use this instructional unit as a template to develop at least 2 additional units. One unit could be our Evidence of Common Ancestry unit and the other could be our Factors that Impact Climate unit. My 8th grade science PLC and I have aligned all of our units to the NGSS and created SBL proficiency scales for each standard. By completing the scales, we have already begun the first stage of Backwards Design. By creating a more Project Based Learning (PBL) approach to each unit, students
have more opportunity to explore, interact and make personal discoveries about information they are learning and why they are learning that specific material. Using a PBL approach to teaching content would extend the length of each unit, but the gains in real world applications would be so beneficial as the 8th grade students move towards high school. I feel that the instructional unit development tools I used throughout the development of this unit will help me develop units that align to the NGSS and the three dimensions, align with the principles of PBL, as well as making sure that all learning activities help students answer the essential questions of the unit. The abbreviated EQuIP rubric is a tool that will help me gauge if I am creating high-quality materials based on my peers' evaluation of my instructional unit. The coursework and project have given me the resources to strengthen additional 8th grade science units by giving me a template to revise and change existing units. By changing existing units to Project Based Learning units that are aligned to the Next Generation Science Standards, I know I can deepen student understanding in different topics and create connections between the content and students' real lives. I know I will continually work to improve the course that I teach and provide the best instruction to my students that I can.
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**Established Goals:**
- **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment
  - *Clarification Statement:* Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible and designing and evaluating solutions that could reduce impact.
  - *Examples of human impacts can include* water usage (such as withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or removal of wetlands), and pollution (such as of the air, water or land).

**Understandings:**
- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing extinction of species.
- Changes to Earth’s environments can have different impacts (negative and positive) for different living things.
- As human population and per-capita consumption of natural resources increase, so the negative impacts on the Earth unless the activities and technologies involved are engineered otherwise.

**Essential Questions:**
- Identify the impact you currently have on the environment, based on your natural resource use.
- How can you use scientific ideas to help design a sustainable society that has a lower impact on the environment than our current society?
- Explain, using cause and effect, how the sustainable society you designed has a lower impact on the environment than our current society.

**Students will know . . .**
- Positive and negative environmental aspects of particular human activities
- Positive and negative economic aspects of particular human activities
- How to determine if a solution is appropriate for a given scenario

**Students will be able to . . .**
- Use scientific information and principles to address the results of a particular human activity
- Incorporate technologies/solutions that can be used to minimize and monitor the negative effects on the environment
- Describe the criteria and constraints for the solution
- Describe how well each solution meets the criteria and constraints
- Identify limitations of the use of technologies/solutions for their solution
## Stage 2 - Assessment Evidence

<table>
<thead>
<tr>
<th>Performance Task:</th>
<th>Other Evidence:</th>
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| ● Summative Assessment Project: Students will work in groups to develop a sustainable society for approximately 3000 people. Each group member will be responsible for developing a plan for their given natural resource sector (electricity, transportation, water and waste) that will have the smallest negative impact on the environment and the people of the community.  
  ○ Students will use data collected from their own homes as a baseline for natural resource usage.  
  ○ Students will explain the cause and effect relationship of the current system and impact on the environment, as well as the relationship between their sustainable choice and impact on the environment.  
  ● Project will be scored using a rubric  
    ○ Each student will be graded separately, based on the knowledge they present. | ● Formative Assessments:  
  ○ Pre-assessment: Students will create a concept map to determine knowledge about “specific content” listed below  
  ○ Common Formative Assessments (CFAs):  
    ■ CFA #1: regarding natural resources, renewable/non-renewable resources, Tragedy of the Commons, Greenhouse Effect and Greenhouse Gases  
    ■ CFA #2: Regarding Electricity, Transportation and Waste: Current Reality and ways to reduce human impact on Environment  
  ○ Homework:  
    ■ Personal home audits (electricity, transportation, and waste)  
  ● Peer Feedback/Self-Reflection:  
    ○ After each audit  
    ○ Mid-point during summative assessment project  
  ● Specific content students will be assessed on:  
    ○ Natural Resources  
    ○ Renewable and Non-Renewable resources  
    ○ Tragedy of the Commons  
    ○ Greenhouse Effect  
    ○ Greenhouse Gases and global temperature change  
    ○ Positive and Negative impacts of: |
electricity sources, transportation/fuel options, waste systems

### Stage 3- Learning Plan

**Engage:** (students are engaged with a challenging situation, prior knowledge is activated, questions are provoked *students’ interest is piqued with novel ideas)

**Explore:** (students investigate the phenomenon, prior knowledge is challenged, ideas are created *hands on activities deepen understanding)

**Explain:** (students explain the phenomenon, new knowledge is gained and applied *students describe ideas in their own words)

**Elaborate:** (Students apply their knowledge towards new situations, knowledge is deepened and extended *ideas are applied in broader context)

**Evaluate:** (Students reflect on their knowledge and the learning process, assessment *students provide a rich picture of their understanding)

### Engage (2 days):

1. **Introduce NGSS performance expectation, proficiency scale, and student tracker**
   - Teacher will review the standard and break it down into student friendly language
   - Students will look over the proficiency scale and student tracker to identify the content they need to be able to prove knowledge of by the end of the unit.

2. **Pre-assessment**
   - Students will create a concept map about how different things/human decisions impact the environment.
     - Teacher will provide the framework and students will attempt to fill in the map with the following framework: What do we “need”? → what natural resource is being used? → impacts to the environment (ex: We need electricity → use coal → burning coal creates Carbon Dioxide (CO2) which leads to earth warming).

3. **Introduce the summative assessment project (creating a sustainable society)**
   - Teacher explains to students the basics of the project to create a “need to know” and tie in for all the information covered throughout the unit.

4. **Calculate personal carbon footprint**
   - Students will use online carbon footprint calculator to assess how much carbon dioxide and methane their lifestyle creates.
   - All of their carbon footprints will be more than one earth, so it starts the conversation about if all the people on earth live the same way you do, we would need more than one earth, but we don’t have that, so what can we do about it?
Explore:

- Each activity (briefly outlined below) will have guiding questions that align the content with the Project Based Learning (PBL) summative assessment project. By the end of the explore (and explain) stage students will have collected enough material to begin working on their summative project (ex: they will learn how to determine if a resource is renewable or non-renewable and they will learn about different waste management systems to determine which type fits best for their community).

- All of the activities will have a paper (or online) guide to be turned in to the teacher so that the teacher can monitor student progress as one form of formative assessment.

- Topics that will be learned about:
  1. Natural Resources (2 days)
     - **Lesson #1: Define Natural Resources and Moana Connection** (*PowerPoint and Note guide with links*)
       - Students develop their own definition of natural resource, compare their definitions with table partners to come up with a detailed description.
       - Students watch a video and read a passage to check their initial knowledge of natural resources. They will answer questions to help them make connections between prior knowledge and new information.
       - Students will use their definition to find the natural resources in a scene from Moana and then students will describe what will happen to the island community if that natural resource is used up.
     - **Lesson #2: Overusing natural resources: Easter Island**
       - Students will read the story of the collapse of Easter Island and will learn about how overusing the trees had a much greater impact that one would expect.
       - Students would make the connection between Easter Islanders use of natural resources and our current use of natural resources.

  2. Renewable and Non-Renewable resources (1 days): *PowerPoint and Note guide*
     - Students will begin the lesson doing a mini-lesson about renewable and non-renewable resources (this will provide the background for the upcoming activity).
     - Students will work in teams to complete a break-out “room” activity.
       - Activity contains various stations about renewable and non-renewable resources
         - [Teacher answers](#) and [copy of breakout stations](#)
     - Students will then have to write a definition of each of the word in a “for kids”.
3. Tragedy of the Commons (1 day)
   ■ **Student connect Tragedy of the Commons to the Lorax: Note Guide**
     - Students will watch one version of The Lorax or teacher will read-aloud the story.
     - Students will analyze the story using 2 of the lenses of sustainability (economic lens and environmental lens) to identify pros and cons. This will help students make the connection that every decision has good and bad aspects.
     - Students will then connect the story to the Tragedy of the Commons.
     - Lastly, students will “re-write” the story to attempt to be the most sustainable.

4. Greenhouse Effect and global temperature change (3 days)
   ■ **Lesson #1: Greenhouse Effect: Note Guide and PowerPoint**
     - Students will interpret images and watch a video to learn about the Greenhouse effect. They will take their basic knowledge and use it to fill in a paragraph explaining the Greenhouse effect.
     - Students will research 3 greenhouse gases (the main 3 that come up in the summative project).
     - Students will research how specific sectors (e.g. agriculture, electricity, etc) contribute to greenhouse gas increase.
     - Lastly, students will research different things we can do to reduce the amount of Greenhouse Gases in the air and explain how they will help minimize human impact on the environment.

   ■ **Lesson #2: Global CO2 change: Note Guide (with links),**
     - Students are given a data set of the CO2 for each month for every year from the 1960s to 2000s that they need to graph.
     - After individual graphs are completed (one for each year), students will look at a large graph depicting the CO2 change over time
       - Students will look for patterns they notice on each individual graph.
       - Students will look for patterns they notice on the large graph.
     - Students will then read a set of passages that explain what is happening to the temperatures and explain why it is occurring.
     - Lastly, students will make connections to the unit which will result in them developing a solution of how humans can minimize negative impact to the environment.

5. Personal and community use of natural resources regarding generating electricity, transportation/fuel options. Water sources/purification, and waste removal systems (3 days)
   ■ **Lesson #1: Electricity**
   ■ **Lesson #2: Transportation**
   ■ **Lesson #3: Waste**
   - Students will complete 3 audits about how they/their nomes use the resources listed above [each audit will have guided instructions to help for accurate data
In the audit, students will:

- Identify how things are used in their home (ex: # of showers taken or listing all things plugged into the wall).
- Calculate usage (ex: gallons of gasoline used or percentage of paper products recycled).
- Read small passages about how we use each resource (ex: waste goes to a sanitary landfill in Mitchellville, IA) and students will answer conclusion questions based on their passages and things they have learned prior (e.g. listing natural resources, renewable or nonrenewable).
- Identify the cons of the current system.
- Start planning for a “perfect world” (like the final project) and identifying the economic and environmental pros and cons of their plan.

6. Positive and Negative impacts of: electricity sources, transportation/fuel options, waste removal systems (various activities) (6 days)

- **Lesson #1: Electricity online dating:** [Note Guide, Post “date” review notes]
  - Students will be given an electricity resource (ex: coal or wind) and will have to create a dating profile to explain positives and negatives about that resource. Students will then go on “dates” to learn about the different resources.

- **Lesson #2: Transportation:** [Game Question, Game Instructions, Game Note Guide, Post Game Notes]
  - Students will play a “CandyLand” style game where they will use game cards to learn about different vehicle types (cars vs public transportation) and fuel sources (gasoline, biofuel and electric).
  - Students will fill out note guide while playing game to use as a resource.

- **Lesson #3: Waste removal systems:** [Note Guide (with links)]
  - Students will read about waste removal systems (ex: sanitary landfill, incinerator, composting, recycling) and their pros and cons. Also including ways to divert things from the landfill.
  - Students will identify items they use and will learn how they should be disposed of [per MetroWaste guidelines].
  - Students will read about different ways other countries are eliminating waste.

**Explain:**

- **Teacher feedback**
  - Teacher will read specific conclusion questions from the “explore” guides and will provide guiding feedback to the students. This will determine which students understand the material the first time and who will need reteaching.
  - If it is evident that a large number of students are not getting a clear picture of the content, teacher will create a note guide for students to fill out as they discuss the topic as a class.
Elaborate:

- **Students begin working on their sustainable society:** Guidelines & Roles/responsibilities, Student Guide, Collaborative Talk Peer Review
  - Students will work in groups of 3 and they will apply their knowledge learned throughout the unit to identify the best way to provide electricity, transportation and a waste removal system for their community of approximately 3000 people.
  - Each community will be built on a specific area (teachers will provide a description) so not all ways will be beneficial (ex: some communities lend themselves to having a dam, rather than solar power).

- During this time, students will give and receive peer reviews and teachers will give feedback on the project.
- Based on the direction the students choose, they may learn they need to do additional research to come up with a compelling reason for their choices.

Evaluate:

- **Formative assessment:**
  - Pre-assessment: explained in “engage” phase
  - CFAs:
    - **CFA #1** (Natural Resources, Renewable/Nonrenewable, Tragedy of Commons, GHE)
      - Given after Exploration Phase #4
      - This will be used to determine if there needs to be full class reteaching on specific content, individual/small group reteaching, or if the class can move on.
    - **CFA #2** (Electricity, Transportation, Waste)
      - Given after Exploration Phase #6
      - This will be used to determine if there needs to be full class reteaching on specific content, individual/small group reteaching, or if the class can move on.
  - Peer-reviews:
    - **GHE/GHG**
    - **Audit Electricity/Transportation/Water/Waste**
      - Students will review each others thinking for the greenhouse effect and global temperature change.
      - Students will look at other people’s audits and will compare them to a checklist to determine if they have enough detail and if the details are correct.
      - **Students will be able to make edits based on the review**.

- **Summative assessment:** sustainable society project presentation:
  - Project Outline (from Engage)
  - Grade Checklist, Scoring Guide

- **Evaluate Instructional Unit:** Revised EQuIP Rubric

Template from Wiggins, G. & McTighe, J. *Understanding by Design* page 22
**APPENDIX B- INSTRUCTIONAL UNIT STORYLINE**

<table>
<thead>
<tr>
<th><strong>Name:</strong> Shannon Power</th>
<th><strong>Driving Question:</strong> How to design a sustainable community that monitors and minimizes human impact on the environment</th>
<th><strong>Phenomena:</strong> Carbon Footprint Calculator</th>
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</thead>
<tbody>
<tr>
<td><strong>Topic:</strong> Sustainability</td>
<td><strong>Grade Level:</strong> 8th</td>
<td></td>
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</tbody>
</table>

**Unit Activity and Assessment links**

**MS-ESS3-3:** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

**Science and Engineering Practices (SEP):** Constructing Explanations and Designing Solutions

**Cross Cutting Concepts (CCC):** Cause and Effect [monitor and minimize]

<table>
<thead>
<tr>
<th><strong>Lesson Level Questions</strong></th>
<th><strong>Activity Description with focus on SEPs and CCCs</strong></th>
<th><strong>What did we figure out?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Essential Question #1:</strong> Explain how the use of natural resources can impact the environment</td>
<td><strong>Introduction:</strong> Engage Carbon Footprint Calculator: Students will use an online carbon footprint calculator to assess how much carbon dioxide/methane their lifestyle creates. This creates the need to know for all the content of the unit. All of their carbon footprints will result in more than 1 earth, so it starts the discussion about what we can do about our usage (CCC Cause and Effect: our lifestyle and Needs more than 1 Earth) (SEP: What can we do about our usage?). <strong>Introducing the Next Generation Science Standards Performance Expectation (NGSS PE). proficiency scale and student tracker:</strong> Students will receive the student tracker and will go through the PE and proficiency scale as a whole class. This will allow students to understand the goals of the unit and will show them what content will be covered. <strong>Pre-assessment:</strong> Students will fill in a concept map that will indicate what they know about how humans impact the environment with our resource usage. This will be completed again at the end of the unit to see how their views have changed. <strong>Introduction to Project:</strong> Students will learn about the final summative project, will get into their group of 3 and will pick their settlement. Students will also receive a guide to the questions they need to answer in the final project so they are able to refer back to this throughout the learning during the unit.</td>
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**Lesson 1**

**Explore**

**Explain**

**Natural Resources and Moana:**

**Explore:** Students will develop their own definitions for NR, check their definitions and use their definitions in a scene from Moana to construct an explanation of what happens when resource are used.

**Explain:** Students will watch a video and read a passage to define natural resources and their usages.

**We learn that natural resources are things that humans use and come from the earth and that if we use up those resources, our lives will change and we will have**
### Lesson 2
#### Explore
What happens when natural resources are overused?

**Easter Island:**
Students will read a story about the collapse of Easter Island due to overuse of trees. They will then come up with a solution that they would give to the islanders to help avoid the collapse.

We learn that you need to monitor the use of natural resources so they will not become overused.

### Lesson 3
#### Explore
What is the difference between a renewable and nonrenewable natural resource?

**Renewable and Nonrenewable Resources Breakout:**
Explain: Students will begin learning about the differences between renewable (R) and nonrenewable (NR) resources.

Explore: They will then check their knowledge of the differences by completing a “breakout room” activity. Then students will explain if they should use R or NR resources to minimize human impact on the environment.

We learn that non-renewable resources (oil, coal, nuclear, etc.) are used up once they are used, while renewable resources can continue to be used (sun, wind, running water).

### Lesson 4
#### Explore
What happens to communities and the environment when we overuse natural resources?

**Tragedy of the Commons: The Lorax:**
Students will read The Lorax (the main character overuses the trees for economic gain, all the trees die, no more business) and will analyze the story through the lenses of sustainability (economic and environmental lens) to identify the pros and cons of the story. Students will then write a story to be sustainable.

We learn that individuals need to consider more than their personal gains if we are going to maintain the environment (and also maintain the individual’s way of life).

### Lesson 5
#### Explore
How do greenhouse gases warm the Earth?

**Greenhouse Effect:**
Explore: Students will interpret pictures about the greenhouse effect. They will then fill in a paragraph explaining the greenhouse effect and how increased Greenhouse Gases (GHG) causes increased trapped heat/temperature.

Explain: Students will watch a video describing the Greenhouse effect. Students will then research the 3 main greenhouse gases from the project and how specific sectors contribute to greenhouse gas.

We learn that the greenhouse gases allow heat to enter the atmosphere and traps the heat on Earth (the heat is important for life on earth). If there are too many GHG, the heat cannot escape and the global temperature increases.

### Lesson 6
#### Explore
How can the global temperature trends be explained?

**Global Carbon Dioxide (CO2) Graphing:**
Explore: Students are given a data set of CO2 levels for each month of every year from the 1960s to 2000s. Students will graph one year and will put together all single graphs into one large graph to identify patterns they notice on the individual graphs and the large graph (Every year, CO2 increases/decreases due to season but overall CO2 is increasing).

We learn that CO2 levels change due to the seasons (higher levels of CO2 in the winter when there are no plants to “breathe” it in), but overall CO2 is increasing.
<table>
<thead>
<tr>
<th>Lesson Level Questions</th>
<th>Activity Description with focus on SEPs and CCCs</th>
<th>What did we figure out?</th>
</tr>
</thead>
</table>
| **Lesson 1** Engage, Explain, Explore | **Electricity Speed Dating:**
Explain: Students will use given resources to learn about different types of electricity production.

Explore: Using the resources, they will create a character based on the electricity production (ex: Carol Coal) and will go “speed dating” with the other electricity sources to learn about the pros and cons of each type.

*This lesson provides background to Lesson 2 | We will learn about coal, oil, natural gas, nuclear, solar, hydro, and wind power and will determine positive and negative aspects of each type. This will be used to help students determine which type of electricity production is best for their sustainable community. |

| Lesson 2 Explore | **Electricity Audit:**
Students will calculate the amount of electricity their house uses and use that data to determine how much electricity a community will use. Then they will determine the sustainability of our current electricity production (using coal) and connect to | We will learn how much electricity we use in our homes and how that impacts the environment |

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Explain: Students will read a passage to help connect the increased CO2 to the increased temperature. Then students will learn about some impacts of these increased temperatures. Lastly, students will develop a solution to minimize an impact they identified.

Due to human activity, the increased CO2 is causing increased temperatures which has a variety of impacts on the environment.

Evaluate Additional Explain
Throughout the 6 lessons, students will be turning in their activity guides and I will be giving them personal feedback on their work as a formative assessment. If enough students are struggling with the concepts, I will take time to do a full class reteach with note guides for them to follow along with. These have not been created yet because there is not an official need.

Evaluate Elaborate
**Common Formative Assessment (CFA) #1:** Students will take a CFA about Natural Resources, Renewable and NonRenewable resources, Tragedy of the Commons and Greenhouse Effect/Greenhouse Gases. This will be an indication to the teacher and student about how well they are doing on these topics and will determine if any reteaching needs to be done (that has not already occurred based on activity).

**Final Project- Summative Assessment:** Students will answer the first set of questions for their final project. These questions will connect to the topics they have learned through this learning cycle. These answers will not be “set it stone” and will be able to be edited if needed.

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**Essential Question #2:** Explain, using cause and effect, how the sustainable society you designed using scientific evidence has a lower impact on the environment than our current society.
<p>| Lesson 3 | Explain | Transportation Game (Research): Explain: Students will play a board game where they answer questions to learn about vehicle options (car or bus) and fuel options (gas, electric, biofuel) and determine the economic and environmental pros and cons of each. Explore: Students will determine if their researched options are sustainable based on the pros and cons. They will then find someone else who chose the other options. Once they learn all of the pros and cons, they will determine which option is the most sustainable. They will then develop a plan for the most sustainable combination and explain how that will minimize the impact on the environment. |
| Lesson 3 | Explore | We will learn about different vehicle options (car or bus) and a fuel option (gas, electric, biofuel) and determine the positive and negative aspects of each of them. This will be used to help students determine which transportation option is going to be best for their sustainable community. |
| Lesson 4 | Explain | Transportation Audit Students will calculate the amount of gasoline their house uses and use that data to determine how much gasoline a community will use. They will then determine the sustainability of our current transportation option (cars using gas) and connect to greenhouse gases and impacts of the GHG. Lastly, they will make a sustainable plan for transportation and determine the pros and cons of their plan. |
| Lesson 4 | Explore | We will learn how much gasoline we use in our lives and how that impacts the environment (burning oil produces CO2, which leads to global temp increase, which causes a variety of issues to the env.) This will be the data used to determine the amount of resources needed for the sustainable community. |
| Lesson 5 | Explain | Waste Removal Systems Stations (Research) Explain: Students will research different waste removal systems (sanitary landfills, recycling, |
| Lesson 5 | Explore | We will learn about 3 waste removal systems (sanitary |</p>
<table>
<thead>
<tr>
<th>Lesson 6 Explore</th>
<th>How much waste do you generate?</th>
<th><strong>Waste Audit</strong> Students will calculate the amount of waste they generate in a day (trash and recycling). They will use this to determine the amount and type of waste their community will use. Then they will determine the sustainability of our current waste removal option (sanitary landfill, recycling plant) and connect to greenhouse gases and impacts of the GHG. Lastly, they will make a sustainable plan for waste generation and determine the pros and cons of their plan.</th>
<th>We will learn about how much waste is generated, what the category of the waste is (paper, metal, plastic, organic, and other) and how we dispose of it (trash, recycle or compost). Then about the different GHGs generated (decomposing waste produced methane, which leads to global temp increase, which causes a variety of issues to the env) This will be the data used to determine the amount of resources needed for the sustainable community.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate</td>
<td>Additional Explain</td>
<td>Throughout the 6 lessons, students will be turning in their activity guides and I will be giving them personal feedback on their work as a formative assessment. If enough students are struggling with the concepts, I will take time to do a full class reteach with note guides for them to follow along with.</td>
<td></td>
</tr>
<tr>
<td>Evaluate</td>
<td>Elaborate</td>
<td><strong>CFA #2:</strong> Students will take a CFA about the 3 audit areas. They will need to explain our current reality (what Des Moines, IA uses now) and explain something we could do about the current system that would help the environment. This will be an indication to the teacher and student about how well they are doing on these topics and will determine if any reteaching needs to be done (that has not already occurred based on activity). <strong>Audit Peer Review:</strong> After each of the audits, students will trade their audits with a peer and they will use a peer review protocol checklist to determine if the audits are completed correctly and with enough details. Students will be able to fix their audits if there are any mistakes found</td>
<td></td>
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</tbody>
</table>
based on their feedback.

**Final Project:** Students will answer the questions from their chosen sector for their sustainable society final project where they are designing a solution to reduce human impact on the environment. These questions will connect to the topics they have learned through this learning cycle. These answers will not be “set in stone” and will be able to be edited if needed.

The sustainable society will be based on a setting they chose at the beginning of the unit and their community will be approximately 3000 people/700 homes. The students will take on the role of the city council and each will be in charge of a different sector (electricity, transportation, waste). Each council member will be responsible for determining the most sustainable option for their community (good for the environment and good for the people). They will need to determine the economic and environmental pros and cons of their choices, which is a cause and effect explanation. There will be specific things that each council member will need to include, which is laid out in the project guidelines. They will be graded only on their portion of the work. During work time, the teams of 3 will be asked to use “Collaborative Talk Peer Review” to assess their presentation.

**Evaluate**

**Final Project Presentation:** Students will present their sustainable society to the class and other outside individuals. Students will be graded on a scoring guide, which they will have access to throughout the unit.
APPENDIX C - INSTRUCTIONAL NOTES

Google document containing all instructional materials can be found at: Unit Materials link

Standard: MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing human impact on the environment

Cross Cutting Concept: Cause and Effect

Science and Engineering Practices: Constructing explanations and designing solutions

Duration: Approximately 6 weeks to complete the unit [45 minute class periods]

Driving Question: How to design a sustainable society that monitors and minimizes human impact on the environment?

- Essential Question #1: Explain how the use of natural resources can impact the environment
- Essential Question #2: Explain, using cause and effect, how the sustainable society you designed using scientific evidence has a lower impact on the environment

<table>
<thead>
<tr>
<th>Day Number</th>
<th>Activity</th>
<th>Instructional Notes</th>
</tr>
</thead>
</table>
| 1          | Introduction | **Instructional Unit Activity:**  
- Teacher will project the proficiency scale on the board and go through the proficiency scale to share about what the upcoming unit is about  
- Students complete the pretest flowchart to determine their introductory knowledge of 3 ways that humans impact the environment (electricity generation, transportation systems, and waste management systems). These are the three categories they will use for the summative assessment project. Clarify that it is OK if students know very little about these topics because they will learn these topics throughout the unit.  
- Briefly introduce the sustainable society project: explain the goal (create a sustainable society), explain they will be working in groups of three and each will be responsible for their own portion of the project.  
- **Engagement Activity:** Students will use the carbon footprint guide and activity link to identify the amount of carbon they personally contribute to the atmosphere. They will determine the number of earths needed if everyone lived like they did (the website will determine that majority of people will need more than 1 earth) so it will create a “need-to-know” about figuring out ways to be more sustainable.** Instructional Unit improvements:**  
- This is a lot of information to be put into 45 minutes, so split into 1.5 or 2 days. By changing the order of activities, students will have time to complete the carbon footprint activity and analyze the results before moving on to the “why” of completing the task [the proficiency scale/project].  
  ○ Day 1: Start with pretest flow chart and carbon footprint
<table>
<thead>
<tr>
<th>2</th>
<th>Natural Resource and Moana</th>
</tr>
</thead>
</table>

**Instructional Unit Activity:**

- Student get their own note guide and project guiding PowerPoint presentation.

- Students develop their own definition of “natural resources” and examples of the resources and share with the class. Teacher writes definition/examples on the board.

- Teacher shows a natural resource definition video and students fill out a note guide. Teacher reviews answers with students by asking them to share answers with the class.

- Teacher introduces the Moana activity and shares the Maui example.

- Class watches the “Where You Are” clip 2x to identify natural resources used on the island, list what they are used for and what would happen if the resources were overused [overuse of natural resources is a theme they will use in the future].

- Students finish the guide by answering conclusion questions and submitting work.

- Teacher looks through Moana chart to determine if students are identifying natural resources correctly [materials people use that come from the Earth] and give feedback on analysis questions to determine their introductory ideas about sustainability.

**Instructional Unit improvements:**

- The note guide includes a reading and set of questions. This is supplementary for students if they are struggling with the ideas of natural resources. The reading could be substituted for the video clip to fit students’ needs.

- Video question 3d: This portion of the video goes very quickly and students miss it while trying to write it down. I walked students through it by asking probing questions like
  - Where does flour come from? - Wheat
  - What does wheat need to grow? - Water, Sun, Soil (and identifying that these are natural resources)

- The video section could be edited to be delivered as a conversation, rather than a video watching experience. The students already answered question 3a and 3b to begin the unit (based on their background knowledge) and I don’t believe that students have the dictionary definition to show they understand the materials.
### Natural Resource use and Easter Island

**Instructional Unit Activity:**
- Teacher reads the story of Easter Island to the class. This is a gruesome story that begins with a society that is booming, they overuse the trees, disaster ensues and it ends with epic fighting and cannibalism.
- Students pick up Easter Island activity guide.
- Students work together to answer the conclusion questions connecting the cause and effect of overusing the trees and the different outcomes. [Cause and Effect is the CCC]
- Students also need to imagine they go back in time to give 3 pieces of advice to the Easter Islanders before their society collapses to help them maintain a sustainable society [giving advice is helping design a solution to a problem, which is the SEP].
- Students submit their work for the teacher to review. Teacher is looking at #4: identify 3 environmental issues that happened due to a loss of trees [cause and effect], #6: simplify the googled definition of sustainability [main idea of the instructional unit], #7a- who should have been monitoring resource use [connection that individual choices make a big impact].

**Instructional Unit improvements:**
- This activity did not take a full 45 minutes since they were completing it and turning it in. To extend the activity, have students switch papers with a partner (who they didn’t work with to complete the activity) and go through the questions as a group. Students could give their peers feedback (stars for correct answers or correct answers if the answer on the paper was wrong). This could give students the opportunity to practice giving feedback, which they should do throughout the unit.

### Renewable and Nonrenewable Breakout Room

**Instructional Unit Activity:**
- Pre-activity: Teachers need to make clue packets for the breakout room. Use the resources linked in Unit Materials linked folder
- Student pick up a note guide
- Teacher reviews renewable and nonrenewable resource definitions. Students attempt to come up with 3 examples of each type of resource. Teacher write down the student generated answers.
- For the breakout “room”, students will attempt to answer the 7 puzzles working with their table group. Each group can answer only 1 puzzle at a time, but they can complete them in any order they want. Once they solve the puzzle, they need to write down the corresponding code.
- When they complete all 7 puzzles, they need to send one representative up to the teacher, the teacher will check that the codes are correct and the first team with all 7 puzzle codes correct wins! (Give some type of reward:}
candy, stickers, etc).

- After about 30 minutes, stop the game and go through the correct answers [content and codes] for students to check their work. This activity is where students will be learning this content, so the teacher needs to make sure they are completing this activity correctly.

- At the end, students will individually answer analysis questions about explaining renewable and nonrenewable resources to younger students [to simplify the information] and to identify and explain if we should use renewable or nonrenewable resources if we wanted to be sustainable [practicing for making sustainable choices].

- Teacher will review analysis questions and leave feedback to students regarding their definitions and note if they are leaving out any important information as well as making sure students make the connection between renewable resources and sustainable choices.

**Instructional Unit improvements**

- Instead of writing student’s examples of the different types of natural resources, have students come up to the board to record their ideas. This allows for more ownership and engagement from students.

- Teacher needs to make sure they complete each breakout puzzle, not just look at the answer key. This allows the teacher to be able to provide students with guidance in completing the tasks, not just giving them the answer to move on.

<table>
<thead>
<tr>
<th>5</th>
<th>Tragedy of the Commons and the Lorax</th>
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| **Instructional Unit Activity:** | Students pick up the Lorax note guide and teacher goes through the activity, explaining the difference between the Economic and Environmental Lense [for the summative project, students will use the economic and environmental lenses to determine if they make a sustainable suggestion].

- Students need to fill out the economic and environmental lense boxes as they hear the Lorax. (Multiple versions of the lorax story are linked to the assignment.)

- After finishing the story, the teacher leads a discussion about the 4 boxes (pro and con economic lens and pro and con environmental lense) and the term “Tragedy of the Commons” listed on the student note guide.

- Independently, students rewrite the story of the Lorax that results in sustainable outcomes. Students will then analyze their story for negative drawbacks for any characters.

- Teacher will review the stories and logical connections to drawbacks to make sure students are able to see multiple sides of their story [this is an important skill because this is what they will be asked to do while
<table>
<thead>
<tr>
<th>Instructional Unit Development</th>
<th>Instructional Unit Improvements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing their sustainable society.</td>
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</table>

**Instructional Unit Improvements:**

- Reading the story of the Lorax with the children’s book is a fun and engaging way to view the story. Make sure you’ve read the story before since the wording can be tricky. Students may stay more engaged since they are not watching a longer video.

- Instead of waiting until students turn in their lorax guide, the teacher should lead a group conversation about the connection between the Lorax and Tragedy of the Commons, since this is a new topic for the students.

<table>
<thead>
<tr>
<th>Instructional Unit Activity:</th>
<th>6 The Greenhouse Effect</th>
</tr>
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</table>

**Instructional Unit Activity:**

- The teacher needs to project the guiding PowerPoint and students need their note guide.

- Teacher shows the students a picture of the greenhouse effect with minimal labels and asks the students to interpret the greenhouse effect (where it comes from, major components, what happens). The teacher leads a conversation about the student observations.

- Next, the teacher makes a connection between the global greenhouse effect (GHE) and the miniature greenhouse effect that occurs in cars parked in the direct sun (sunlight comes through a barrier, is absorbed by something and converts to heat that can not escape). This is an example that makes the GHE accessible.

- Teacher shows a short video clip about the GHE and students determine what would happen to the Earth if the GHE didn’t exist. Students record results on their note guide.

- Students help the teacher fill out the GHE paragraph by identifying the correct answer in the answer pairs. This is a teacher guided activity because students need to have the correct information so they can make connections between increased greenhouse gases and the greenhouse effect.

- Teacher identifies the major natural and anthropomorphic greenhouse gases.

- Students use the links of the guide to learning on:
  - Sources of Greenhouse Gases (GHGs),
  - What GHGs are produced by different life sectors (e.g. industry, agriculture, etc), and
  - Solutions humans can do to reduce GHGs.

- Students analyze the charts they filled out to develop solutions to reduce GHGs and have a lower impact on the environment.

- Since these were guided notes and not new ideas, students will not turn in
this note guide.

**Instructional Unit Improvements:**

- This is a very long activity that should take 1.5 or 2 days. That would give time for students to give feedback to each other on their information, rather than wait for only teacher feedback.

- Make connect with students about their carbon footprint and the greenhouse effect (more carbon dioxide means more heat is trapped on Earth, so climate change happens more rapidly).

- Question #6 (solutions) were challenging for students to complete. The article showed many examples of things people could do to reduce climate change, but students needed help making the connection from “turning off the lights when you leave the room” and a reduction of GHG production. It would be helpful to use a flowchart (e.g. turn off the lights → use less electricity → burn less coal → create less CO2).

- Question #7a and #7c were already answered in the charts above and can be removed.

| 7 | Global Carbon Dioxide Graphing |

**Instructional Unit Activity:**

- Students make an electronic copy of the activity since they will be electronically graphing CO2.

- Teacher explains that the data collected came from a remote observatory in Hawaii, so data is not obscured from people directly.

- Students open the data set and choose one years data (ex: 1970) and open the graph document and input the data points. The graph document will plot the points of the graph. To analyze the data, students need to follow the picture instructions to zoom in and see the minor changes during the year.

- Students will make a prediction about why they believe there are small changes. After predicting, they will read a small reading explaining these small changes [CO2 levels increase and decrease with the seasons].

- Next students will look at a picture of all of the yearly data on one graph. Students will make a prediction about why they believe there is an increase in CO2. Again, they will read a small reading explaining the increase [Humans adding more CO2 due to burning fossil fuels for electricity and transportation].

- Lastly, students will connect the increase CO2 to the impacts on global temperature and the impacts to the environment.

- Students will turn their guide in and the teacher will review #4: causes of yearly changes in CO2, #7: Causes of increase CO2 over 50+ years, and #8: unit connection.
### Instructional Unit Improvements:

- Many students have a hard time graphing the data because they are unfamiliar with GoogleSheets. Walk them step-by-step through the process and have the students complete the steps as they are being explained (e.g. pick a year, enter the data on the graph, click this symbol to open up this page, etc). It is helpful to complete a yearly graph with them as well.

- Alternatively, students could graph this data by hand. It would take a long time since some 8th graders struggle with graphing (identifying a scale, plotting points, etc). Teacher could set up graph paper for the students for each year and then the scale would be accurate and could be placed together to identify large scale changes.

### Instructional Unit Activity:

- Teacher wrote the CFA topics on the board (natural resources, renewable and nonrenewable resources, Greenhouse Effect and Greenhouse Gases/impacts, Tragedy of the Commons). Students had 10 minutes to review their notes.

- Students complete the Common Formative Assessment (CFA) independently without notes. This is the first formal check in.

- Students will be asked to:
  - Describe how the GHE heats the Earth,
  - Identify a natural resource that causes CO2 to be produced,
  - Identify if the natural resource is renewable or nonrenewable and explain how they know,
  - Explain Tragedy of the Commons (TOC),
  - Explain why CO2 in the atmosphere is an example of TOC, and
  - Identify a major impact CO2 has on the atmosphere related to the GHE.

### Instructional Unit Improvements:

- Some students struggled with the wording of questions so I had to remind them of the different activities they did through the unit so far. Once they were reminded of the activities, they were much more successful.

- I realized that Question #2 (natural resource that causes CO2 to be produced) did not make sense to students, so I would need to change it to directly discuss electricity production (to discuss coal) or transportation fuel (to discuss oil).
<table>
<thead>
<tr>
<th>9-11</th>
<th>Electricity Speed Dating</th>
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**Instructional Unit Activity:**

- Pre-lesson, teacher assigns electricity sources to each member of the class (ex: coal, wind, hydro, and solar).

- Teacher explains the lesson by showing an example of a Nuclear Power “online dating profile”. Make sure to explain each component they are looking for. Complete this BEFORE showing the students their assigned roles to avoid students starting to work on the assignment without understanding the process.

- Students need to make a copy of the electronic online dating profile document and create a character based on their electricity source and answer the questions (ex: “a little bit about myself” - explain how the electricity source produces electricity or “my last relationship didn’t work out” - 3+ environmental or economic negatives).

- Students have 2 days (day 9 and day 10) to complete their online profile and submit them to the teacher. Resources to complete the profile are included on the dating profile document.

- After the dating profiles are submitted and vetted, the teacher creates 4 separate PowerPoint slide shows that contain all of the dates for the specific resource (e.g. one PowerPoint for Coal profiles, one for solar power profiles, etc).

- Students use the profiles to fill out a note guide based on the information they found on the dates *these are the students notes to use for future electricity lessons*.

**Instructional Unit Improvements:**

- I vetted the presentations for appropriate information (Junior High students creating dating profiles has the potential to be inappropriate) not correct information. The students had to look at multiple dating profiles to determine if the information was correct and detailed (ie: if they find the same information on multiple slides, it is most likely correct).

- Before submitting their assignment, it would be helpful for a peer feedback check where students who completed the same resource (ex: both completed a character profile for coal) to make sure they include the accurate information. The teacher should provide a checklist of things to include on the profile that the students can physically check off. I have found that some students are more likely to add all the information if it is presented in a checklist, opposed to individual questions.

- After reviewing the dating profiles, I realized that many students lacked details with the “how does it generate electricity?” question, so I created a quick PowerPoint review to review the content for each of the electricity generation sources. This has been included in the unit materials that have been linked.
**Instructional Unit Activity:**

- *The actual audit WILL be challenging for students, so walk them through step-by-step. Let students work independently when answering calculation and conclusion questions.*

- Students need their electricity audit guide and teacher needs to project the audit guide on the whiteboard.

- Teacher begins by reading the introductory paragraph because it is a reminder in what Iowa uses and the impacts of that usage.

- **Day 1 - Audit completion steps:**
  
  - Have students go on a “mental walk” through their home and record EVERYTHING that is plugged into the outlets or is often plugged into the outlets. Remind students of things that use electricity that they don’t think about (e.g. light bulbs, ceiling fans, air conditioners, etc).
  
  - In the second column, have them identify the number of each item they have (e.g. 5 lamps, 3 ceiling fans, 1 hair dryer).
  
  - In the 4th column, have them record the number of hours the item is plugged in a day.
  
  - **PAUSE instruction until majority of students have completed this part.**

- **Day 2 - Audit completion steps:**
  
  - Find the Power Rating (kw) of each of the items. Many items are listed on the front page of the audit, but if students cannot find a specific item, they need to google “item wattage” and convert from watts into kilowatts.
  
  - To determine kilowatt hours (unit of electricity bill), students need to multiply: number of appliances * power rating * hours plugged in.
  
  - Add all kilowatt hours (kWh) together to determine total kWh in 24 hours.
  
  - Students complete additional calculation questions to determine electricity used in 1 year, cost for electricity, and needs of the community.
  
  - Lastly, students are responsible for finishing the conclusion questions: issues with the current electricity system and mini-sustainable plan.

- Have students submit their audit and teacher give feedback on correct numbers (general range, since no student will have the same number of kwh used in their home), correct and detailed information about the current
electricity system, for the sustainable society: identified a renewable electricity source and included correct and detailed information about the environmental and economic impacts.

**Instructional Unit Improvements:**

- Revisit the Carbon Footprint activity before beginning this lesson. The audits are a way to show students their individual usage of the resource and the carbon footprint showed students the impact of their usage.

- When the students finished their audit and conclusion questions, have the students give peer feedback, using a checklist. Checklist is included in the unit materials. Correct audits are necessary for correct information on their summative project.

- After students had finished the audits, I saw that they struggled with the calculations. Because this is not part of the standard, I created an Audit/Sustainable Society calculator that did the calculations for them. Students are still responsible for monitoring their use (per NGSS). This calculator is found in the unit materials.

<table>
<thead>
<tr>
<th>14</th>
<th>Transportatio n Game</th>
<th><strong>Instructional Unit Activity:</strong></th>
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<tbody>
<tr>
<td></td>
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<td>- Pre-lesson: The teacher needs to create game boxes that include 1 die, 1 set of playing cards, 1 game board, and 2 game pieces. Create enough game boxes for students to work in pairs.</td>
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<td>- The teacher begins class by doing a BRIEF discussion about personal transportation, public transportation, gasoline, biofuel, and electric “fuel”. This is to provide minimal feedback about the information on the game cards.</td>
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<td>- The teacher explains the game and projects the rules on the white board: (1) player 2 draws a card for player 1 and reads the question, (2) player 1 attempts to answer the question, (3) player 2 determines if player 1 has correctly answered the question using the answer key on the game card, (4) if player 1 correctly answered the question, they roll the die and move that many spaces. If player 1 got it wrong, they stay at their current spot, (5) BOTH students write the information on their note guide before switching roles <em>this note guide are the notes for any transportation activities</em>, (6) switch roles and repeat the steps for player 2.</td>
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<td>- Play the game for the allotted class time (approximately 20 minutes). Player that is the farthest on the game board is the winner and receives a prize (candy, sticker, etc).</td>
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<td>- At the end of class, complete a quick review of the game by having the students help fill out the slides projected on the whiteboard. I told students that I would go into detail about anything they put on the whiteboard, but I wouldn’t discuss it if it was not included. This encouraged students to be VERY detailed about the information they put on the whiteboard.</td>
</tr>
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</table>
## Instructional Unit Improvements:

- In the future, it would be more helpful to do a more detailed introduction about the different transportation topics. Some students came into the lesson with very little knowledge in the material, so they struggled moving forward the game, since they could only move if they got correct answers.

- Initially, the game cards had information like “is carbon neutral” but I discovered that students did not know what phrases like that meant. I added descriptors to the answers to provide more detail. These detailed cards are provided in the unit materials.

## Instructional Unit Activity:

**Transportation Audit**

- *The actual audit WILL be challenging for students, so walk them through step-by-step. Let students work independently when answering calculation and conclusion questions*.

- Students need their transportation audit guide and teacher needs to project the audit guide on the whiteboard.

- Teacher begins by reading the introductory paragraph because it is a reminder in what Iowa uses and the impacts of that usage.

- Day 1 Audit completion:
  - Show students a personal transportation audit for a normal day, so they understand what they will be doing
  - Have students write down locations traveled in 1 day with starting spot to ending spot (e.g. home to school). Make sure when the students end at a location, that is where they start on the next like (e.g. school to Target, Target to Hyvee, Hyvee to home).
  - Open up google maps and have students determine the distances traveled. Benefit of google is that you don’t need to have exact addresses if you know the general location (ex: Target in Des Moines) since it will automatically give you the address. Record the distances on the chart.
  - Add distances together to get total miles traveled in a day.
  - Determine the gas mileage of the vehicle that the students drove in. If they use multiple vehicles, have students use the vehicle they are in most often. Use the link provided and search out the specific vehicle.
  - Using the miles driven and the gas mileage of the vehicle, students calculate the number of gallons of gasoline used in 24 hours.

- Day 2- Audit completion:
  - Students complete additional calculation questions to determine
gallons of gasoline used in 1 year, cost for gasoline, and needs of the community.

○ Lastly, students are responsible for finishing the conclusion questions: issues with the current transportation system and mini-sustainable plan.

○ Have students submit their audit and teacher give feedback on correct numbers (general range, since no student will have the same number of gallons of gasoline used in their home), correct and detailed information about the current transportation system, for the sustainable society: identified a renewable transportation system and included correct and detailed information about the environmental and economic impacts.

**Instructional Unit Improvements:**

- Revisit the Carbon Footprint activity before beginning this lesson. The audits are a way to show students their individual usage of the resource and the carbon footprint showed students the impact of their usage.

- When the students finished their audit and conclusion questions, have the students give peer feedback, using a checklist. Checklist is included in the unit materials. Correct audits are necessary for correct information on their summative project.

- After students had finished the audits, I saw that they struggled with the calculations. Because this is not part of the standard, I created an Audit/Sustainable Society calculator that did the calculations for them. Students are still responsible for monitoring their use (per NGSS). This calculator is found in the unit materials.

**17-19 Waste Removal System Station**

**Instructional Unit Activity:**

- Pre-lesson: The teacher needs to print out station links and place them on the tables around the room. Rather than give students the links electronically, print them out to get students to move around the room and take a brain break between stations.

- Students need their waste station note guide. The guide has specific questions that they can find using the specific resources provided.

- Teacher begins class by doing a brief instruction set to describe what is happening at each of the 8 stations and to give details of how and when to move to each station. 8-9 minutes is ideal for each station. Some stations are longer and some are shorter, but the goal is to get a lot of information on what we can do to reduce the amount of waste going into the landfill. It is not as important that they finish every question on every station if they understand the general ideas.

- Working in a group of 4, students fill out their note guide and wait for the timer to ring to move to the next station *these notes are used for any waste
activities through the unit*.

**Instructional Unit Improvements:**

- I didn’t provide a recap to the stations, but this was definitely needed after looking at the summative assessment details. Students stated on “recycle more”, but couldn’t provide details of how to do that, so it is important to help them go through alternative ideas of ways to reduce waste going to the landfill.

<table>
<thead>
<tr>
<th>20</th>
<th>Waste Audit</th>
<th><strong>Instructional Unit Activity:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><em>The actual audit WILL be challenging for students, so walk them through step-by-step. Let students work independently when answering calculation and conclusion questions</em>.</td>
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<tr>
<td></td>
<td></td>
<td>Students need their transportation audit guide and teacher needs to project the audit guide on the whiteboard.</td>
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<tr>
<td></td>
<td></td>
<td>Teacher begins by reading the introductory paragraph because it is a reminder in what Iowa uses and the impacts of that usage.</td>
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<td><strong>Day 1 Audit completion:</strong></td>
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<td></td>
<td></td>
<td>○ Students need to go on a “mental walk” through their last 24 hours. Start with the second they woke up to the second they go to sleep and record everything that they threw away, recycled or composted. Record the number of each item (e.g. 2 apple cores) and where they put it (e.g. trash).</td>
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<tr>
<td></td>
<td></td>
<td>○ Categorize this waste into the 5 main categories: paper, metal, plastic, organic matter and other.</td>
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<tr>
<td></td>
<td></td>
<td>○ Lastly, students need to determine if the item COULD BE recycled or composted, and if yes, record the number of items that could be recycled/composted.</td>
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<td><strong>Day 2 Audit completion:</strong></td>
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<td></td>
<td></td>
<td>○ Students will count the number of items of trash that could go into the different categories (ex: number of items thrown away, number of items that could have been recycled, number of plastic items, etc).</td>
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<tr>
<td></td>
<td></td>
<td>○ Students use the number totals to determine the percentages of their waste (ex: percentage of waste that was paper, percentage of waste that was recycled, percentage of waste that COULD be recycled, etc).</td>
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<tr>
<td></td>
<td></td>
<td>○ Student answer conclusion questions about the current waste removal system and the issues with that system.</td>
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</tbody>
</table>
|    |             |   ○ Students also try to determine a sustainable waste plan. They are
instructed to go beyond “recycle more” or “throw away less” and to come up with creative strategies to keep things out of the landfill.

- Have students submit their audit and teacher give feedback on correct numbers (general range, since no student will have the same number and composition of waste generated in their home), correct and detailed information about the current waste removal system, for the sustainable society: identified a renewable waste removal system, and included correct and detailed information about the environmental and economic impacts.

**Instructional Unit Improvements:**

- When the students finished their audit and conclusion questions, have the students give peer feedback, using a checklist. Checklist is included in the unit materials. Correct audits are necessary for correct information on their summative project.

- After students had finished the audits, I saw that they struggled with the calculations. Because this is not part of the standard, I created an Audit/Sustainable Society calculator that did the calculations for them. Students are still responsible for monitoring their use (per NGSS). This calculator is found in the unit materials.

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**CFA #2**

**Instructional Unit Activity:**

- Teacher suggested that students take out their electricity, transportation and waste notes/audit and review the following topics for 10 minutes:
  - What do we use now?
  - What is wrong about the current system?
  - What could we do instead?
  - Why would the choice be more sustainable?

- Students complete the CFA independently and without notes

- Teacher score the CFA looking for:
  - Correct identification about what we use now (ie: coal, personal vehicles/gasoline, landfill).
  - Issues: students can discuss overusing natural resources, producing greenhouse gases which lead to climate change, addition of pollutants that impact the environment.
  - Future plans: students need to identify a renewable resource (e.g. solar or wind), something that is less non-sustainable (e.g. electric cars) or systematic changes (e.g. tax breaks for small trash cans and large recycle bins).
### Instructional Unit Improvements:

- Since the summative assessment allows students to have access to their notes while creating the project, allow students to use their notes on the CFA.
- Make sure students are providing detailed evidence about why their choices are beneficial or why the original resource is a problem. Students need to be detailed on their summative project, so this is making sure they practice with detailed descriptions.

### Instructional Unit Activity:

*This project is very detailed, so follow the materials provided in the unit materials*.  

#### Day 1:

- Teacher begins project by acting out the scenario of the project (Our current community was destroyed and we need to develop many smaller sustainable societies and the students are responsible for coming up with a plan).
- Teacher explains the 10 potential settlements and the three roles and shows the students where to access this information.
- Students can pick their own teams of 3 and need to get with their group. They need to decide their top 3 settlements because only one group gets a particular settlement.
- Teacher randomly selects teams to select their settlement. Once all teams have a settlement, have one student come up to the teacher to tell which role each group member will have. *The teacher will keep a detailed list of everyone's settlement and role to help remind students of their responsibilities throughout the project*
- Teams need to create a PowerPoint presentation and share it with each member of the group, so they can build the presentation together. They are responsible for creating the introduction slide describing the settlement location.
- Any time remaining, students should finish/edit/submit their audits.

#### Day 2-3:

- The teacher will remind students where to find the questions they need to answer and checklists of what is required in each section. Teacher will also explain and show students the supplementary information provided to help the students correctly answer their specific section. The supplementary information includes average costs, lists of pros and cons for specific choices, and other information to help students make realistic choices.
- Students answer the specific questions required for their role in the
settlement (e.g. Waste Systems expert).

- Once questions are answered, students can start creating their slides.

Day 4:

- Students need to finalize their slides and submit them to the teacher. *The slides are created as a GoogleSlide presentation, so submitting the project does not mean the students needs to be fully finished with their slides, since they will update in real time*.

- The teacher can add the slides link to the settlement/role list that was created on day 1.

- Once submitted, students should practice delivering their presentation by talking out loud and not just reading off of the slides. The teacher will have notecards to use if students want to take notes.

**Instructional Unit Improvements:**

- On day 2, give students a hard copy of the questions they need to answer in their project. I originally gave them a choice of electronic copies or paper copies. Most students chose the electronic copy and didn’t actually answer the questions on the guide (they just used the questions as an outline of what to put on their slides). By not directly answering the questions, many students answered part of the question, not the entire thing.

- Before creating the slides, have students trade their answer papers with a member of their group. The group member will be used to giving feedback based on checklists, so this will not take too much time.

- Before creating slides, the teacher should go through a sample set of slides for students to model their slides after, if they want. Another easy way to do this would be for the teacher to make a template presentation that includes places to record the information for each of the roles. This would make sure all questions were answered, but would eliminate some of the independence that comes from PBL learning.

- 4 days to complete this task will not be enough for students who are off task. Teacher needs to make sure they are motivating students to be productive during work time.

<table>
<thead>
<tr>
<th>26-29</th>
<th>Sustainable Society Project presentation</th>
<th><strong>Instructional Unit Activity:</strong></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Give the students a few minutes to organize themselves for the presentation. Once it is “go time” have all students put away their computers and other class work</td>
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<td>Give students the opportunity to volunteer to present first, and after the first presentation, ask who would like to go next, etc</td>
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<td>During the presentation,</td>
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</table>
- The students should listen to their peers' presentations. At the end of the presentation, students have the opportunity to ask questions about the sustainable society.

- The teacher is filling out the grading rubrics. If the teacher misses anything from the rubric, ask the group member directly.

**Instructional Unit Improvements:**

- During the presentation, students got antsy listening to projects. Have them fill out a guide while groups are presenting. Guide should include:
  - Description of the settlement,
  - Identification of sustainable electricity, transportation, and waste management choices,
  - Brief reasoning for picking the sustainable choice, and
  - Would you want to live there?

- To increase the PBL aspect of the project, students should present this to people outside of the classroom. Invite the administration or community members (maybe city planners) to watch the presentations. Students could also take the presentation home and present to their household and report back on if their household would be willing to make the sustainable choices they suggested.

<table>
<thead>
<tr>
<th>30</th>
<th>Unit Conclusion</th>
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**Instructional Unit Activity:**

- Have students revisit the pretest flow chart and have them answer the questions again.

- After completing the flow chart, give students back their grade checklist and scoring guide. Discuss final grades and how they can improve their scores (per Standards Referenced Grading protocols).

**Instructional Unit Improvements:**

- Flow charts could be revisited individually after the completion of the 3 audits. This is when students would be most familiar with the materials, since they were only responsible for determine a sustainable plan for one part of their society.
APPENDIX D- CURRICULUM ANALYSIS TOOLS

Pretest and Post test Unit Flow Chart

- How could we minimize the negative impact of the resource use?
- How can we monitor use of the resource?
- What is a negative impact of the resource?
- What natural resources are being used?

What we need:
- Electricity
- Transportation
- Waste Removal
Abbreviated EQuIP Rubric

NGSS INSTRUCTIONAL MATERIALS EVALUATION

Evaluator(s): ____________________________ Ranking: 4 – Excellent
Program Title ____________________________ 3 – Good
Copyright ________________________________ 2 – Average
Publisher ________________________________ 1 – Fair
Grade Levels ______________________________ 0 – Unacceptable
NA – Not Available

1. Alignment with the NGSS

- Provides opportunities for students to use specific elements of Science and Engineering Practice(s) to make sense of phenomena or design solutions. 4 3 2 1
- Provides opportunities for students to construct and use specific Elements of the disciplinary core idea(s) to make sense of phenomena or design solutions. 4 3 2 1
- Student sense-making of phenomena or design solutions require student performance that integrate the SEPs, CCCs, and DCIs. 4 3 2 1
- Lessons fit together to target a set of performance expectations. 4 3 2 1

AVERAGE RATING FOR THIS SECTION: _____

2. Instructional Supports

- Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world and that provide students with a purpose. 4 3 2 1
- Develops deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts by identifying and building on students’ prior knowledge. 4 3 2 1
- Use scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students’ learning. 4 3 2 1
- Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written form as appropriate to support student’s learning. 4 3 2 1
- Provides guidance for teachers to support differentiated instruction in the classroom so that every student’s needs are addressed by the following: connecting instruction to student; providing appropriate modifications for students
who are English Language learners, have special needs, or read well below
the grade level; providing extra support for students who are struggling;
and providing extensions for students with high interests or who have already
met the performance expectations.

AVERAGE RATING FOR THIS SECTION: ______

3. Monitoring Student Progress

- Includes pre-, formative, summative, and self-assessment measures
  that assess student learning. 4 3 2 1
- Elicits direct, observable evidence of students’ performance of practices
  connected with their understanding of core ideas and crosscutting concepts. 4 3 2 1
- Formative Assessments of student learning are embedded throughout the
  instruction. 4 3 2 1
- Includes aligned rubrics and scoring guidelines that provide guidance
  for interpreting student performance to support teachers in planning
  instruction and providing ongoing feedback to students. 4 3 2 1
- Assessing student proficiency using methods, vocabulary, representations,
  and examples that are accessible and unbiased for all students. 4 3 2 1

AVERAGE RATING FOR THIS SECTION: ______

4. Gold Standard Project Based Learning

- Instructional unit is driven by standards and success skills including
  critical thinking/problem solving, collaboration and self-management. 4 3 2 1
- The project is based on a meaningful open-ended and engaging driving question. 4 3 2 1
- The project is active where students generate questions, find and use resources,
  ask questions and develop their own answers. 4 3 2 1
- The project has a real-world context, uses real-world processes, makes a
  real impact and/or is connected to student’s own concerns, interests, and
  identities. 4 3 2 1
- The project allows student to make some choices about the product they create,
  how they work, and how they use their time, guided by the teacher. 4 3 2 1
- The project provides opportunities for students to reflect on what and
  how they are learning, on the project’s design and implementation 4 3 2 1
The project includes processes for student to five and receive feedback on their work in order to revise their ideas and products or conduct further inquiry

The project requires students to demonstrate what they learn by creating a product that is presented or offered to people beyond the classroom

AVERAGE RATING FOR THIS SECTION: ______

5. 21st Century Skill

- Provides opportunities for students to creatively collaborate with others towards a common goal. 4 3 2 1
- Provides opportunities for students to accept and provide feedback. 4 3 2 1
- Provides opportunities for students to effectively communicate with group while demonstrating productivity and accountability to the group. 4 3 2 1
- Provides opportunities for students to adapt to various roles and responsibilities while demonstrating leadership and social responsibility. 4 3 2 1

AVERAGE RATING FOR THIS SECTION: ______

6. Teacher Resources

- Materials and resources needed to plan and facilitate instruction are complete. 4 3 2 1
- Teaching guide(s) clearly organized, easy to follow, and easy to use. 4 3 2 1
- Teaching & learning strategies, information on how to use resources, and solutions and answers to questions provided along with teacher support resources. 4 3 2 1
- Utilizes various types of instructional technologies that are integrated with the instructional materials. 4 3 2 1

AVERAGE RATING FOR THIS SECTION: ______

Comments:

Complete Reference Information (Title, Year, Author(s), Publisher, etc.)
APPENDIX E- COMPLETED FLOWCHART EXAMPLES

Examples of student completed flow charts are linked and individual components are scored and recorded on each flow chart.

Pretest Flow Charts

Electricity
Transportation
Waste

Post test Flow Charts

Electricity
Transportation
Waste