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How Does a Next Generation Science Standard Aligned, Inquiry Based, Science Unit Impact Student Achievement of Science Practices and Student Science Efficacy in an Elementary Classroom?

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How does a Next Generation Science Standard Aligned, Inquiry Based, Science Unit Impact Student Achievement of Science Practices and Student Science Efficacy in an Elementary Classroom?

by

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Abstract

This study examined the impact of an inquiry based Next Generation Science Standard aligned science unit on elementary students' understanding and application of the eight Science and Engineering Practices and their relation in building student problem solving skills. The study involved 44 second grade students and three participating classroom teachers. The treatment consisted of a school district developed Second Grade Earth Science unit: *What is happening to our playground?* that was taught at the beginning of the school year. Quantitative results from a Likert type scale pre and post survey and from student content knowledge assessments showed growth in student belief of their own abilities in the science classroom. Qualitative data gathered from student observations and interviews performed at the conclusion of the Earth Science unit further show gains in student understanding and attitudes. This study adds to the existing literature on the importance of standard aligned, inquiry based science curriculum that provides time for students to engage in science practices.

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Introduction

The world today is a place of innovation, constantly growing and changing. The jobs that will be most popular ten years from now, we haven't even dreamed up yet. Many of today's college majors didn't exist ten years ago, so what will our current students study in the next ten years? As parents and educators "We are currently preparing students for jobs and technologies that don't yet exist… in order to solve problems we don't even know are problems yet." (Fisch & McLeod, 2007) Our world demands every citizen to think on a global scale, to be flexible and ready to change with the world, to be competent, creative and resilient problem solvers. When we are born, we have the innate sense of curiosity about our world. It starts with touching objects and putting them in our mouths as infants and moves into the parent-feared toddler years of asking why. As an educator, I've observed that in the transition of becoming a young adult, curiosity is often lost, or rather, squashed. In such a fast-paced world of immediate gratification, adults are quick to brush off the young and seemingly unimportant wonderings of children. What adults do not realize is the negative effect this has on children. It implies to children at a very young age, that wondering is not of importance.

Nearly a decade of experience as an educator has shown me that children are curious and resilient. These are skills that need to be honed and practiced, in order to be a successful member of our current and future society. The Partnership for 21st Century Learning declares in their mission statement that we need to be building a collaborative environment for learners to acquire knowledge and skills to thrive in a world where change is constant and learning never stops. (2008) They focus on creativity as one of their top four constructs that need to be a skill to succeed in our current and future society. This practice should be a lifelong process that begins in childhood, starting with public education.

Public education is where each individual begins learning how to be a citizen, as well as how to interact with and make sense of the world around them. In school students not only gain content knowledge but also skills and practices that are transferable to everyday life. As Cuevas et al. (2005) state in *Journal of Research in Science Teaching:* "Today's complex society requires members to analyze and respond to issues and a constantly expanding knowledge base. To achieve this goal, classrooms must be transformed from environments that encourage students to go beyond memorizing facts into taking the initiative and responsibility for their own learning." Cuevas et al,(pg 337). By the time they reach adulthood and enter the workforce, each person needs to be able to show resilience and perseverance, curiosity and the ability to inquire, as well as flexibility and creativity in the face of problems.

I believe that these characteristics can be developed through a quality science education beginning in the elementary years. In their research study on the relationship between scientific creativity and scientific inquiry with 158 elementary students in Taiwan, Yang, Shu-Fen, Zuway, & Huann-shyang, (2016) discovered that scientific creativity is putting content knowledge together with process skills and divergent thinking which together are problem solving. In the conclusion of their study, the authors demand a "call to action for exploring affective and creative attributes as learning outcomes and how these attributes relate to science achievement and the practices – especially in elementary [education]." Yang, et. al (2016, p17) This led to the development of my research question: How does a Next Generation Science Standards aligned, inquiry based, science unit impact student achievement of science practices and student efficacy in an elementary classroom?

I have seen that asking questions and being able to find the answers empowers students in their own learning. It gives children the desire to learn, the will to learn, which increases engagement in the classroom and with the world around them. Giving children the opportunity to find an answer on their own breeds creativity, which is a necessary life skill in the innovative age that we live in. It also helps children know that their thoughts are important and to value them. We, as adults in the world at our time, have to be on our toes and open to new ideas to survive; in the future that will only increase in importance. "Science inquiry encourages the development of problem solving, communication, and thinking skills as students pose questions about the natural world and then seek evidence to answer their questions." Cuevas, Lee, Hart, Deaktor (2005, pg 338).

I believe that we can provide our future workforce the skills needed to create a sophisticated and scientifically literate community with a well rounded curriculum focusing on: curiosity through inquiry, and utilizing problem solving skills through the NGSS Science and Engineering Practices. (NGSS Lead States, 2013) A scientifically literate citizen is one who can engage in public policy issues, make informed everyday decisions and open new worlds to explore that can enrich their life and others lives. (NRC, 2012) The following research study tests this theory within three second grade classrooms in a large suburban school district setting, with a Next Generation Science Standard aligned Earth Science unit.

Literature Review

The following is a review of current and relevant literature pertaining to the traits of resiliency and perseverance, creativity and problem solving as well as inquiry education and the use of the Next Generation Science Standards Eight Science and Engineering Practices.

Why resiliency and perseverance?

As adults, we all know, that in each person's life, they will encounter conflicts and tasks of all types: conflicts with friends or coworkers and tasks and assignments on the jobsite. To face these conflicts and tasks, a person needs to be resilient and have the ability to persevere. To be resilient is to have the ability to recover quickly in the face of a difficulty or struggle, to bounce back in order to keep moving forward. To be resilient and persevere, students need to build an amount of confidence in themselves to continue working without giving up. This idea holds true in learning science literacy. In their research report Beghetto and Baxter state, "When it comes to enhancing students' understanding in science, it is important to help students develop confidence in their science ideas, encourage students' willingness to take intellectual risks, and help them develop more sophisticated epistemological beliefs regarding the certainty of scientific knowledge." Beghetto & Baxter (2012, pg 942)

Beghetto and Baxter (2012) believe that exploring the relationship between students self beliefs and teachers' ratings or views of their students' self beliefs can give important insights. They looked at student self beliefs through four different constructs: 1. Epistemological beliefs which refer to having knowledge of content or a subject area. 2. Certainty beliefs which pertains to the ideas that content knowledge is fixed and can not change or that there is the possibility for revision of the content ideals. 3. Source beliefs which is associated with where the knowledge comes from, for example, a teacher or a book. 4. Creative Self-Efficacy beliefs which is a reflections of one's confidence in their ability to come up with new ideas. These insights help guide research and instructional practices aimed at cultivating healthy student motivational beliefs, which in turn they found, create better science and math learning. They conducted a research experiment that involved 276 students in 3rd through 5th grades from 12 elementary schools in a midsized city in the Pacific Northwest. Data was used on a larger teacher development project that the teachers of the students participated in, which involved 120 hours of workshop instruction and lesson planning over two years. The development project aimed at helping the teachers learn effective approaches for teaching science and math that develop understanding of the content as well as the students' belief in their own ability. According to student survey and teacher observation of their students, Beghetto and Baxter found students' intellectual risk taking, perceived competence and understanding were all slightly above average. Students who had more confidence in their ideas were more willing to take risks in both science and math. The researchers found that in order to persevere in tasks, students needed to develop confidence; in order to develop confidence students needed time to take multiple attempts at completing tasks, explore on their own, create their own ideas and take risks. “When it comes to enhancing students’ understanding in science, it is important to help students develop confidence in their science ideas, encourage students’ willingness to take intellectual risks, and help them develop more sophisticated epistemological beliefs regarding the certainty of scientific knowledge.” Beghetto & Baxter (2012, pg 954) Beghetto and Baxter also shared that based on their review of relevant literature and the results of their research, it is most advantageous to begin the process of creating more confident and resilient people at the beginning of life, in childhood. “Researchers, in recent years, have come to recognize the value of exploring such beliefs in younger students – acknowledging that such beliefs seem to have their genesis quite early in children’s cognitive development and have been linked with academic performance.” Beghetto & Baxter (2012, pg 944) This project has shown the importance of research in the area of students’ self beliefs in science with attention to the skills of resiliency and perseverance in the elementary classroom.

Why creativity and innovative problem solving?

With our world now in an innovative age, it takes much, well, innovation to survive. We need to be able to navigate our world as consumers of information to ensure we have a career and home. The Partnership for 21st Century Skills’ mission is to build collaborative partnerships for learners to acquire knowledge and skills to thrive in a world where change is constant and learning never stops. They believe that a successful participant in the modern workforce needs to be able to, “Act on creative ideas to make a tangible and useful contribution to the field in which the innovation will occur.” (2008, pg 3) With creativity being a skill for the future, it is most beneficial to begin the development of these skills as early as possible.

Yang, Shu-Fen, Zuway, & Huann-shyang (2016) created a study to find out how divergent creativity and convergent creativity were related to scientific inquiry. In their report they define divergent creativity as the ability to create a list of possible solutions to a problem and convergent creativity as the ability to select the most appropriate solution from their list. They conducted their research in 158 elementary schools in Taiwan with an age group that would correlate with 3rd through 6th grades in America. They used a scientific creativity test that was comprised of two open ended parts, one on divergent creativity and the second on convergent creativity. They graded this test with a four point rubric. The activities in the test were answering open ended questions and developing models to solve different problems with ordinary objects. They found that in comparing students results by grade level, there was a large gap in third to fourth grade with ability in divergent and convergent creativity. While the fourth, fifth and sixth grade students were closer in ability. This was determined to be a results of the fourth, fifth and sixth grade student curriculum being much richer in scientific inquiry. “Use of more student-directed projects and assignments allow creativity to be expressed, valued, and flourish.” (2016, pg 21) Their results show that creativity is a skill that can be practiced, improved, and continually applied as students move on through their education and then into their lives. Their results also show that scientific inquiry needs to begin at a younger age to help foster more creativity in student problem solving. In their conclusion, Yang, K., Shu-Fen, L., Zuway, H., & Huann-shyang, L. desire to see science inquiry curriculum in all schools in order to continue to build creativity and problem solving in all students in order to build a better society. “The most significant relationship between the science inquiry competency of designing investigation and divergent scientific creativity seems to remind science educators and teachers that engaging students to design their own experimental procedures is very likely to promote students’ scientific creativity, as well. In other words, this finding provides additional evidence of supporting the potential benefits of inquiry based teaching.” Yang, et al (2016, pg 22)

Why would we not want to promote the development of the most creative scientists now, starting in our elementary classrooms? “Creative scientists are more aesthetically oriented, ambitious, <u>confident</u>, deviant, dominant, expressive, <u>flexible</u>, intelligent and <u>open to new experiences</u> than their less creative peers.” Yang et al (2016, pg 17)

Why inquiry curriculum and the science practices?

I agree with the evidence from the relevant literature presented above that characteristics of resiliency and problem solving are of importance and can be developed through a quality science instruction beginning in the elementary years of public education. Best practice science education should produce students who are scientifically literate and prepared to take on the world around them. “Inquiry based learning provides students with opportunities to reflect on, question, and analyze the enormous amount of digital, print, and media information that characterizes our complex technological society.” Cuevas, et al (2005, pg 337).

In their study on looking at instructional interventions that would promote science inquiry in elementary schools, Cuevas, Lee, Hart and Deaktor found that there was significant improvement on student’s scientific ability when inquiry is a part of instruction. “Inquiry is agreed upon as student centered or open when students generate a question and carry out an investigation. Teacher guided inquiry when the teacher selects the question and both students and teacher decide how to design and carry out an investigation, and teacher centered or explicitly when the teacher selects the question and carries out an investigation through direct instruction or modeling.” (2005, pg 339). Cuevas, Lee, Hart & Deaktor chose to work with elementary schools that were in an urban setting with over 70% free and reduced lunch and and 35% ELL population. Seven third and fourth grade teachers were involved in the research project and were educated on inquiry practices, language integration into science and incorporating student's home language into the curriculum. This learning done by the teachers was spread between four workshops throughout one school year and was based on two inquiry-based science units for each grade level. The focus was on growing the teachers' ability to understand and implement the gradual release of responsibility from the teacher-explicit instruction to student initiated learning. The students of these seven teachers were then followed from one grade to the next in order to see the continued improvement that they had made. With this education of teaching practices the teachers began implementing two three-month science units in their classroom. At the end of these units the teachers used performance tasks to see their student's abilities in applying the knowledge and skills that they gained throughout the unit. The researchers found great results in the improvement of student's inquiry skills regardless of the students' grade, gender or ethnicity. They believe that inquiry instruction is one way to help narrow the achievement gap with students who come from a disadvantaged background. This study shows the importance of science inquiry for student success for ALL students. It also shows that learning the skills involved, not just the content, helps students in their future years in school, not just in the current unit they are working on in the classroom. These 3rd and 4th grade students were able to continue to use their skills in the following school year, which shows an ability for continual application of these skills after exposure to best practice inquiry based science.

Best practices in science, like the ones that Cuevas, Lee, Hart, and Deaktor (2015) focused on in their study, include a focus on science practices and inquiry . “Science inquiry has long been regarded as one of the critical requirements for school learning outcomes and for a scientific literate citizen.” Yang, Shu-Fen, Zuway, & Huann-shyang (2016, pg 17) I believe, based on the information provided in Cuevas, Lee, Hart, and Deaktor and Yang, Shu-Fen, Zuway, & Huann-shyang research projects that the repetitive utilization and performance of best practice science education of teachers will build the above mentioned skills of resilience and perseverance, creativity, and innovative problem solving in students. “Learners need to be given opportunities to experience authentic inquiry or problem-solving as they mature. This applies to younger students and is supported by recommendations from many sources.” J. A. Morrison (2013. pg 584).

The Eight Science and Engineering Practices (SEPs) included in the Framework for K-12 Science Education defined by the National Research Council (2012) have been carefully thought out and planned to help create a mindset and skillset of scientific literacy. Together the NRC committee who authored A Framework for New K-12 Science Education (2012) worked to create a set of standards that would uphold a vision of science where students are actively engaged in learning experiences that provide opportunities to question the world and give them skills to answer those questions. The committee was charged with identifying the scientific and engineering content ideas and practices as well as Cross Cutting

Concepts that are most important for all students in grades K-12 to learn. A process of gathering research-based evidence alongside deeply investigating previous science standards, while constantly reassessing what they found, was used in order to create drafts of the Framework. As the drafts were continually revised, they took public input and continued researching and information gathering. This two year process resulted in the completed Framework. The Next Generation Science Standards (NGSS) with their performance expectations were then born from the Framework as a way to guide and shape curriculum, instruction and assessment in a way that encompasses the three dimensions of Science and Engineering Practices (SEPs), Crosscutting Concepts (CCCs), and the Disciplinary Core Ideas (DCIs).

These eight scientific practices are considered essential elements of K-12 science and that are embedded in the Next Generation Science Standards are:

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

The Eight Science and Engineering Practices (SEPs) are the first dimension of the Next Generation Science Standards (NGSS Lead States, 2013) and are meant to be taught along a progression throughout a student's journey in their K-12 education. The NRC calls these eight skills sets 'practices' rather than 'skills' in order to place an importance on the idea that engaging in these practices takes skill and knowledge together, compared to merely completing the actions. These practices are also meant to "better specify what is meant by inquiry in science and the range of cognitive, social and physical practices that it requires." NRC (2012 pg 30) The goal is that students will engage in the practices rather than merely learn about them as in many past and current science curriculums around the nation. "Students cannot comprehend scientific practices, nor fully appreciate the nature of scientific knowledge itself, without directly experiencing those practices for themselves." NRC (2012 pg 30)

Not only do these eight Science and Engineering Practices promote scientific literacy, but they are intertwined with the eight mathematical practices and the English language practices written in the Common Core Standards. This emphasis on disciplinary practices indicates just how important they are to create a well balanced person who is ready to be an active and successful part of the future workforce.

Summary

The literature regarding inquiry education and science practices, and the skills of creativity and problem solving with resiliency and perseverance, all emphasize their importance of beginning with elementary education. Teacher use of the NGSS Science and Engineering Practices provide students with time throughout their K-12 educational career to grow important skills and abilities. The combination of the content that is provided in the Framework, the application of the Science and Engineering Practices applied from the Next Generation Science Standards and a carefully designed inquiry unit, create best practice science education for elementary students. Many general education settings may lecture students about the skills that will be needed in their future workforce. But, a well-designed hands-on science curriculum that is based in the practices will actually allow students the opportunity to master these skills and to apply them to real, relevant situations. “The consistency for the creativity and inquiry performance patterns provides additional evidence that care must be taken in planning curriculum and instruction for the purpose of promoting student scientific creativity and science inquiry.” Yang, et al (2016, pg 22).

The above findings in the recent literature have helped to formulate my research question: **How does a Next Generation Science Standard aligned, inquiry based, science unit impact student achievement of science practices and student science efficacy in an elementary classroom?**

Methods

This section outlines the study, the participant group, as well as the instruments I used to measure the outcomes of my question.

Overview

This quasi-experimental study was created to show how elementary students can benefit from an NGSS based inquiry science unit using the eight SEPs to promote problem solving skills including innovative and creative thinking as well as resiliency and perseverance.

Participants

The suburban elementary school used as the project site for this research project has a diverse student body including 12% Asian or Pacific Islander, 2% Black, 31% Hispanic, 47% White, 1% American Indian and 7% Other (BSD, 2015). This project site was selected because it is the school in which I currently teach, and I had support for my research from my principal and teaching partners. In this study, 44 students of the 72 total students from the three second grade classrooms in this school and their parents agreed to their participation. The teachers of the three classrooms agreed to participate in the research study which created three different groups of students ages seven to eight, divided into the three different classrooms, that would receive the treatment. The three second grade teachers were of varying years of experience ranging from three to

20+ years. They also had experience teaching in different states, districts, communities and positions throughout their careers.

Curriculum/ Treatment

In conducting this study, I have aimed to find the benefits of a Next Generation Science Standard aligned, inquiry based science unit on elementary students' problem solving skills including innovative thinking and creativity, resilience and perseverance. In order to gather data on these constructs, first the curriculum needed to be chosen.

The curriculum chosen for this study is a district developed, Next Generation Science Standard aligned, inquiry based unit on Earth Science: *What is happening to our playground?* (Appendix D). This unit is named 'home-grown' because it was developed by myself alongside another state science instructional specialist and the science TOSA (teacher on special assignment) for district-wide use. Myself and the other science instructional specialist have had over 300 hours of training and development with the NGSS and how to integrate all three dimensions into the classroom. This unit was created to better align the current district science curriculum to the Next Generation Science Standards. Three units per school year were developed for Kindergarten, first, and second grades to create an aligned progression of the science practices and content through the primary years. The work was funded through the school district curriculum budget and approximately 80 hours of development was spent on each unit, including the second grade Earth Science unit. Along with the development of the units, the district funded optional science support sessions for the 110 K-2 teachers from its 33 different schools to learn about the instructional shifts with the NGSS and be given an overview of the units created. The two support sessions for the second grade Earth Science unit had a total of 50 second grade teachers in attendance. In order to support the K-2 teachers even more with the shift to more hands-on science and investigations through the NGSS materials kits were also provided for each unit. The unit storyline for the second grade Earth Science unit: *What is happening to our playground?* is included in the appendix D of this document, and shows that the focus was on Earth Science according to the following Next Generation Science Standards (NGSS Lead States, 2013):

2-ESS1-1 Use information from several sources to provide evidence that Earth events can occur quickly or slowly.

2-ESS2-1 Compare multiple solutions designed to slow or prevent wind and water from changing the shape of the land.

2-ESS2-2 Develop a model to represent shapes and kinds of land and bodies of water in an area.

This unit was created to target the above standards and utilize a selection of the following the eight Science and Engineering Practices (SEPs) throughout the learning process:

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

In one unit, it is best to hope to use all of the SEPs, but the curriculum development team believed it unwise to assume that you will be able to teach mastery or elevated ability of them all. For this reason, this unit put an emphasis on direct development of student abilities in the following Practices: Asking questions and defining problems, developing and using models, planning and carrying out investigations, and constructing explanations and designing solutions. These were chosen because they tie the best to the skill goals of the research study of resilience, perseverance, and problem solving through innovative and creative thinking.

The unit created has 13 lessons that cover inquiring into a place based phenomena. The lesson sequence included hands on investigations to discover answers to student inquiry based on the phenomena and engineering and design projects to scaffold learning. The unit included technology suggestions to enhance learning and the performance expectation at the end to apply all content knowledge and SEPs together. See the chart below for more information on each lesson as the unit unfolds.

What is happening to our playground? Unit Storyline			
	Lesson Question	Lesson Practice(s)	Lesson Learning and Next Question
1	What happened to our playground? I notice... I wonder… What else does this remind me of?	Asking questions and developing models	Too much water in one area is flooding. What creates flooding? How do we know? How can we find out?
2	What creates flooding?	Plan and conduct an investigation. Obtain and evaluate information.	Soil can only absorb so much water. We can use observations and readings to create more wonderings. Does flooding happen in all areas?
3	Does this flooding happen in all areas of our playground? I wonder…. I notice… Claim-Evidence….	Construct explanations.	Water can flood areas differently. Some factors that cause or prevent flooding may be the type of land, the shape of the land and the amount of water. Does the type of land affect the amount of flooding on our playground?
4	Does the type of land affect the amount of flooding on our playground? I wonder…. I notice… Claim-Evidence….	Plan and conduct an investigation.	There are many types of ground surfaces on our playground (topsoil, soil with grass, bark chips, blacktop) They all have different properties which absorb water to different degrees. Does the amount and movement

			of water impact the amount of flooding?
5	Does the amount and movement of water impact the amount and rate of flooding? How does water move?	Developing and Using Models Planning and Carrying out Investigations Constructing Explanations	The shape and kinds of land has a relationship to the bodies of water formed. Water pools and flows creating lakes, rivers etc. Does where the bodies of water and landforms are impact flooding risk?
6	Does where the bodies of water and landforms are impact flooding risk? Focus on Claim-Evidence	Obtaining, evaluating and communication .Develop and use models and constructing explanations.	The size and shape of the body of water and the slope of the land impacts flood risk. Water pools and flows creating lakes, rivers etc. The bodies of water and landforms in an area can be modeled. Does the amount of water affect the wearing away (erosion) of the land?
7	Does the amount of water affect the wearing away (erosion) of the land??	Plan and carry out investigations. Analyze and interpret data	Water moves land and causes erosion. We can predict patterns of erosion. What other events can cause changes to the land?
8	What other events can cause changes to the land?	Constructing Explanations	Wind and ice can make changes to the land. Does where bodies of water and landforms are impact other changes to the land?
9	What changes happen slowly on the earth? What changes happen quickly on the earth? Can we engineer a solution to reduce the impact of these changes? Engineering Design: Reducing the Impact of Weathering	Engage in argument from evidence	Slowly - wind and water erosion (on rocks). Quickly: earthquakes, human impact students can define difference between slowly/quickly Is all soil the same? slowly on Earth? What changes happen quickly on Earth?

10	Does location of bodies of water and landforms impact other changes to the land?	Obtain, evaluate and communicate information Construct explanations	The location of bodies of water and landforms can increase the amount of erosion, weathering or landslides. Are all of earth's changes helpful or harmful?
11	Are events that change the Earth mild or severe?	Constructing Explanations	Some of Earth's changes are mild and some are severe. How can we prevent unwanted changes to the Earth caused by wind and water?
12	How can we prevent unwanted changes to the earth caused by wind or water? Flood Plain Modeling	Develop and use models Plan an investigation	
13	How can we design a solution to the playground flooding problem?	Design solutions	Students compare and contrast solutions.

Figure 1
[Find the full unit: *What is happening on our playground?* in Appendix D]

All three of the teachers received the same unit storyline and printed lessons to implement. They had weekly meetings to discuss the upcoming lessons, prepare and plan together and ask or answer questions for clarification. Each teacher then led one of the three student groups through the curriculum. There was no control group for this study; all students received the same treatment. Though the lesson plans were identical, the actual implementation of them varied with each individual teacher's implementation of the curriculum. The three teachers instructing each had varying levels of experience and background which created an expected difference in teacher craft, style and presentation.

Instruments

Three different instruments were used to assess student growth in the areas of content knowledge based on the Second Grade NGSS Earth Science Standards and student understanding, perspectives and abilities with scientific skills based on the eight Science and Engineering Practices.

Content Knowledge Assessment

To measure growth in content knowledge a pre and post assessment process chart was developed as an open ended assessment by the creators of the 2nd Grade Earth Science Unit: *What is happening to our playground?*. A copy of this chart is included in appendix E. The process charts were scored based on a rubric created by the three participating teachers of the second grade teaching team, this rubric is included in appendix F.

Figure 2

This content assessment used the practice of modeling to describe what was happening in the picture above (figure 2). Students were to model by drawing what they think happened to the playground in order to make it flooded as seen in the picture. This was students' first attempt at modeling, and being a pre assessment of knowledge there was no instruction before this first attempt. This content assessment was also given at the conclusion of the unit and graded with the teacher created rubric (Appendix F). In order for students to achieve proficiency on the content assessment, according to the rubric students needed to: (1) *Explain by showing evidence that the Earth can change quickly or slowly. (2) Describe one solution to preventing wind or water from changing the land and describe why it is better than another solution. (3) Tell many ways how the land*

and its shape affect the water in the area. (4) Create a model that is easy to follow, organized, and neat and includes many labels and clarifying text.

The content pre and post assessment process chart, found in Appendix E, created another opportunity to gather data on student ability with the Science and Engineering Practice of modeling. The student ability to model what was happening in the playground flooded picture (figure 2) was scored on the content rubric using a scale of 1-4; 1-Developing; 2-Nearing Proficiency; 3-Proficient; 4-Highly Proficient. In order to achieve a Proficient score on the rubric students needed to: Explain by showing evidence that the Earth can change quickly or slowly. Describe one solution to preventing wind or water from changing the land and describe why it is better than another solution. Tell many ways how the land and its shape affect the water in the area. Create a model that is easy to follow, organized, and neat and includes many labels and clarifying text.

For students at the second grade level a proficient score looked like an accurate picture of this playground area which showed the curves and shapes of the land that would or could hold water in the 'before' section of the process chart. The 'during' section of the process chart would show a picture with labels in which the playground is being rained on, in order for the water to pool as shown in figure 2. The last section of the process chart, 'after', in order to be scored proficient needs to be a picture of the rain gone and water staying in the lower parts of the ground creating flooding.

Performance Expectations

At the end of the unit, in alignment with the Next Generation Science Standard: "*2-ESS2-1 Compare multiple solutions designed to slow or prevent wind and water from changing the shape of the land.*", students were required to complete a performance task that integrated their content knowledge as well as engineering and design skills. After learning about quick and slow changes that are made on earth throughout the unit, this performance task involved students thinking through a design that would help protect their model home from a flood. Students began by creating an individual design and drawing a model of their flood protection system for their own home. Next, they combined their homes with three to four other students to create a small neighborhood. They then communicated their ideas and shared their individual designs, and together, with pieces from each design, created a new group model, drew up the plans, built it and then tested it. This performance task was used a summative post-assessment for the application of content knowledge and the selected SEPs: Asking questions and defining problems, developing and using models, planning and carrying out investigations, and constructing explanations and designing solutions. The evidence statements provided in the NGSS (2013) were used to score the students' abilities within the performance tasks. If students covered all of the observable features on the evidence statement they received a plus, students who partially completed the observable features earned a check, and students who exhibited little to none of the features earned a minus sign. The evidence statement provided by the NGSS can be found in Appendx J.

Pre and Post Student Survey

In addition to the content curriculum pre and post content assessment tool, a second tool was needed to measure students feelings toward science as well as their reflection of their own ability in the eight NGSS Science and Engineering Practices and in the constructs emphasized in this research project; creativity, perseverance, and innovative and creative problem solving skills. As written by the NGSS Lead States in the Next Generation Science Standards, scientific literacy is not only about the engagement of the scientific practices, but also about students reflecting "on how these practices have contributed to their own development and to the accumulation of scientific knowledge" (2013, pg 400). For this a pre and post unit survey that rated students own perceptions of their feelings toward science and their scientific abilities was used (Appendix H). The 16 statements in the survey were created based on the eight Science and Engineering Practices and the three measured constructs of the study. The other second grade teachers and I conducted the pre and post survey. This survey was created in a kid friendly form using smiley faces to depict a Likert scale. This student friendly survey, as well as the delivery instructions, are included in appendices G and H of this report.

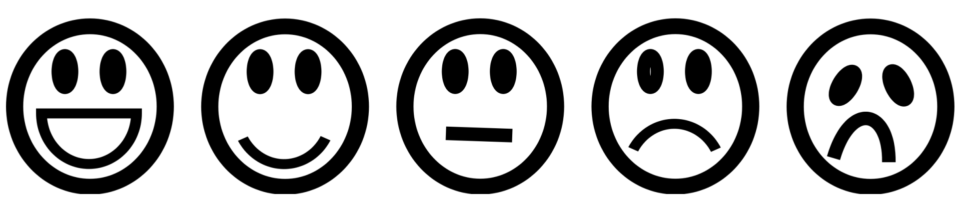


Figure 3

As most students at second grade age have not taken a survey like this before, the statements were written to be read aloud by the teacher to the students.

Student Interviews

The third tool of data collection in this research project were semi-structured student interviews conducted by each classroom teacher to at least five participating students were chosen at random in their classrooms. These interviews were conducted after the science unit had concluded and after the post-surveys were completed. The questions created for the student surveys were based on the pre and post survey statements, but were open ended to gather more information than the survey could show. The students were interviewed one at a time with the teacher as not to have pressure from their classmates to answer a certain way, as well as to avoid students piggy-backing on other students thoughts or ideas. These interviews provided the students time to answer more specifically to their experience with the science unit and gave vital qualitative data to the research project. The interview questions used are included in Appendix I.

Procedure

This research project timeline began in the late summer and continued into fall with the beginning of a new school year. The timeline was as follows:

Project Timeline	
August	
Teacher Pre-Service Week	Teacher Assent forms signed (Appendix C)
September	
Back to School Night	Presentation to parents given, student assent and parent consent forms given out. (Appendices A & B)
5th, 12th, 19th, 26th	Weekly teacher meeting held
	Pre-Survey conducted (Appendix H)
October-November	
	Earth Science Unit Implemented (Appendix D)
	Post-Survey conducted (Appendix I)
	Student Interviews conducted (Appendix F)
December-March	
	Data Analyzed

Figure 4

The second grade teaching team was approached during pre-service week for involvement with the research project. The unit was explained in its entirety by sharing the 2nd Grade Earth Science Unit: *What is happening to our playground?* The two teachers signed their assent forms at that time.

At the school site's Back to School Night, parents were given a brief description of the research project, describing its alignment with the content required to be taught and the involvement of the participants. At that time parents were given the consent forms to sign. For the parents who did not attend Back to School Night the consent forms were sent home to be signed and returned. Student assent forms were given to the students during the school day with another brief description of the research project and what it would mean to be involved. Students were also made aware that parents also had to give consent for them to be a participant. The students assent forms were collected during class.

Before the unit began the teachers conducted the pre-survey of students' feelings toward science and their ability with science skills. The survey was read aloud, question by question to the students as a whole class and students were explained what each rating meant in the scenario of the statement. Teacher instructions for the survey are found in Appendix G. Students were then to shade or color in the smiley face that they believe best matched their feelings toward that statement.

The day following the pre-survey we began conducting the inquiry based NGSS aligned Earth Science unit with a pre-assessment of content knowledge using the blank process chart titled, 'What are you thinking? What happened?' to have students try to explain what happened in the picture phenomena. That same day we proceeded with the unit beginning with Lesson 1 from the unit storyline. The unit took about six weeks to complete, depending on the classroom. The length of time for the unit varied since inquiry gives freedom to the students, it also changes the possible pathways that students can go, what questions they want to investigate, how deeply they look for answers, and how long the unit can take. This Earth Science unit was the first science unit of the year for these second grade students. The unit followed the basic inquiry cycle described by Kath Murdoch in *The Power of Inquiry* (2015) of immersion or tuning in, research or finding out, sorting information and researching further, making conclusions, sharing their thinking and finally applying their thinking. Throughout the unit formative assessment was gathered through student discussion and student work samples. Information from these formative assessments was communicated at the weekly meetings held by the second grade teaching team. After drawing conclusions at the end of the unit students then took a post-assessment on content knowledge. From there students participated in a performance task that utilized their content knowledge as well as the Science and Engineering Practices.

Following the performance task students took the post-survey that measured their feelings towards science and their view of their own science skills. In the days following student interviews were conducted at random by the students' own classroom teacher to get a deeper understanding of how the students felt about the unit and how they felt about their own scientific skills.

The data collected from this research project was coded to a master list with each child's name and classroom teacher name redacted from the instrument. The pre and post surveys, assessments and interview data were then given a class letter and student number. This gave anonymity to each student and the teacher involved and helped to reduce bias when it came time for me to analyze the data.

Results

The data collected in this research project shows how highly effective a science unit, with a focus on inquiry, the Next Generation Science Standards, and a selection of the Science and Engineering Practices can increase elementary students attitudes toward their abilities in science and the application of skills in science. The following section outlines the data collected.

The data included in this section was gathered from three instruments that were designed to measure growth associated with the second grade Earth Science Unit: *What is happening to our playground?.* These tools were a pre and post survey of student self-beliefs, a content knowledge post assessment and post unit individual student interviews. The Likert scale rated data from the pre and post survey and the content post assessment were used for quantitative analysis while the students interviews and observable student actions were used as qualitative analysis. The pre and post survey and the content assessment were administered before the unit began and at the conclusion of the unit. 44 total students make up the sample of pre and post surveys. 17 student content assessments were collected for additional data. Student interviews were conducted after the Earth Science unit concluded. 24 total students were interviewed from the three second grade classes. The interview data was analyzed and divided looking at positive responses from students.

Data Collected by Student n						
September	September	October	October	October	November	Full Length
Pre Survey	**Pre Content**	**Post Content**	**Post Survey**	**Performance Task**	**Student Interviews**	**Student Actions**
n = 44	n = 17	n = 17	n = 44	n = 17	n = 24	n = 17

Figure 5

The results are organized to answer the research question by each of the construct groupings examined; resiliency and perseverance, creativity and innovative problem solving, and Science and Engineering Practices and inquiry curriculum. Because of the number of statements examined in the construct of Science and Engineering Practices and inquiry curriculum, this construct has been broken down into three sub categories for deeper analysis. These three sub categories are: Science Project Practices, Science Communication Practices, and Inquiry Specific Statements.

Pre and post survey data and student interview data are represented in graph form in each construct section. A chart containing data from the content knowledge post assessment shows scores that were graded by the teacher with a teacher created rubric. The student interview table shows interview questions that aligned with the constructs of this study, example student responses given to those questions and the total number of positive responses given to those questions from the total students interviewed. A table is also provided containing observable student actions and which construct and SEP they are correlated with. Cumulative pre and post survey data for each construct, as well as data divided by class are also presented in tables at the end of the results section.

Resiliency and perseverance

Overall, student assessment of their own abilities of resilience and perseverance improved. The average growth of each student within the sample was +.16. These results were determined by analyzing student scores on statements 12 and 14 on the pre and post survey: 'If something is hard, I try harder' and 'I give up when something is too hard' respectively. In order to find the average growth for the student sample the sum of the total responses on the Likert type scale used for the survey statements were added up. In this project, there were 44 students who could have answered up to a score of 5 for each statement. If all students selected the most positive reflection which was represented by a large smiley face and rated as a 5 on the scale, then total score for the sample would be 220. When analyzing two statements together for this construct of resiliency and perseverance the total possible sum would be 440. On the pre survey the total reached for this sample was 379. Taking this total and dividing it by the two statements would produce an average of a total sum of 189.5 for each construct. This then divided by the size of the sample (44) gives an average score for the student sample of 4.31 on a scale of 1-5. The same process was used to calculate the post survey data. The total sum for two statements for the post survey was 393 which gives an average for the two statements of 196.5. This again divided by the number of students in the sample gives an average of 4.47

for each student on a scale of 1-5. These calculations provide the average growth for the student sample to be +.16.

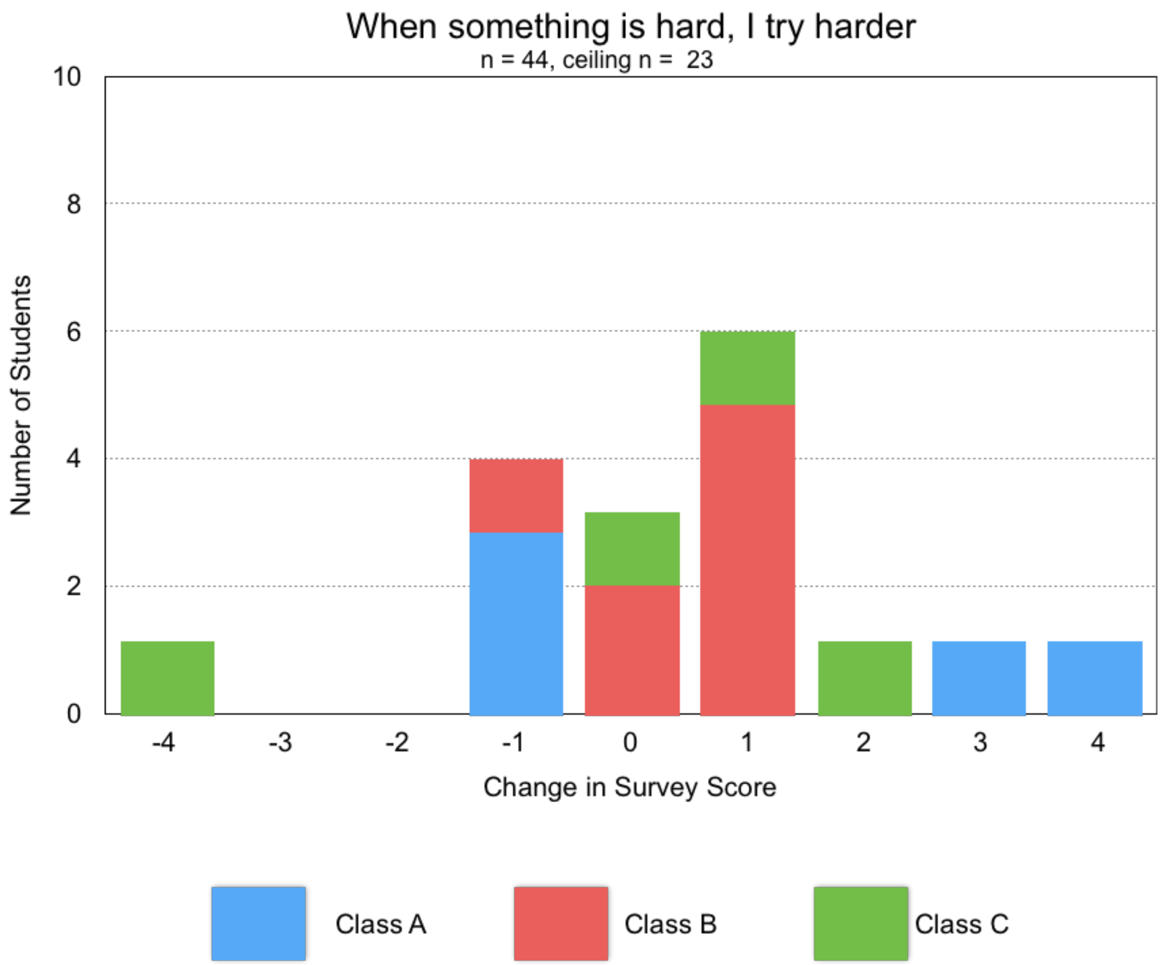


Figure 6

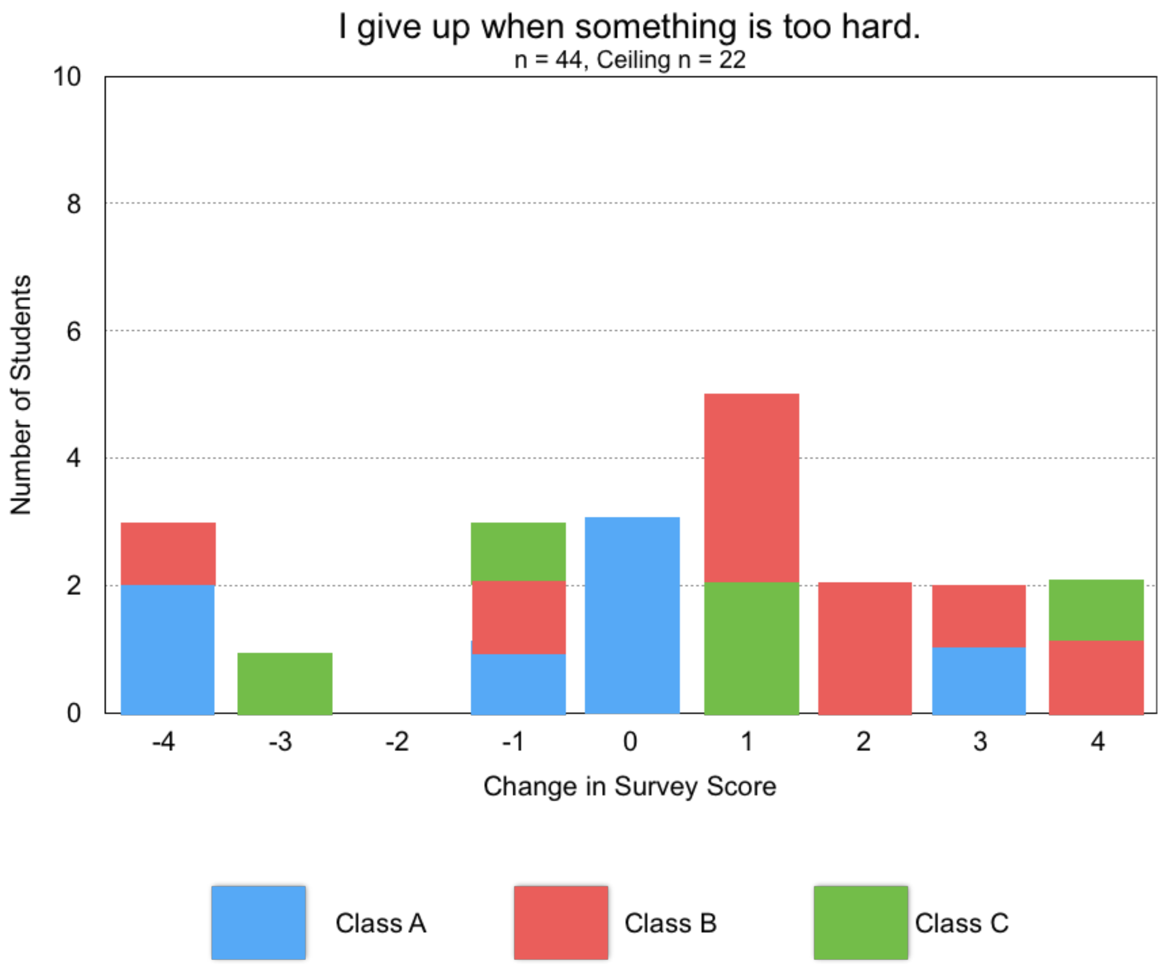


Figure 7

The ceiling effect is not illustrated with bars in the graphs above. It is noted under the title on the above, and all following graphs. The ceiling effect is identified as students who rated themselves the highest possible score (5) on the pre-survey and post-survey and therefore had already reached the height of reflection the survey would allow, resulting in an inability to indicate more growth on the post survey. Students on the graph indicating a growth of zero had an unmoving pre and post survey score between 1 and 4.

The percentage of students who rated themselves above neutral on the pre-survey, with a score of a 4 or a 5 was 82.9%. This percentage grew to 84.1% on the post survey.

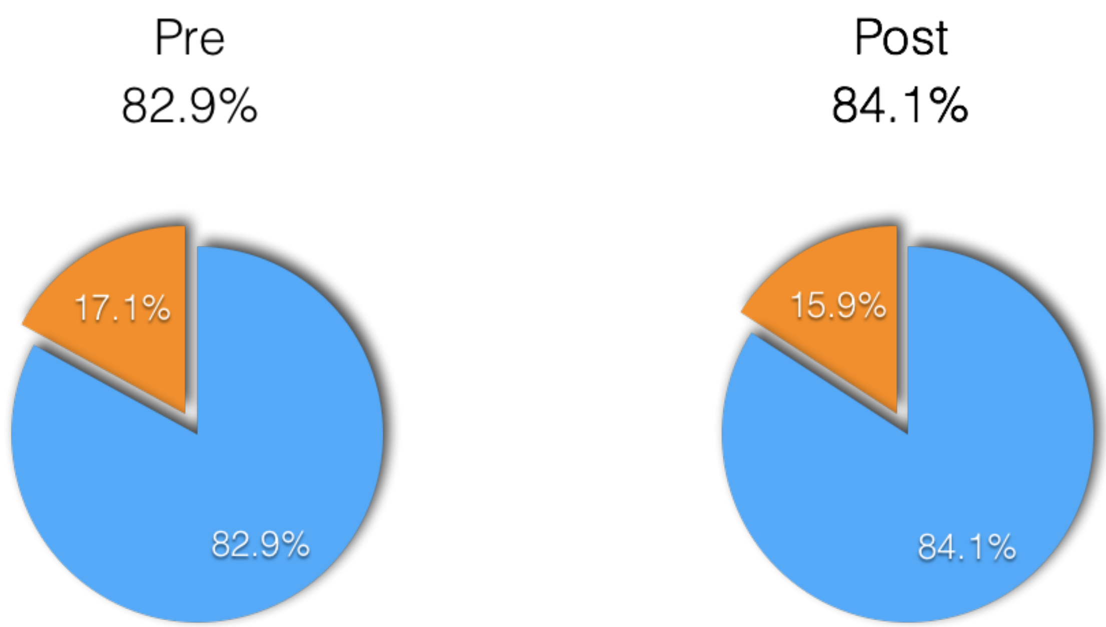


Figure 8

The student interview data taken at the conclusion of the Earth Science unit showed that 20 of the 24 students interviewed had positive responses on their ability to persevere through a task when asked, ‘What do you do when something is really hard?’ Some of the positive responses gathered from students were: I keep trying; don’t give up.

Creativity and innovative problem solving

Student ability with the construct of creativity and innovative problem solving was displayed in the execution of the performance task at the conclusion of the Earth Science Unit. Students were scored on a three-point scale of a plus, check or minus according to the NGSS evidence statements (Appendix J).

Performance Task n=17			
Evidence Statement Observable Feature	**minus**	**check**	**plus**
Using scientific knowledge to generate design solutions	1	2	14
Describing specific features of the design solution, including quantification where appropriate	0	1	16
Evaluating potential solutions	0	0	17

Figure 9

The above chart shows student ability according to the evidence statements. Again, student ability with creativity was not found in a score, but in an action. For this reason, the table below shows student actions during the performance task that relate to creativity and innovative problem solving.

Performance Task Observable Student Actions n=17	
Creativity and Innovative Problem Solving Observable Student Actions	**number of students**
Placement of home in an area with the prediction of least amount of destruction	17
Building walls with wood or rocks	11
Creating sand bag like objects from plastic bags filled with air or dirt	14
Building stilts for the house	1
Creating a floating platform for the home similar to a boat	1
Redirecting river flow by moving dirt	3

Figure 10

The student interview data taken at the conclusion of the Earth Science unit showed that 24 of the 24 students interviewed had positive responses when asked, ‘What types of things in the world are you curious about?’ Examples of student responses were: how lightning happens; oceans and deserts; and animals. This question was a lead in to the next which is targeted to the construct of creativity and innovative problem solving. When asked, ‘Do you know how to find answers/information to this things you are curious about?’ 19 of the 24 students provided positive responses. Some of the positive responses were: read nonfiction; watch a video; ask a scientist; test it out; and go outside and look.

Science and Engineering Practices & Inquiry Curriculum

The analysis of the construct of Science and Engineering Practices and Inquiry Curriculum had the most statements and therefore data points to gather from. There were seven survey statements that were used to measure student belief of their abilities in these categories. The following statements were used from the pre and post survey: #2 'I wonder many things about the world,' #3 'I can draw a picture or build a model that shows an object,' #4 'I can plan a science project,' #5 'I can do a science project,' #6 'I can write or draw what I learn from a science project,' #9 'I can tell what happened in my science project,' and #10 'I can agree or disagree with my friends about science.' These statements focus on the science practices of: Asking questions and defining problems, developing and using models, planning and carrying out investigations, and constructing explanations and designing solutions. The overall sample growth for this construct grouping was an average of +.3 per student. When analyzing seven statements together for this construct of resiliency and perseverance the total possible sum would be 1,540. On the pre survey the total reached for this sample was 1,245. Taking this total and dividing it by the seven statements would produce an average of a total sum of 177.86 for each construct. This then divided by the size of the sample (44) gives an average score for the student sample of 4.04 on a scale of 1-5. The same process was used to calculate the post survey data. The total sum for seven statements for the post survey was 1,338 which gives an average for the seven statements of 191.14. This again divided by the number of students in the sample gives an average of 4.34 for each student on a scale of 1-5. These calculations provide the average growth for the student sample to be +.3.

The percentage of students who rated themselves above neutral on the presurvey, with a score of a 4 or a 5 was 73.7%. This percentage grew to 80.8% on the post survey.

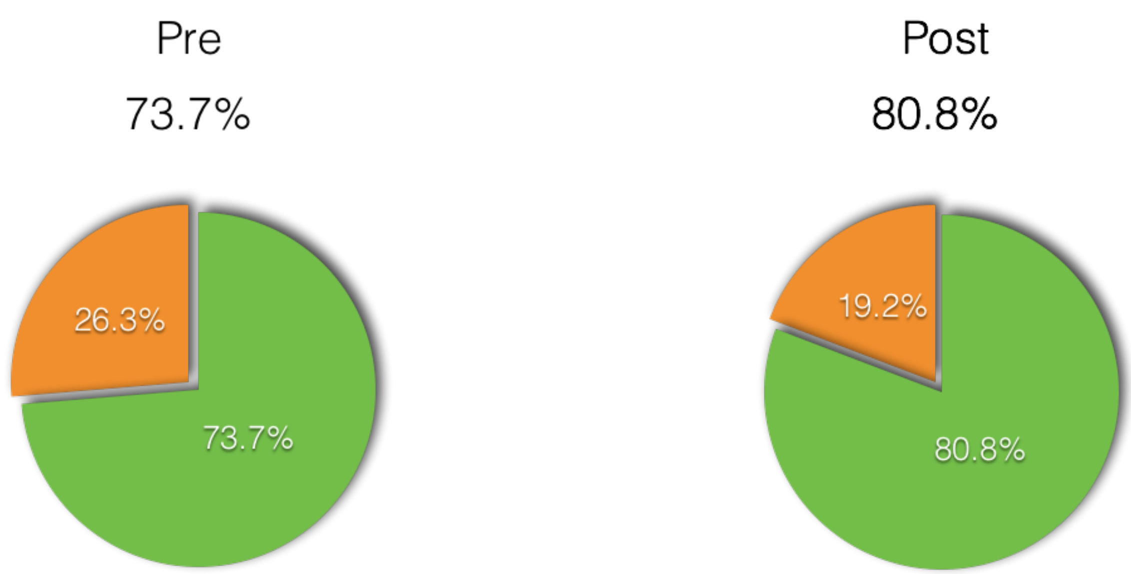


Figure 11

For deeper analysis the survey statements used in this construct have been grouped to create smaller sub-categories within the overall examined construct of Science & Engineering Practices and Inquiry Curriculum. These categories are as follows:

- **Science Project Practices**: #3 'I can draw a picture or build a model that shows an object,' #4 'I can plan a science project,' and #5 'I can do a science project.'

- **Science Communication Practices**: #6 ‘I can write or draw what I learn from a science project,’ #9 ‘I can tell what happened in my science project,’ and #10 ‘I can agree or disagree with my friends about science.’
- **Inquiry Specific Statements**: #2 ‘I wonder many things about the world.’ This statement was chosen to analyze because inquiry is the act investigating - and you must first wonder in order to investigate.

Science Project Practices

Of the sample, the average score for student perception of their ability with science project specific practices showed growth with a score of +.4. This was measured with the students’ scores on the survey statements 3, 4, and 5: ‘I can draw a picture or build a model that shows an object,’ ‘I can plan a science project,’ and ‘I can do a science project,’ respectively. These statements were derived from the science practices emphasized in the curriculum: Developing and using models and planning and carrying out investigations. When analyzing three statements together for this construct subcategory of science project specific practices the total possible sum would be 660. On the pre survey the total reached for this sample was 525. Taking this total and dividing it by the three statements would produce an average of a total sum of 175 for each construct. This then divided by the size of the sample (44) gives an average score for the student sample of 3.98 on a scale of 1-5. The same process was used to calculate the post survey data. The total sum for three statements for the post survey was 578 which gives an average for the three statements of 192.67.

This again divided by the number of students in the sample gives an average of 4.38 for each student on a scale of 1-5. These calculations provide the average growth for the student sample to be +.4.

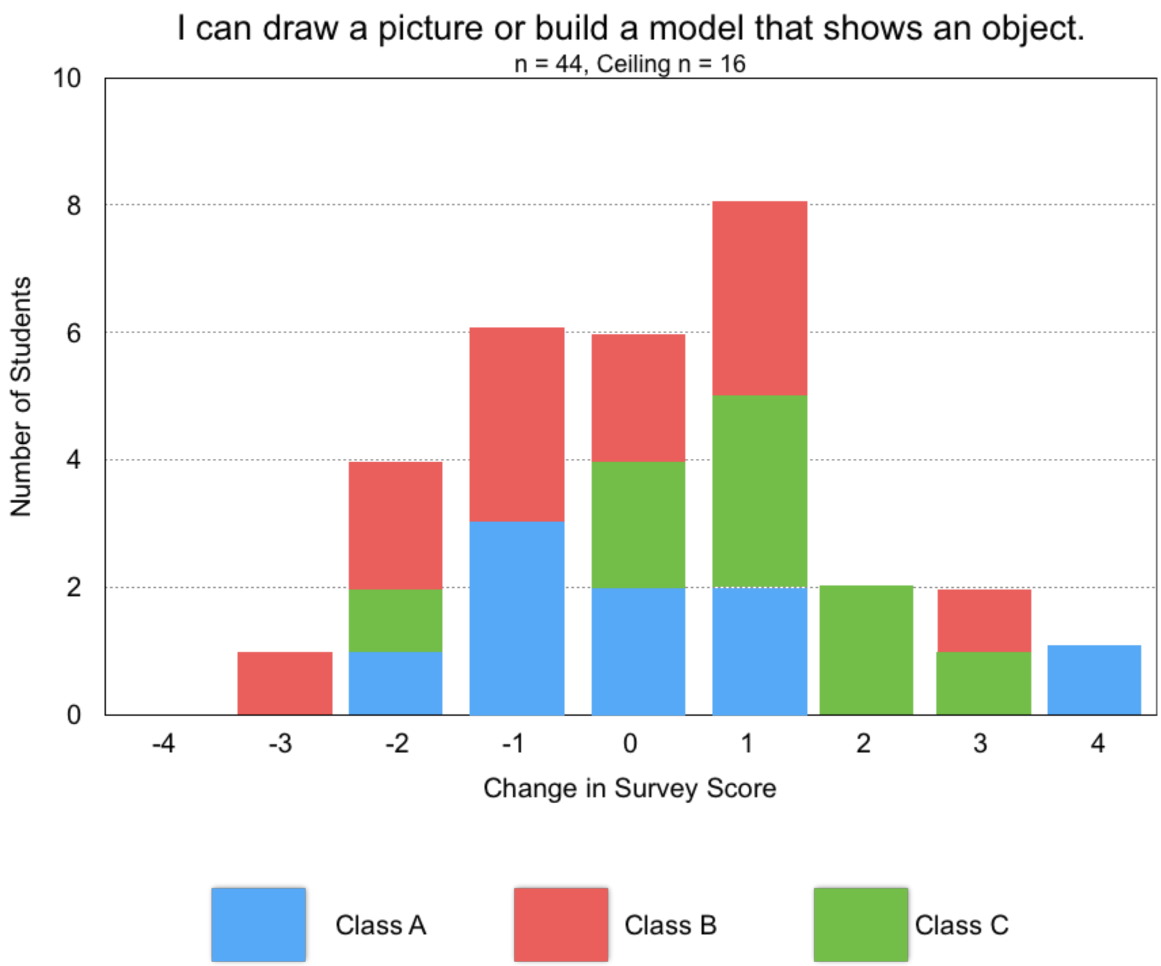


Figure 12

I can plan a science project.
n = 44, Ceiling n = 12
Number of Students
10
8
6
4
2
0
-4
-3
-2
-1
0
1
2
3
4
Change in Survey Score
Class A
Class B
Class C

Figure 13

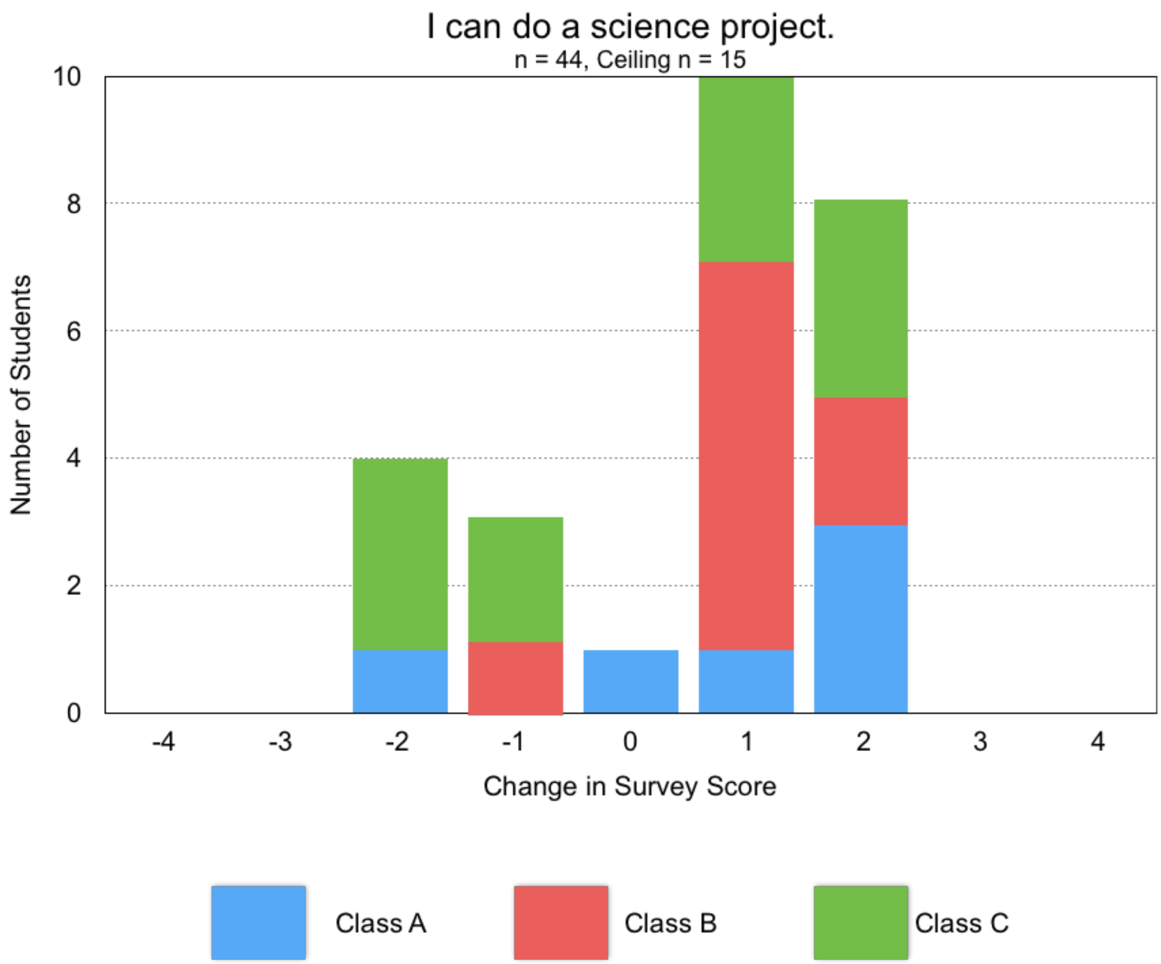


Figure 14

The percentage of students who rated themselves above neutral on the presurvey, with a score of a 4 or a 5 was 73.5%. This percentage grew to 80.3% on the post survey.

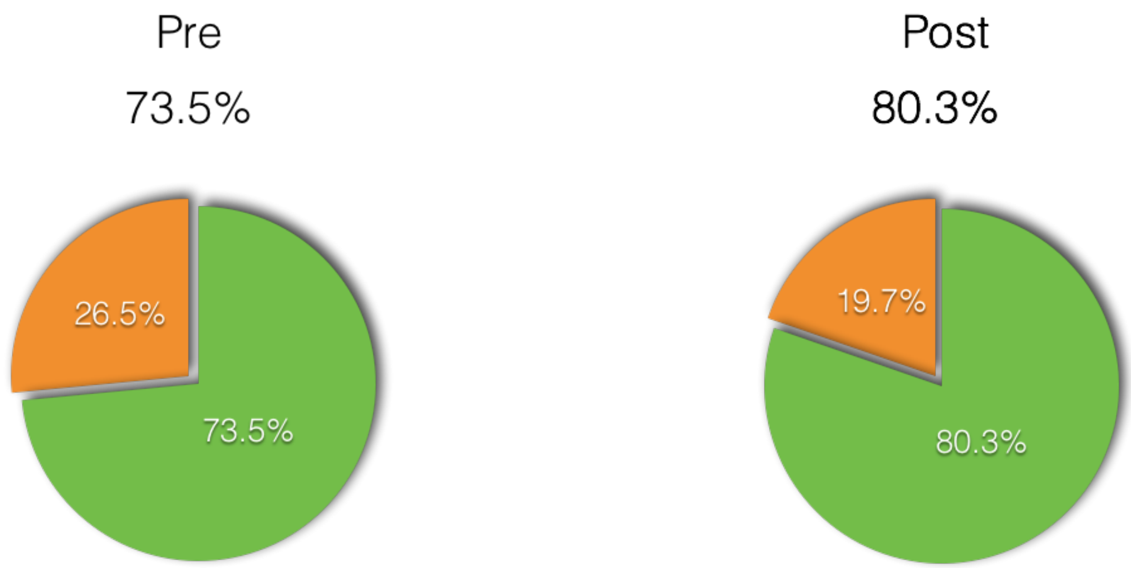


Figure 15

The student interview data taken at the conclusion of the Earth Science unit showed that 23 of the 24 students interviewed had positive responses on their interest and ability with the science practices when asked, 'What do you think about science?' Students responded with statements like; It's fun and You can learn different things. Asking students their general feelings on science helped to get an understanding of how they felt about being involved with the hands on practices that this sub-construct addresses. When asked, 'Would you do a science project act home?' 17 of the 24 students provided positive responses such as; If I got to choose, If my parents let me and YES!

The data presented here is from class B which had a sample size of n= 17. The data shows that of the 17 student post-assessment process charts examined there were 1 Nearing Proficiency and 16 evaluated in the Proficient and Highly

Proficient ratings with 11 rated proficient and 5 rated highly proficient. A pre-assessment was given, but the data was unable to be collected as this additional method of data collection was realized as beneficial at the conclusion of the unit. This assessment not only shows students' understanding of content but they were also scored on their ability to model that understanding. The data below shows students score on the rubric for how students used the skill of modeling to show their content knowledge.

Post-Unit Content Assessment n=17			
Developing	**Nearing Proficiency**	**Proficient**	**Highly Proficient**
0	1	11	5

Figure 16

In order to be proficient on the rubric used to score the practice of modeling students needed to be able to draw the process of the event of the flooding of the playground with text and labels giving a description. Some examples would be an accurate representation of the playground before any rain, a during picture of rain falling with labels of water and slopes or shapes of the land, and an after picture showing standing water with labels again of the water and the shape of the land. A highly proficient score would have more labels and descriptive statements a nearing proficiency may have a picture with very limited labeling.

Science Communication Practices

From the whole student sample, the average score for students' perception of their ability with science communication specific practices showed growth with a score of +.3. This was measured with the students' scores on the survey statements 6, 9, and 10: 'I can write or draw what I learn from a science project,' 'I can tell what happened in my science project,' and 'I can agree or disagree with my friends about science' respectively. These statements were derived from the science and engineering practice emphasized in the curriculum of: Constructing explanations and designing solutions. When analyzing three statements together for this construct subcategory of science communication specific practices the total possible sum would be 660. On the pre survey the total reached for this sample was 533. Taking this total and dividing it by the three statements would produce an average of a total sum of 177.67 for each construct. This then divided by the size of the sample (44) gives an average score for the student sample of 4.04 on a scale of 1-5. The same process was used to calculate the post survey data. The total sum for three statements for the post survey was 573 which gives an average for the three statements of 191. This again divided by the number of students in the sample gives an average of 4.34 for each student on a scale of 1-5. These calculations provide the average growth for the student sample to be +.3.

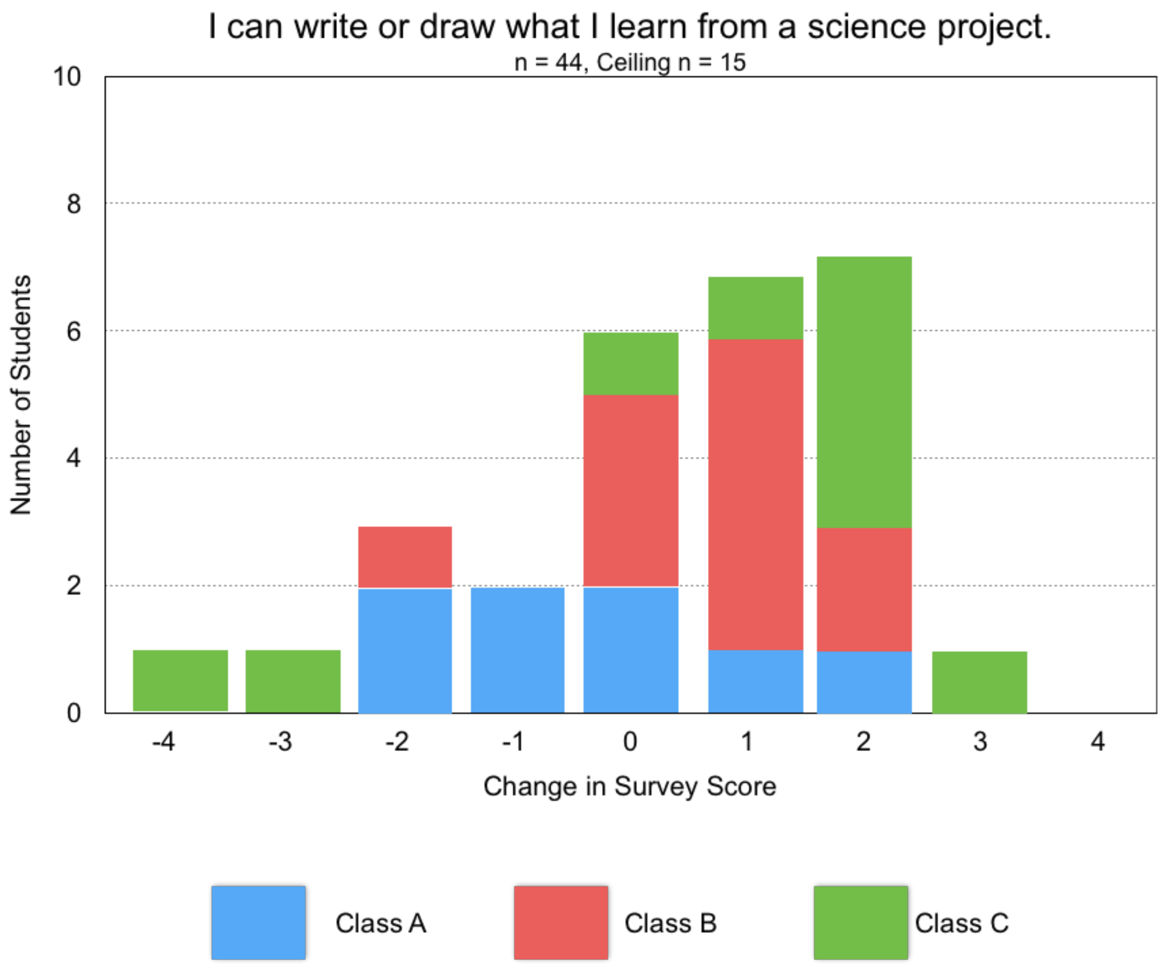
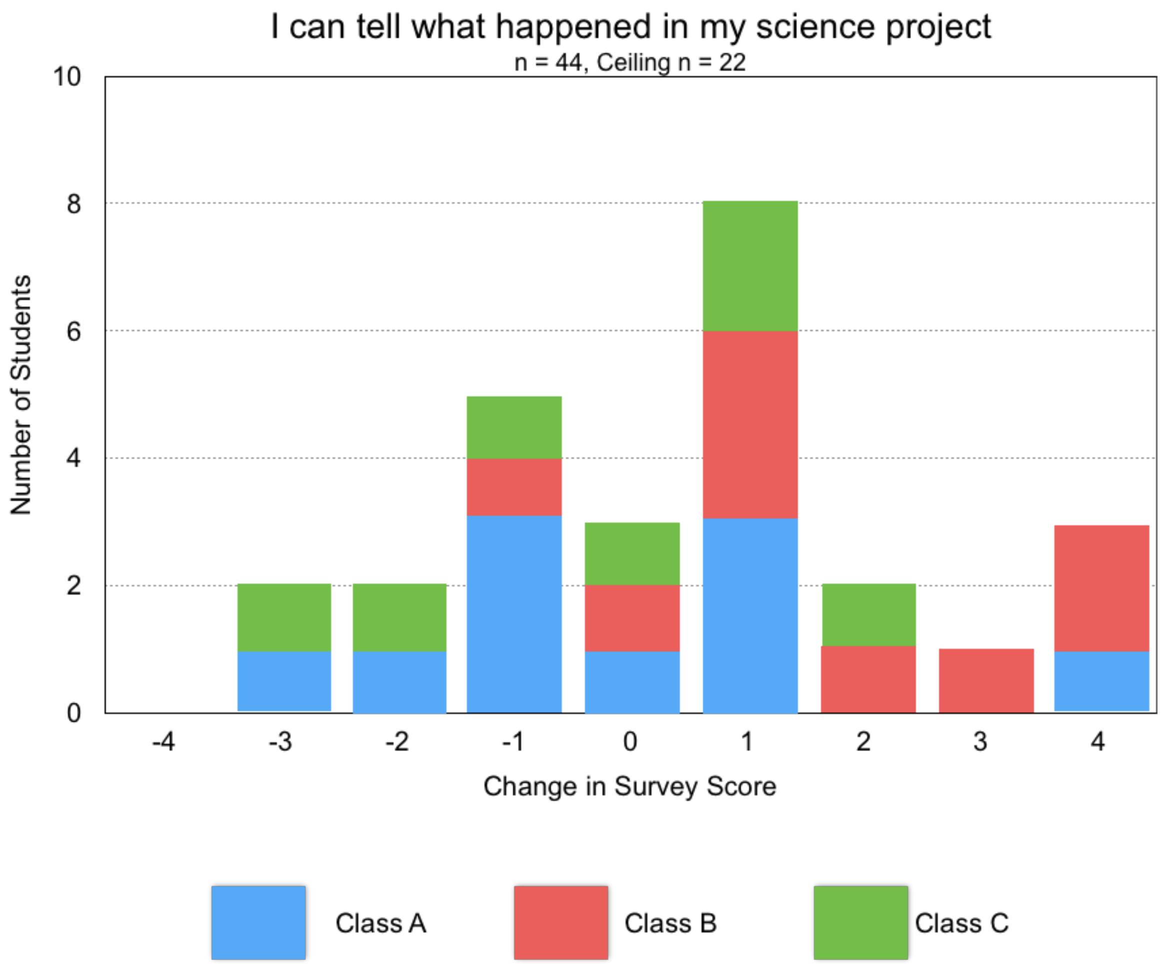

I can write or draw what I learn from a science project.
n = 44, Ceiling n = 15
Number of Students
10
8
6
4
2
0
-4
-3
-2
-1
0
1
2
3
4
Change in Survey Score
Class A
Class B
Class C

Figure 17



I can tell what happened in my science project
n = 44, Ceiling n = 22
Number of Students
10
8
6
4
2
0
-4
-3
-2
-1
0
1
2
3
4
Change in Survey Score
Class A
Class B
Class C

Figure 18

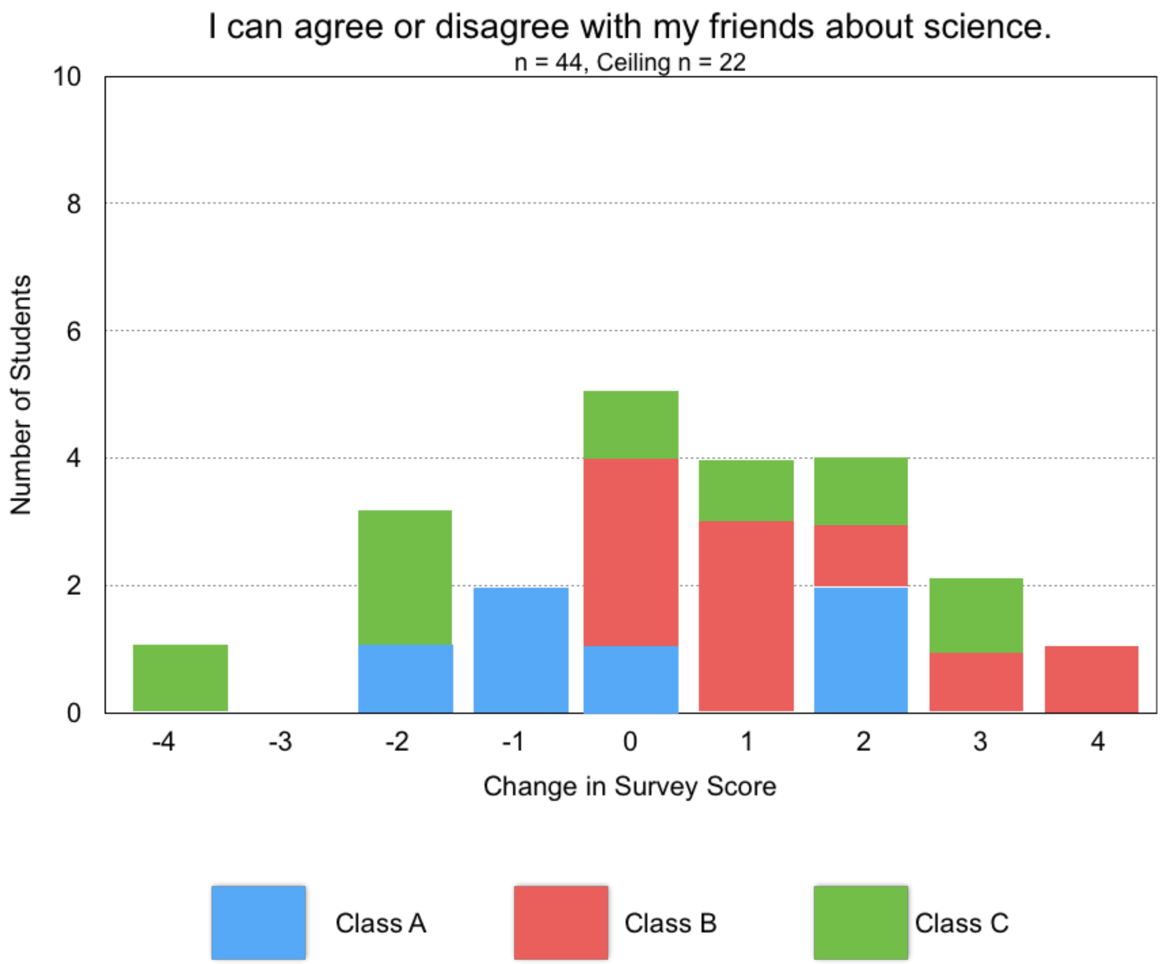


Figure 19

The percentage of students who rated themselves above neutral on the presurvey, with a score of a 4 or a 5 was 71.2%. This percentage grew to 80.8% on the post survey.

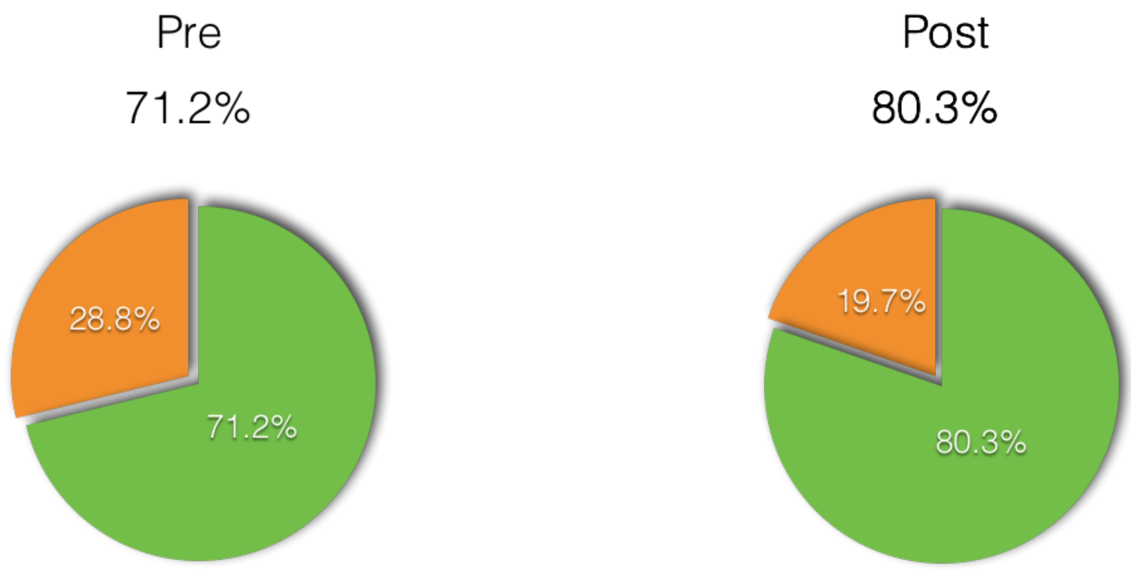


Figure 20

17 students offered positive responses to the question, ‘Do you talk to your friends about science? What about your family?’ Examples of these positive responses were sometimes and yes, about what we did in school. 21 students responded positively when asked, ‘How do you feel about telling your classmate what you learned while doing science?’ These positive responses were some of the most exciting to hear with examples like: inspired and happy, I like to share my ideas, accomplished when I explain something, and we can agree and disagree.

Inquiry Specific Statements

The average score from the sample for student view of their ability with inquiry specific statements showed no growth with a score of +0. This was measured with the students’ scores on the survey statement 2: ‘I wonder many things about the world.' These statements were created in part by the idea of inquiry and curiosity and the science and engineering practice of: Asking questions and defining problems. When analyzing one statement the total possible sum would be 220. On the pre survey the total reached for this sample was 187. This then divided by the size of the sample (44) gives an average score for the student sample of 4.25 on a scale of 1-5. The same process was used to calculate the post survey data. The total sum the statement for the post survey was 187. This again divided by the number of students in the sample gives an average of 4.25 for each student on a scale of 1-5. These calculations provide the average growth for the student sample to be +0.

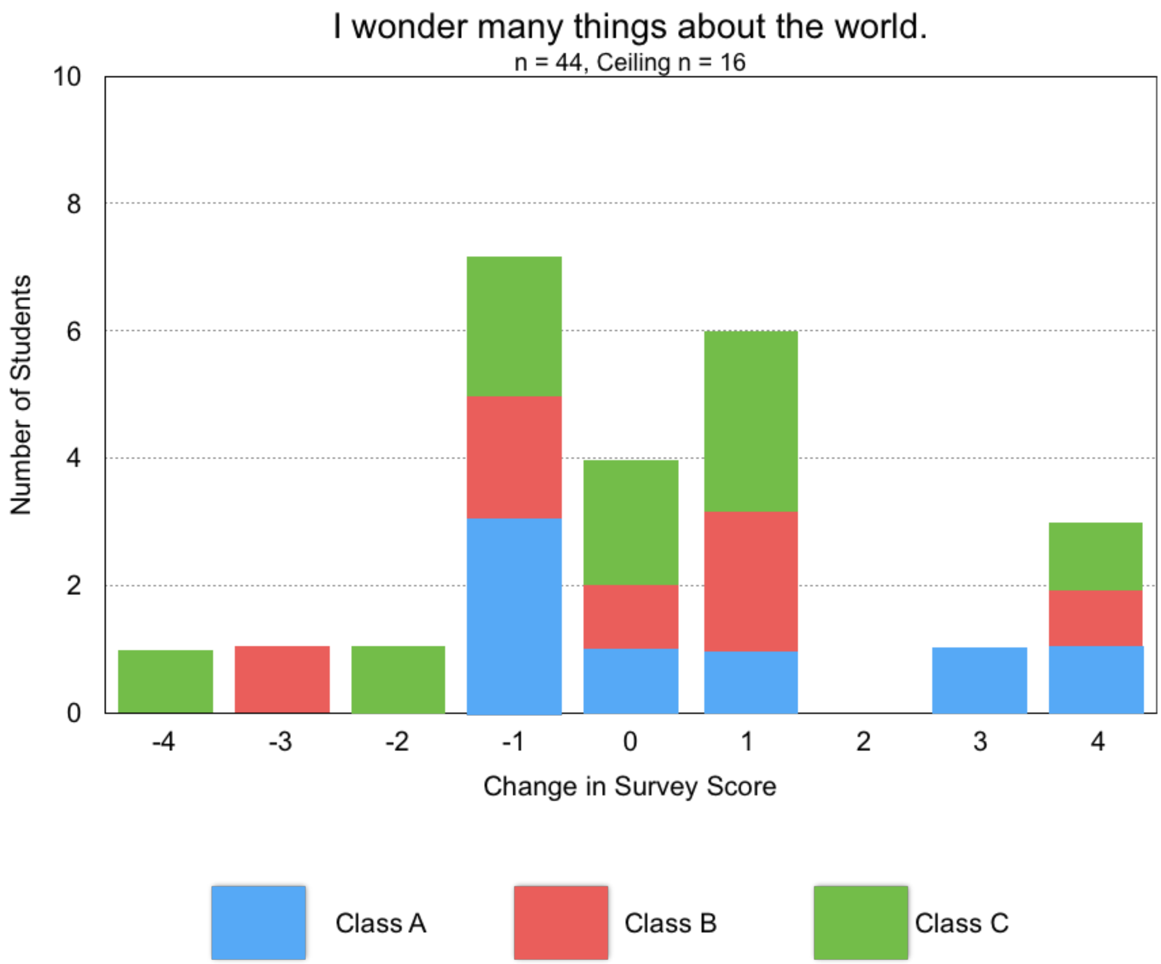


Figure 21

The percentage of students who rated themselves above neutral on the presurvey, with a score of a 4 or a 5 was 71.8%. This percentage grew to 84.1% on the post survey.

Figure 22

The student interview data taken at the conclusion of the Earth Science unit showed that 24 of the 24 students interviewed had positive responses when asked, ‘What types of things in the world are you curious about?’ Examples of student responses were: how lightning happens; oceans and deserts; and animals.

Observable Student Actions

Throughout the unit data was collected through observations of student actions. Meaningful observations that were noted by the teachers were added to figure 19.

Observation of Student Actions During the Treatment		
Emphasized SEP	**Construct Applied**	**Observable Student Action**
Asking questions and defining problems	● Creativity and Innovative Problem Solving ● Science and Engineering Practices and Inquiry Curriculum	● Students discussing the shape of the land and defining where flooding would be a problem. ● Students asking each other clarifying questions about the shape of the land and earth's processes. ● Students examining the shape of the land at recess.
Developing and using models	● Creativity and Innovative Problem Solving ● Resiliency and Perseverance ● Science and Engineering Practices and Inquiry Curriculum	● Drawing out individual maps of the land shape provided. ● In their performance task students built walls with wood or rocks, they created sand bag like objects from plastic bags filled with air or dirt. One student put his house on stilts and another put his home on a floating platform, similar to a boat.
planning and carrying out investigation s	● Creativity and Innovative Problem Solving ● Resiliency and Perseverance ● Science and Engineering Practices and Inquiry Curriculum	● Creating materials lists needed based on individual model drawn. ● Sharing models with a group. ● Creating group materials list jointly. ● Gathering materials. ● Building the group design. ● Revising the group design and materials list throughout building time. ● Students conducting investigations on their own at home.
constructing explanations and designing solutions	● Creativity and Innovative Problem Solving ● Science and Engineering Practices and Inquiry Curriculum	● Describing why they believe their individual design will work to their groupmates. ● Describing why or why not their design was successful in its testing. ● Students implementing flood prevention solutions in their neighborhood. ● Students examining the shape of the land at recess. ● In their performance task students built walls with wood or rocks, they created sand bag like objects from plastic bags filled with air or dirt. One student put his

		house on stilts and another put his home on a floating platform, similar to a boat.

Figure 23

Pre and Post Survey Data by Construct			
n=44	**Pre Survey student average**	**Post Survey student average**	**Degree of Change**
Resiliency and Perseverance	4.31	4.47	**+.16**
Creativity and Innovative Problem Solving	3.80	4.33	**+.53**
Science and Engineering Practices and Inquiry Curriculum	4.04	4.34	**+.3**

Figure 24

Pre and Post Survey Data By Class			
n=44	**Pre Survey student average**	**Post Survey student average**	**Degree of Change**
Class A n = 13	4.26	4.33	**+.07**
Class B n = 17	3.83	4.57	**+.74**
Class C n = 14	4.24	4.24	**+.0**

Figure 25

Pre and Post Survey Data Sub Categories of the Construct: Science and Engineering Practices and Inquiry Curriculum			
n=44	**Pre Survey student average**	**Post Survey student average**	**Degree of Change**
Science Project Practices	3.98	4.38	**+.4**
Science Communication Practices	4.04	4.35	**+.3**
Inquiry Specific Statements	4.25	4.25	**+0**

Figure 26

Student Interview Data			
Construct	**Interview Question**	**Example Student Responses**	**# of positive responses (n=24)**
Resiliency and Perseverance	What do you do when something is really hard?	• I keep trying • don't give up • get mad	20
Creativity and Innovative Problem Solving	What types of things in the world are you curious about?	• How lightning happens • oceans and deserts • animals	24
	Do you know how to find answers/information to this things you are curious about?	• Read Non Fiction • Watch a video • Ask a scientist • Test it • Go outside and look	19
Science and	What do you think	• It's fun	23

Engineering Practices and Inquiry Curriculum	about science?	● You can learn different things!	
	Would you do a science project at home?	● YES ● If I got to choose ● If my parents watched me ● No - it would be a mess ● If I had a kit	17
	Do you talk to your friends about science? What about your family?	● Sometimes ● Yes, about what we did in school ● Not really	17
	How do you feel about telling your classmate what you learned while doing science?	● Inspired and happy ● I like to share my ideas ● accomplished when I explain something ● We can agree and disagree	21

Figure 27

Summary

The above results show the success of this integrated and inquiry focused science unit. Students not only had growth in their content knowledge of the earth's processes as seen in the content knowledge assessment but they made overall gains in their abilities and skills in applying science knowledge as well as their thoughts and ideas about science in general. These ideas will be further covered in the discussion section.

Discussion

This research was conducted to answer the following research question: How does a Next Generation Science Standard aligned, inquiry based, science unit: '*What is happening to our playground?'* impact student achievement of science practices and student science efficacy in an elementary classroom?

The results of this project indicate that an inquiry based Next Generation Standard Science aligned unit promotes student growth in their understanding and abilities pertaining to the emphasized Science and Engineering practices as well as grow their beliefs in themselves as scientists. This growth was quantitatively measured through a pre and post survey in which students reflected on their own ability with the NGSS Science and Engineering Practices selected and emphasized in the unit *What is happening to our playground?* as well as their reflection on how they performed with science tasks and whether or not they enjoyed science. Of the constructs examined in the pre and post survey, the effects of the treatment were greatest in resiliency and perseverance and followed by the understanding and ability within an inquiry curriculum and the eight science and engineering practices. As seen in the results section, the data for the three constructs is derived repeatedly from the selected science and engineering practices for this unit, either through students' reflection, student work samples and perception or teacher observation. The four practices chosen to be emphasized in this unit gave evidence toward each of the three constructs analyzed. As explained in Appendix F by the NGSS Lead States (2013), the scientific practices do not operate in isolation, but overlap and are intertwined. One practice involves another or leads to another, this connection between the practices created a connection in the collection of data for the constructs. Each construct examined showed student growth which indicates the positive impact of an inquiry based Next Generation Science Standard aligned science unit in an elementary classroom on students' ability to be resilient and persevere through a task, be creative and innovative in their choice of direction in problem solving, and their ability with the science practices and inquiry process.

Resiliency and perseverance

As students progressed through the unit, their ideas of perseverance and their abilities to persevere grew. Post-survey data showed that, as an entire sample, students began to see themselves as someone who did not give up when facing something difficult. In both survey statements examined, the overall sample of students' responses showed growth in the ability to persevere through a task. The student average for this construct climbed from 4.31 to 4.47 show a growth of +.16.

Through chances to be unsuccessful in many tasks and the modifying of their work to make themselves successful throughout the 13 lessons of the unit, students saw that perseverance would get them where they needed to be. The unit was designed by the curriculum development team to give students many opportunities to try and try again not only on one task, but on many. This agrees with Blanchard, Frieman and Lirrete-Pitre's (2010) work where they found that "Students needed a certain level of 'strategy flexibility' in conjunction with situation awareness of the environment in which they were presented. This flexibility is very important and helps induce success in problem-solving situations." (pg. 2855) The performance task used as the summative assessment of the unit: *What happened to our Playground?*, provided students with a chance to create a model of a system they designed that would protect their neighborhood from a flood. They were able to compare their own designs with others, then revise their designs to make them better, before building and testing their models. The inquiry view on teaching allows for students to try investigations of their own designs even if they fail, the unit used as the treatment for the project allowed that to happen. Observation of students during the unit revealed that success after a few attempts at a task created a feeling of accomplishment in the students which in turn boosted their confidence and made them more likely to take on another hard task. Finding this in my research project agrees with what Beghetto and Baxter (2012) found in their own research, that students need more than ability to become successful with a task, they need to believe that they are capable of accomplishing the task in order to persevere until the end.

In the student interviews conducted at the completion of the Earth Science unit when students were asked, "What do you do when something is hard?" few students answered with any statements like just throw in the towel. 20 of the 24 students interviewed responded with positive statements like, “Try harder!” “Don’t give up!” and “Take a break and try later, maybe try something else.” This shows that students are building confidence in themselves and striving to persevere through the task.

Creativity and innovative problem solving

Because the school site was new to the implementation of the NGSS and an inquiry based curriculum students in the sample group had not had much prior experience with being a part of student centered work. They had not previously been able to make wonderings and decide how to find their answers before, it was teacher directed with the previous curriculum. The unit: *What is happening to our playground?* provided a multitude of hands on experiences through the lessons which allowed students to see new and different ways that problems could be viewed. Then led them through the gradual release of responsibility toward student independence in conducting the investigations (Cuevas et al. 2005) that would give them answers to their wonderings. This provided new approaches for students to follow, but also inspiration for new ideas to try. Allowing students to fail at a task that they had planned on their own provides a catalyst to think up new ideas that would work. This was observed in the samples of student work on the performance task at the end of the unit. This agrees with the findings of Yang et. al (2016) that the science practices and inquiry develop creativity.

The student work in the performance tasks showed more creativity than the survey ended up being able to produce. In the creation of a flood protection system students devised many different plans to protect their homes. They built walls with wood or rocks, they created sandbag like objects from plastic bags filled with air or dirt. One student put his house on stilts and another put his home on a floating platform, similar to a boat. These different students created systems that showed their ability to come up with a new and different idea. The ability to come up with new and different ideas is emphasized in the framework of skills that enable students to learn in relevant, real world 21st century contexts by the Partnership for 21st Century Learning (2015).

Students that were interviewed, at the conclusion of the unit, shared many positive and excited responses about being able to 'do science.' 23 of the 24 students interviewed had positive responses in how they felt about science and 17 of the 24 students interviewed wanted to be able to conduct science experiments outside of school and also knew many different ways to find answers to their own scientific wonderings. The data taken from the pre and post survey under the constructs of creativity and innovative problem solving showed the largest gain for the group of 44 second grade students with an average growth of +.53. This survey data shows students reflection on their own abilities within this construct.

Science and Engineering Practices & Inquiry Curriculum

This was the first science unit of the year for these students, and since the NGSS is a new adoption for the school site, their first science unit aligned with the NGSS. Not having the Next Generation Science Standards implemented at the school site in previous years meant that students had not yet had exposure to the science and engineering practices. As seen by scores of 5s on the pre-survey, some students came into second grade with a knowledge of science practices and skills. Of the seven statements analyzed for this construct the range of students who had 5s on the pre-survey were 12 students on statement #2 'I wonder many things about the world,' and 22 students on statements #6 'I can write or draw what I learn from a science project,' #9 'I can tell what happened in my science project,' out of a total sample size of 44. These numbers are a quarter to half of the students involved in the study.

This construct was the largest of the three examined and because of its size has been broken down into three subcategories; science project practices, science communication practices, and inquiry specific statements.

Science Project Practices

This subcategory showed the second most growth out the three sub-construct groupings examined, with an increase in the average student score of +.4. One reason for this growth were the many opportunities throughout the unit when students were given opportunities, as seen in the unit storyline (Appendix D) to engage in the specific Science and Engineering Practices analyzed: 'Developing and using models' and 'Planning and carrying out investigations.' These opportunities were given with a guided release of responsibility, in which each teacher showed more directly how to begin, then guided the students alongside them through the practices, ultimately allowing the students the freedom to try the skill on their own after having instruction and practice (Cuevas, et al, 2005). By the time of the performance task students had drawn numerous models with teacher guidance as well as independently (see appendix D). During the performance task they were able to use these practiced skills to individually create a three dimensional model of their design, then, as a group, combine their designs into one group model. Formative assessments of student work and watching student create models throughout the lessons showed that their skills increased. As the unit progressed students began adding more details to their drawings to show processes as well as added more labels to define what was in their model. In the post assessment of content knowledge students' modeling skills were assessed. This data showed that 16 of the 17 student samples were scored as proficient or highly proficient in their ability to model an event.

During the performance task students took their models to a higher level than drawing and physically built their design. These observations of student progression correlates with the Learning Progressions found in Appendix F of the NGSS: "Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions." and "Develop a simple model based on evidence to represent a proposed object or tool." (NGSS Lead States 2013, pg. 387)

Two more science practices analyzed in this subcategory are to plan a science project and carry out the science project. The unit lessons gave student opportunities to ask questions, or wonderings, and find the answers on their own.

After the unit the percentage of students who rated their perspective of their abilities with these practices above neutral, at a 4 or a 5 on the scale, grew from a 73.5% to 80.3%. According to student interviews conducted after the unit, students had previously thought that conducting a science experiment meant following instructions from a kit. The data collected from the pre and post survey seen in figures 11, 12 and 13 combined with the observational data gathered on students being able to find answers to their own wonderings as seen in figure 23, imply that students now understand that they can conduct an experiment that will help them find answers to different things that they want to know. When asked how to find answers to their own wonderings in the post-unit interviews there were 19 positive responses of the 24 students interviewed. The responses gave examples of how students would answer their own wonderings like: test it out, read nonfiction, go and observe and ask a scientist. These attempts at answering their own wonderings were students' actions that support the idea that, "Creative problem solving requires scientists and engineers to explore the universe of possible solutions before selecting the most promising and practical options to engage into their inquiry and design process." (Yang, 2016). Which also shows the intertwining of the practices that the NGSS Lead States intended (2013).

Science Communication Practices

Growth in the communication specific statements in the survey was +.3 which is supported by the 21 out of 24 positive student responses in the post-unit interviews. During the student interviews, it was exciting to hear students, who were only seven to eight years of age, be able to describe how they felt when they were given the opportunity to share what they thought. Some of these 21 positive responses were that students felt 'inspired' and 'happy' to share their thoughts and hear those of others. These 21 students liked to be able to 'agree and disagree' with one another. And most of all, students felt 'accomplished' when they could explain something to their peers (See figure 23 for more student responses from the interviews). Data from the survey showed that before the science unit 71.2% of students rated themselves above neutral, by the conclusion of the unit this percentage had grown to 80.3% of students selecting a rating of 4 or 5. Not only did the positive statements from the interviews show the excitement of the students, the survey show overall growth, but it also showed that students were aligning themselves with their appropriate age group in the learning progressions set by the NGSS Lead states in the NGSS: "Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument. Construct an argument with evidence to support a claim. Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.” (2013, pg 397) These student ideas and quotes suggest that taking these intellectual risks of sharing their ideas on each investigative task throughout the 13 lesson unit created a place of comfort where students are OK with the feeling of vulnerability enough to welcome feedback and ideas from their classmates. This agrees with the work of Beghetto and Baxter (2012) on Intellectual Risk Taking. They found that students who engage in these learning behaviors, such as sharing ideas, place themselves at risk of making mistakes, and the students who put themselves in this position develop their skills further.

Inquiry Specific Statements

The use of the inquiry curriculum, defined as the process when students generate a question and carry out an investigation with varying levels of teacher support (Cuevas, et al 2005), for the implementation of the content seemed to be very successful according to qualitative data, but did not show as much growth in quantitative data. On their pre-unit survey, many of the students had identified themselves as already curious about the world around them, so there was little growth to see by the time of the post-survey. In fact, the growth shown through the data was +.0 on the statement: ‘I wonder many things about the world.’ Though, through observation, students had high engagement in the learning that was taking place all throughout the unit. Students asked for more time to work on science investigations and designs, students shared that it was one of the favorite parts of their day, students talked about ideas for their designs outside of the classroom. Engagement in the learning itself is of large importance, without engaging in the task, students would not be involved in the use of skills or learning of content. The NGSS Lead States (2013) tell us that "In the NGSS, "inquiry-based science" is refined and deepened by the explicit definition of the set of eight science and engineering practices," and that "Successful application of science and engineering practices… will demand increased cognitive expectations of all students." (pg 359) The extent of student engagement and interest was made evident by seeing students take their learning out of the classroom and onto the playground where they were found researching the land shapes and different puddles that they saw. This was also made clear in students making connections at home with what they saw happening around their own homes as well as doing more research at home and bringing it in to share. 7 students from class B brought in information on the earth science topics that they had independently researched at home to share with the class and increase understanding. One student even took action in his neighborhood by working to clear the storm drains to help prevent possible flooding that could happen (see Figure 23 for more observable student actions). This agrees with the study referenced in the earlier literature review by Beghetto and Baxter, "Students' belief in their ability in science, the value they place on science, their desire to master science, and their interest in science all have consequences for the quality of their engagement in the classroom and subsequent learning."

(2012, pg 942) Students must be interested in what they are doing in order to be engaged and create a quality learning environment. This data shows that students were engaged and that an inquiry based, NGSS aligned science unit can help students create that rich learning environment suggested in the quote.

Qualitative growth can also be seen in the students who were interviewed at the end of the unit. 24 of the 24 students interviewed were all able to name many different things that they were interested in learning more about, like different animals or habitats around the world, and talk about their wonderings in an excited manner. Daniel Pink (2011) in his book DRIVE states, “For artists, scientists, inventors, schoolchildren, and the rest of us, intrinsic motivation - the drive to do something because it is interesting, challenging and absorbing - is essential.” (pg 48) This motivation with curiosity has grown with the inquiry curriculum. The emphasized science practices and inquiry curriculum have tied together, as the NGSS Lead States have intended, to work together to build these constructs of curiosity and problem solving and resiliency and perseverance which are imperative to cultivate scientifically literate citizens (2013).

Limitations

When the data gathered in this research project is clustered by class, it did not always show growth. As seen in figure 21 data collected in the pre and post survey for Class A, showed a growth of only +.07 while Class C showed +0 on the student pre and post survey. This was vastly different than Class B which showed a great deal of growth at +.74. This is attributed to the possibility that the actual implementation of the unit: *What is happening to our playground?* varied with each individual teacher's implementation of the curriculum. The three teachers instructing each had varying levels of experience, professional development, background and history of their careers which created a difference in teacher craft, style and presentation. When comparing the backgrounds of professional development between the three participating teachers, the teacher with the most development had the best results. Staying up to date on professional development helps teachers know current best practices which they can implement in their rooms. A recommendation from this project is that teachers should have access to and attend professional development on inquiry strategies and the Next Generation Science Standards in order to follow the written units with more fidelity. As the researcher and a participating classroom teacher I was not able to make observations of the other teachers participating in the study to see what implementation of the unit was like. Things that I do know, students in class A had less time to work collaboratively as in this room student desks were not grouped, but were lined in rows. This severely decreases student talk time and was a popular classroom management strategy in the past. Observations of participating classrooms is also a recommendation for studies like this in the future. It is imperative that the unit be taught with fidelity and not solely based on teacher feedback that things are going 'great.'

Teacher Background			
	A	**B**	**C**
Years of Experience	20+	7	3
NGSS Professional Development	No	Yes	No
Inquiry Professional Development	No	Yes	No
Unit Storyline + Lesson Plans	Yes	Yes	Yes

Figure 29

Another limitation was the language on the pre and post survey. The wording of the statement based on the practice of modeling involved the words ‘drawing a picture’ which may be misleading to young students. Children could see the idea of drawing a picture and know that they are familiar with this, but not see it is a scientific term that includes labels and scale related to an actual event. There were also two negative statements written into the survey. Students in this age range seemed to have a hard time deciphering how they were supposed to react to them based on their own feelings. Statement 16 on the survey is one of these statements: ‘I give up when something is too hard.’ Since the survey was using smiley faces instead of numbers a ‘strongly agree’ for the other statements would have been a smiling face. For these negative statements a strongly agree was switched to frowning face. The switch of where the agree statement was could have and seemed to lead to some confusion in students of this age group.

I had originally planned to use only the student survey to collect data on creativity. As the science unit went on, I realized that creativity was not apparent in student reflection as strongly as it was in observable student action, specifically in the conducting of the performance task. This was a limitation to only be prepared with one instrument for data collection. As I was a participating teacher in the project, I was only able to gather observable student actions as data from the class that I was teaching which resulted in a sample size of 17.

Summary

The major findings, supported by the data in this research project, are that hands on science tasks build resiliency and perseverance in students. The openness of an inquiry based curriculum built creativity. The NGSS Science and Engineering Practices were intertwined and together built student confidence which leads to risk taking, resiliency and creativity. Proper professional development for teachers in the areas of inquiry teaching practices and the Next Generation Science Standards is needed.

Map of Constructs			
Construct	**Data Source**	**Findings**	**Notes**
Resiliency and Perseverance	• Student pre/post survey • Observable student actions: Revising student designs and models.	Resiliency and perseverance are traits students can grow through repeated attempts at tasks. Increase student confidence created by a safe and supportive environment enhances growth in this construct.	
Creativity and Innovative Problem Solving	• Student pre/post survey • Observable student actions: creating • Performance Task	Creativity and innovative problem solving are built with a strong inquiry curriculum. Students need the openness of determining their own strategies in order to progress in being creative and innovative.	This construct was harder to define within the student survey statement s.
Science and Engineering Practices and Inquiry Curriculum	• Student pre/post survey • Observable student actions throughout unit • Performance Task • Content Assessment of modeling	SEPs are intertwined together and the practice of one promotes growth with the others. This construct ended up being a large part of growth in both the resiliency and creativity constructs.	

Figure 30

Conclusion

The data collected in this study helps provide an answer to the research question: How does a Next Generation Science Standard aligned, inquiry based, science unit impact student achievement of science practices and student science efficacy in an elementary classroom? What we can see in the data collected in this project is that the science practices and inquiry curriculum are beneficial to elementary students, not only within the realm of their current education but in the beginning of the process of creating life skills as seen by observable student actions of students in my classroom extending their learning outside of the classroom. This agrees with the current literature by Huay-Keng, Shu-Fen, Zuway-R, and Huann-Shyang “Science inquiry has long been regarded as one of the critical requirements for school learning outcomes and for a scientifically literate citizen.” (2016, pg 17) Using inquiry in the classroom plays a great role in furthering students engagement with the curriculum as it gives students power over what they are learning, providing them with a strong intrinsic motivation. In this study, motivation was shown through resiliency and perseverance through observable student actions, as seen in the performance task, through designing, discussing, and redesigning investigations. It was also shown in growth of student reflection on their own abilities with each of the constructs analyzed. The NGSS Lead States, that took part in creating the Next Generation Science Standards, believe that “The actual doing of science or engineering can also pique students’ curiosity, capture their interest, and motivate their continued study; the insights thus gained help them recognize that the work of scientists and engineers is a creative endeavor—one that has deeply affected the world they live in." (NGSS Lead States, 2013, pg 383). Continuing more units like this will continue to lead students to recognize what it means to be a scientifically literate citizen as well as motivate them to continue with science in their lives.

Recommendations

If the tools for this research project are to be used again, wording on the student survey for statement number three should be analyzed. The wording of the statement involving 'drawing a picture' may be misleading to students. Students could see the idea of drawing a picture and know that they are familiar with this, but not see it is a scientific term that includes skills of labels and scale. This is something that I would recommend for adjustments if this tool were to be reused. A rewriting of the negative statements on the survey into positive ones would also be beneficial as students in this age range seemed to have a hard time deciphering how they were supposed to react to them based on their own feelings.

The differences in growth in the three second grade classrooms brings about the idea for more teacher professional development in the area of the NGSS and inquiry based curriculum. J. A. Morrison states that "Teachers need to recognize a problem with the traditional way of teaching before they will change to more inquiry-based practices'' (2013, pg 580) my research suggests that we can recognize a need. In future projects it is also recommended that the researcher be able to observe the participating teachers at work in order to ensure fidelity to the unit and lesson plans.

This project recommends that more research is conducted to prove the positive impact the Science and Engineering practices embedded in an inquiry curriculum have on elementary students' attitudes toward their abilities in science and the application of skills in science. An impact that benefits students, not only in their current education, but can also progress into their future. It is also recommended that in order to provide this best practice education, that teachers receive professional development. This professional development should build and strengthen their abilities with inquiry that empowers students to take control of their own education as well as create a deeper understanding of the Science and Engineering Practices and the Next Generation Science Standards.

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Appendices

Appendix A: Parent Consent Form

How do NGSS aligned - inquiry based - science and literacy integrated units impact student achievement and student efficacy in an elementary classroom?

Parent Consent Form

Dear Parent or Guardian,

Your child is invited to participate in a research study conducted by Kayla Whittington, teacher in the Beaverton School District and graduate student from Portland State University, Center for Science Education. This project hopes to learn the impact of Next Generation Science Standard aligned a science and literacy integrated units on students' content knowledge and skills. This project is being conducted to fulfill the requirements for Mrs. Whittington to achieve her master's degree at PSU under the supervision of her faculty advisor Stephanie Wagner. Your child was selected to participate in this study because they are in the target age group (second grade) and attend school at the project site (Hazeldale Elementary).

If you decide to let your child participate he/she will be asked to do nothing different than the rest of the class will for this science unit. The participation in the project allows the pre and post assessment data be gathered to analyze as well as your child to be involved in informal student interviews while working on the science lessons. During this study your child will not be excluded or alienated in anyway whether they are part of the study or not a part of the study.

Any information that is obtained in connection with this study and the can be linked to your child or identify your child will be kept confidential. Each student's pre and post assessment, as well as interview data will be coded with a letter and number instead of a name. All of the information will be kept confidential from others. Like any other unit in school, you will have access to your child's pre and post assessments and see the growth that they have made

Your child's participation is voluntary. He/she does not have to take part in this study, and it will not affect his/her grade or relationship with their teacher or classmates. You may also withdraw your permission for your child to participate form this study at any time without affecting his/her grades or relationships with their teacher or classmates.

If you have questions or concerns about your child's participation in this project, please contact Kayla Whittington at Kayla_whittington@beaverton.k12.or.us or

541.207.4150. If you have concerns about your child's rights as a research subject, please contact the PSU Office of Research Integrity, 503.752.2227.

Your signature indicates that you have read and understand the above information and agree to let your child take part in this study. You will receive a copy of this form for you own records.

Sincerely,

Kayla Whittington
Second Grade Teacher, Beaverton School District
Graduate Student, Center for Science Education
Portland State University

_______________________________ _______________________________
Student Name (Printed) _
Date

_______________________________ _______________________________
Parent/Guardian Signature

Parent Guardian Name (Printed)

_______________________________ Date _______________
Investigator name

____
Investigator Signature

Appendix B: Student Assent Form

How do NGSS aligned - inquiry based - science and literacy integrated units impact student achievement and student efficacy in an elementary classroom?

Student Assent Form

Dear Student, June 2016

Your parent (or guardian) has said that it is okay for you to take part in a project that looks at your interest and attitudes toward science and school. If you choose to do it, you will be asked to take two tests that will show what you know about science and how you feel about it. Your teacher will also ask you some questions about what you are doing for science in class. It will be the same as what all of the other students are doing and feel just like regular class.

If you want to rest, or stop, just tell your teacher – you won't get into any trouble! If you don't want to do it at all, you don't have to. Just say so. If you have any questions at any time about what you will be doing just ask your teacher to explain.

If you do want to try it, please sign your name on the line below. Remember – you can stop to rest at any time, and if you decided not to do it anymore, let your teacher know.

Thank you!

Kayla Whittington
Second Grade Teacher, Hazeldale Elementary
Graduate Students, Portland State University

______________________________ ________________
Student name Date

____
Student Signature

______________________________ ________________
Investigator name Date

____
Investigator Signature

Appendix C: Teacher Assent Form

How do NGSS aligned - inquiry based - science and literacy integrated units impact student achievement and student efficacy in an elementary classroom?

Teacher Assent Form

Dear Teacher, June 2016

You are invited to participate in a research study that focuses on NGSS aligned science and literacy integrated units and student efficacy. The aim of this research study is to see how integrated units can benefit students.

The data gathered for this research is through student interviews and student pre and post assessment data. The data gathered is based on you teaching an NGSS aligned literacy integrated science unit. Your participation in the research project is voluntary.

If you decide to participate, you can withdraw your consent at any time, without penalty. By participating you are not waiving any legal claims or rights. Your identity will be kept completely confidential. Before any analysis is performed in this study, your name will be replaced with a letter just to indicate which classroom the data is from. All information and data collected in this study will be kept in a locked file cabinet at the Center for Science Education during the study where only the researcher and Principal Investigator will have access. After the study is complete all information will be safely stored in the same office for three years.

This study will provide information that may help schools, leaders, school districts and universities to better prepare teachers for educating students.

If you have any questions or concerns about your participating in the study please contact me by email kayla_whittington@beaverton.k12.or.us or by phone 541.207.4150.

Thank you for your time and caring for the future of education!

Kayla Whittington
Second Grade Teacher, Hazeldale Elementary
Graduate Students, Portland State University

Teacher name Date

Teacher Signature

Investigator name Date

Investigator Signature

Appendix D: Second Grade Earth Science Unit: *What is happening to our playground?*

A Tool for NGSS Storyline Coherence

<table>
<tr><td colspan="4">

Beaverton School District 2nd Grade Earth Science Unit:
What is Happening to Our Playground?
Erosion Unit Adapted From Emily Miller's NGSS Soil Unit
2nd Grade Earth Science Unit Supply List
2nd Grade NGSS Earth Science Photo Cards
Master Set of Activity Sheets-Possible Student Journal: Horizontal Format Sheets; Vertical Format Sheets
BSD NGSS 2nd Grade Earth Science Unit Individual Lesson Plans
Beaverton School District Sample Parent Unit Letter

Next Generation Science Standards Performance Expectations

2-ESS1-1 Use information from several sources to provide evidence that Earth events can occur quickly or slowly.

2-ESS2-1 Compare multiple solutions designed to slow or prevent wind and water from changing the shape of the land.

2-ESS2-2 Develop a model to represent shapes and kinds of land and bodies of water in an area.

Essential Questions
How does land change and what are the some things that cause it to change? (*How do we know? How can we find out?)*

What are the different kinds of land and bodies of water? (How do we know? How can we find out?)

</td></tr>
<tr>
<td>Lesson: #</td>
<td>Question----Phenomena----Context
Unit Questions:
What caused our playground to flood? How do we know? How can we find out?
How does the type of soil affect playground flooding?

Unit Phenomenon:
Flooded Playground: Flooded Playground Video

Unit Context:
Kids' experiences with seeing areas of their playground flooded and noticing different soil in different areas.</td>
<td>Scientific Practices to Engage in</td>
<td>What We Figure Out and Next Investigative Question(s)</td>
</tr>
</table>

	Lesson Question	Lesson Phenomenon	Lesson Context	Lesson Practice(s)	Lesson Learning and Next Question
1	What happened to our playground? I notice... I wonder… What else does this remind me of?	Flooded Playground Pictures Flooded Playground Video	Experiences with not being able to play on flooded playground	Asking questions and developing models	Too much water in one area is flooding. We can use our observations to create "I wonders..." What creates flooding? How do we know? How can we find out?
2	What creates flooding?	Soaked soil area Flooded Playground Video (Freeze at 9 seconds into video)	Puddles, soaked grass areas	Plan and conduct an investigation. Obtain and evaluate information.	Soil can only absorb so much water. We can use observations and readings to to create more wonderings. Does flooding happen in all areas?
3	Does this flooding happen in all areas of our playground? I wonder…. I notice… Claim-Evidence….	Pictures or video of water affecting nearby surroundings Flooded Playground Video	Playground observation. News stories or experiences with flooding.	Construct explanations.	Water can flood areas differently. Some factors that cause or prevent flooding may be the type of land, the shape of the land and the amount of water. Does the type of land affect the amount of flooding on our playground?

4	Does the type of land affect the amount of flooding on our playground? I wonder…. I notice… Claim-Evidence….	Flood areas focusing on the different surfaces. Flooded Playground Video	Experiences with different playground surfaces. Soil observation around school and home	Plan and conduct an investigation.	There are many types of ground surfaces on our playground (topsoil, soil with grass, bark chips, blacktop) They all have different properties which absorb water to different degrees. Does the amount and movement of water impact the amount of flooding?
5	Does the amount and movement of water impact the amount and rate of flooding? How does water move? Investigating shape of land, amount of water and rate of water. Part 1: Guided investigation around shape of land Part 2: Group investigations on amount of water or rate of water Optional Part 3: Open inquiry on own at home	Flooded Car Simulation	Waterflow observations	Developing and Using Models Planning and Carrying out Investigations Constructing Explanations	The shape and kinds of land has a relationship to the bodies of water formed. Water pools and flows creating lakes, rivers etc. Does where the bodies of water and landforms are impact flooding risk?
6	Does where the bodies of water and landforms are impact flooding risk?	Flash flood in neighborhood video Start at 5 min if don't want	Neighborhood bodies of water and landforms	Obtaining, evaluating and communication.Develop	The size and shape of the body of water and the slope of the land

	Focus on Claim-Evidence	to watch all 8 min of the progression		and use models and constructing explanations.	impacts flood risk. Water pools and flows creating lakes, rivers etc. The bodies of water and landforms in an area can be modeled. Does the amount of water affect the wearing away (erosion) of the land?
7	Does the amount of water affect the wearing away (erosion) of the land??	Dirt mountain with rain Video of kids playing in the sand	Kids' experiences playing with sand or soil with water. (Video of beach sand playing.)	Plan and carry out investigations. Analyze and interpret data	Water moves land and causes erosion. We can predict patterns of erosion. What other events can cause changes to the land?
8	What other events can cause changes to the land? Wind on sand inquiry. Ice and sponge cracking. Wind blowing away footprints in sand Water washing footprints away	Playground wind and ice damage pictures or videos Fallen tree on playground	Experiences with windy days or ice storms	Constructing Explanations	Wind and ice can make changes to the land. Does where bodies of water and landforms are impact other changes to the land?
9	What changes happen slowly on the earth? What changes happen quickly on the earth?	Fast Changes Video Probe on Earth Events	Slow and rapid changes in their bodies (hair, teeth,	Engage in argument from evidence	Slowly - wind and water erosion (on rocks). Quickly: earthquakes, human impact

	Can we engineer a solution to reduce the impact of these changes? Engineering Design: Reducing the Impact of Weathering		bones, fingernails, sunburns)		students can define difference between slowly/quickly Is all soil the same? slowly on Earth? What changes happen quickly on Earth?
10	Does where bodies of water and landforms are impact other changes to the land?	Google Earth Flooded playground picture (river nearby)	Playground observation walk of water and types of land areas	Obtain, evaluate and communicate information Construct explanations	The location of bodies of water and landforms can increase the amount of erosion, weathering or landslides. Are all of earth's changes helpful or harmful?
11	Are events that change the Earth mild or severe?	Fast Changes Video	Mild and severe flooding and wind damage connection	Constructing Explanations	Some of Earth's changes are mild and some are severe. How can we prevent unwanted changes to the Earth caused by wind and water?
12	How can we prevent unwanted changes to the earth caused by wind or water? Floodplain Modeling	Disaster Simulation Disaster Detector Bonneville Dam Simulation	Disasters and solutions	Develop and use models Plan an investigation	

13	How can we design a solution to the playground flooding problem?	Landslide Risk in Oregon	Playground observation	Design solutions	Students compare and contrast solutions.

Lesson or Unit Notes

Teacher Background:

- Water is found in the ocean, rivers, lakes and ponds.
- Water exists as solid ice and in liquid form, it carries soil and rocks from one place to another.
- Wind and water can change the shape of the land.
- Rocks, soils and sand are present in most areas where plants and animals live. There may also be rivers, streams, lakes and ponds.
- Maps show where things are located. One can map the shapes and kinds of land and water in any area.
- Some events on earth occur in cycles, like day and night and others have a beginning and an end like volcanic eruptions.
- Some events, like an earthquake, happen very quickly, others like the formation of the Grand Canyon occur very slowly over a time period much longer than one can observe.

Reference::

National Research Council. (2012). *A Framework for k-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Scientific and Engineering Practices

Literacy Resources

Brain Pop Jr. Video Land Changes (Free video - fast land changes in a video if you have an account)
Books from 2nd grade ELA adoption and 2nd grade science booster pack
Floods by Mary Winget
Examining Erosion by Joelle Riley
Water Everywhere by Jill Atkins
Earth's Land and Water by Bonnie Beers
Volcanoes by William Rice
Fearsome Forces of Nature by Anita Ganeri
Weather by Anita Ganeri
Earthquakes! by Cy Armour
Eruption! The story of Volcanoes by Anita Ganeri
Super Storms by Seymour Simon

How Mountains are Made by Kathleen Weidner Zoehfeld
Engineers Build Dams by Henrietta Lily
Engineers Solve Problems by Reagan Miller and Crystal Sikkens
Other titles not included in Bookshelf
Water by Susan Canizares and Pamela Chanko
Wind by Susan Canizares and Betsey Chessen

Extension Activities From Accelerated Learning

Earthquake Probe

Appendix E: Content Knowledge Pre/Post Assessment

What Are You Thinking? What Happened?

Name_____________________________Date:_____________

Before	During	After

Create a model to explain what you think happened before, during and after what you see. Use words and pictures to show your thinking.

Appendix F: Content Assessment Rubric

Earth Science Rubric

	Highly Proficient 4	Proficient 3	Nearly Proficient 2	Developing 1
2-ESS1-1 Use information from several sources to provide evidence that Earth events can occur quickly or slowly	**I can explain by showing different types of evidence that the Earth can change quickly or slowly.**	**I can explain by showing evidence that the Earth can change quickly or slowly.**	**I can explain that the Earth can change quickly or slowly.**	**I can explain that the Earth can change.**
2-ESS2-1 Compare multiple solutions designed to slow or prevent wind and water from changing the shape of the land.	**I can describe many solutions, in detail, to preventing wind or water from changing the land and describe why one is better than other solutions.**	**I can describe one solution to preventing wind or water from changing the land and describe why it is better than another solution.**	**I can describe part of one solution to preventing wind or water from changing the land, but it is unclear.**	**My example is unclear.**
2-ESS2-2 Develop a model to represent shapes and kinds of land and bodies of water in an area.	**I can tell many ways and give/show examples about how the land and its shape affect the water in the area.**	**I can tell <u>many</u> ways about how the land and its shape affect the water in the area.**	**I can tell <u>some</u> ways about how the land and its shape affect the water in the area.**	**I can tell <u>one</u> way about how about how the land and its shape affect the water in the area.**
Model Presentation	**My model is well-organized, neat, and includes strong details. It includes many labels and clarifying text.**	**My model is easy to follow, organized, and neat. It includes many labels and clarifying text.**	**My model is mostly neat, but maybe hard to follow. It includes some labels and clarifying text.**	**My model is difficult to follow.**

Appendix G: Teacher Survey Instructions

How does a Next Generation Science Standard aligned, inquiry based, science unit impact student achievement of science practices and student efficacy in an elementary classroom?

Dear Teacher,

Thank you for taking the time to agree to involve your second grade classroom in this research project. Included in this packet are your instructions for your student's pre and post assessment measuring how they feel about the eight science practices as well as their resiliency and academic identity.

Please give students each one copy of this pre assessment to conduct before you begin the first lesson of your science unit in the fall. Read and explain the rating scale to the students before beginning. Practice with simple statements like, 'I love ice cream' or 'I like to eat worms for breakfast' and have students touch the face on the scale they would associate with that statement. After being silly, please remind students that this is part of a research project where another teacher would like to learn as much about science and students as she can.

As you conduct the pre and post assessments. Please read each statement out loud to the class and read the options to color in each time. This will help students understand the statements and remember the rating scale, which will help with accuracy. You may answer student questions and gives examples for better understanding of each statement.

Thank you again for your participation and time.

Kayla Whittington
Second Grade, Hazeldale Elementary
Graduate Student, CSE, Portland State University

Appendix H: Student Pre/Post Survey

Pre Assessment

Name:______________________________ #:____________ Date:____________________

	Yes	I think so	Maybe	I do not think so	No

I like science.					
I wonder many things about the world.					
I can draw a picture or build a model that shows an object.					
I can plan a science project.					
I can do a science project.					
I can write or draw what I learn from a science project.					
I can find answers to my science wonderings.					

I can use math to find answers.	
I can tell what happened in my science project.	
I can agree or disagree with my friends about science.	
I can talk with my friends about what I've learned in science.	
If something is hard, I try harder.	
Science is fun!	
I give up when something is too hard.	
I'm good at science.	
Science is not fun.	

Post Assessment

Name:______________________________ #:____________ Date:____________________

Yes	I think so	Maybe	I do not think so	No

I like science.					
I wonder many things about the world.					
I can draw a picture or build a model that shows an object.					
I can plan a science project.					
I can do a science project.					
I can write or draw what I learn from a science project.					
I can find answers to my science wonderings.					

I can use math to find answers.					
I can tell what happened in my science project.					
I can agree or disagree with my friends about science.					
I can talk with my friends about what I've learned in science.					
If something is hard, I try harder.					
Science is fun!					
I give up when something is too hard.					
I'm good at science.					
Science is not fun.					

Appendix I: Student Interview Questions

How does a Next Generation Science Standard aligned, inquiry based, science units impact student achievement of science practices and student efficacy in an elementary classroom?

Student Interview Questions

These questions will be read aloud to students individually or in small groups after conducting the post assessment. Depending on time allotted and student interest in taking the survey, some or all of the questions could be asked.

Do you like school? What do you like/dislike about it?

What do you think about science? Do you like it? Why?

Do you know any scientists?

Tell me something cool you know about science?

What do you think about doing science experiments?

What was the best part of this science unit?

What types of things in the world are you curious about?

Do you know how to find answers/information to the things you are curious about?

Would you do a science project at home? If so, how would you do it?

Do you talk to your friends about science? What about your family?

How do you feel about telling your classmate what you learned while doing science?

What do you do when something is really hard?

Appendix J: NGSS Evidence Statements for 2-ESS2-1

NEXT GENERATION SCIENCE STANDARDS
For States, By States

*Unless otherwise specified, "descriptions" referenced in the evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.

2-ESS2-1 Earth's Systems

Students who demonstrate understanding can:

2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.* [Clarification Statement: Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.

- Compare multiple solutions to a problem.

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems

- Wind and water can change the shape of the land.

ETS1.C: Optimizing the Design Solution

- Because there is always more than one possible solution to a problem, it is useful to compare and test designs. *(secondary)*

Crosscutting Concepts

Stability and Change

- Things may change slowly or rapidly.

- -

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

- Developing and using technology has impacts on the natural world.

- -

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

- Scientists study the natural and material world.

Observable features of the student performance by the end of the grade:		
1	Using scientific knowledge to generate design solutions	
	a	Students describe* the given problem, which includes the idea that wind or water can change the shape of the land by washing away soil or sand.
	b	Students describe* at least two given solutions in terms of how they slow or prevent wind or water from changing the shape of the land.
2	Describing* specific features of the design solution, including quantification where appropriate	
	a	Students describe* the specific expected or required features for the solutions that would solve the given problem, including:
		i. Slowing or preventing wind or water from washing away soil or sand.
		ii. Addressing problems created by both slow and rapid changes in the environment (such as many mild rainstorms or a severe storm and flood).
3	Evaluating potential solutions	
	a	Students evaluate each given solution against the desired features to determine and describe* whether and how well the features are met by each solution.
	b	Using their evaluation, students compare the given solutions to each other.