

THE EFFECT OF VARIED FEEDBACK ON STUDENT PERFORMANCE IN A
MIDDLE SCHOOL SCIENCE CLASSROOM

by

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ABSTRACT

The middle school classroom is one of the first places where students have the opportunity to have more control on their own learning. This study analyzes how students use feedback to improve learning and attitudes in science, as well as how different forms of feedback enhance student learning. Nearly 90 grade 6 students participated in the study where they provided their opinions on which mode of feedback provides the best opportunity for them to improve their knowledge of disciplinary core ideas and demonstration of scientific practices. Results show that varied feedback had a positive impact on student's attitudes towards sixth grade science, most notable positively impacting male students. Student's shows improved learning of disciplinary core ideas and demonstrated improvement in their science skills. Every student had at least one form of feedback they agreed can help them with their learning, but narrative written or typed feedback was the form that most students preferred. The impact on student learning and improvement in scientific skills is discussed.

INTRODUCTION AND BACKGROUND

I have been teaching for 17 years at the elementary (ES) and middle school (MS) levels. This is my twelfth year teaching at the American Community School of Abu Dhabi (ACS AD) and my first year as a science teacher at the grade six level. Until the 2018-19 school year, I, like my fellow science colleagues, taught two content areas, math and science. Over the past couple of years, our school recognized that content specific educators in their specialization field would provide consistent grading and content delivery to all students at their specific grade level.

Although my past experience was working in a dual capacity role, with a voice on the Common Core Mathematics committee as well as on our middle school science team, my passion leaned toward science. I have been a leader in our school, focused on learning about and delivering the Next Generation Science Standards (NGSS) since the end of 2013. Our school did not begin full implementation until the 2016-17 school year, but I had a leading role in working with the development of the science curriculum in our middle school since 2013. My first work began in grade eight and the past four years has been in grade six. My early focus was on understanding the meaning of the three dimensions of the standards: core content, scientific practices, and crosscutting concepts. At the earliest stages of curriculum development, my focus was on being able to unpack a standard to understand the core ideas that needed to be understood by students. This led to the development of a unit path that included three dimensional learning practice statements for each lesson in the unit. Additional focus surrounded the development of a common rubric that could be used across multiple standards that focused primarily on scientific practices. This also required specific rubric strands for content or crosscutting concept understanding.

With the rubric developed, it was now an opportunity to develop assessments that aligned to the standards, as well as the rubric. Throughout each of these stages of development one common theme that I noticed was the involvement primarily of the educator side of the work and little from the viewpoint of students. What I began to wonder was how could I make sure students had some ownership of their learning.

Initially this began with a shift to an inquiry model of teaching. Students are provided with opportunities to explore their own testable questions through investigations and data collection in order to make connections to our content standards. The second shift was to ensure students were aware of the scientific practices that they would need to employ in order to answer their testable questions and the crosscutting concept or concepts that would best help them connect their practices to their standards. For this to be successful, appropriate feedback and explanations are necessary to provide opportunities for a student to confidently demonstrated necessary skills and content knowledge.

In the past, when I provided my classroom climate surveys, students have mentioned that they sometimes feel like they do not get enough feedback to know how to improve their science skills that are graded on our middle school science rubric continuum. I provide informal feedback often in the form of further questions or compliments of appropriate demonstration of skills while they are working or formally on lab/ activity documents. Unfortunately, they sometimes feel they cannot use this to help them move forward. I am hoping that by formalizing this process they can better understand how to use the questions and feedback I provide.

I set specific goals each school year to help me improve student learning and throughout the past two years, my goals related to specific NGSS practices or cross-

cutting concepts. Last year, while working through EDCI 505- Foundations of Action Research course with Montana State University, I was analyzing my student climate surveys. I recognized that although students felt they enjoyed my class and they felt like I was clear in what they were going to learn, they wanted more clarity on what they needed to do in order to do better. It felt logical that the step in my evolution as an educator was to ensure my informal discourse and formal feedback could provide the details necessary for students to feel like they were successfully reaching an understanding of core ideas and/ or successfully demonstrating scientific practices. In addition to providing the most appropriate feedback to students, I also wanted to look at different ways of providing feedback, then determine if one or more methods are more effective in improving student learning.

This led me to my project focus. I thought about how I could help students know how to improve upon areas of difficulty and to ensure students clearly understood teacher expectations.

Purpose and Focus Questions

The purpose of this study was to improve student understanding and attitudes towards the learning of middle school science concepts and practices through feedback. My focus question was: What are the effects of using varied feedback styles on students' understanding of sixth grade science concepts? My sub questions were:

1. What are the effects of using varied feedback styles on students' attitudes towards sixth grade science?
2. What specific forms of feedback might be more effective at enhancing student learning?

3. What are the effects of using varied feedback styles on my preparation time and teaching methods?

Support Team and Roles of Team Members

I could not complete my work without a great support team. I was able to find a diverse group of colleagues from ACS AD and present or former professors in the Master of Science in Science Education (MSSE) program. Each of them have provided a different perspective to help me successfully navigate the Capstone project.

Emma Carroll, a Grade Seven Science educator from ACS AD is in her 13th year as an educator and her first year as a science-only educator in the middle school. Emma and I worked together in Kuwait and were reunited in our school in Abu Dhabi. She is a tireless worker and has been a great support for me while working together in the middle school. Emma, our grade 8 science colleague, and myself are working on a book study that I am leading to help with bringing inquiry into all our middle school science rooms. We are a part of a team dedicated to creating a model teaching system that ensures inquiry is at the basis of our instruction.

Brent Raven is a MS Physical Education teacher with ACS of Abu Dhabi and is in his tenth year as an educator. Brent and I are two of the only teachers that directly educate all of our grade 6 students. His educational background in Sports and Recreation has always intrigued me. His university physical education program in New Zealand required substantial action research and he has been an invaluable resource while working through my research. His familiarity with the students and his background in action research provides a unique perspective my other colleagues may not be able to provide.

Eric Richards is our High School (HS) Science Department Chair at ACS of Abu Dhabi. He is in his 16th year as a high school science educator. Although he and I also met in Kuwait, our paths were originally via hockey. He has been one of my most trusted advisors throughout his time at ACS. He and I have worked on helping to provide the scaffolding necessary for successful implementation of NGSS at the HS and MS levels and we have worked on trying to provide a natural progression between the two schools. He has showed a genuine interest in my Masters work and often provides suggestions for activities for my classroom or that we work on together that relate directly to my coursework.

Matt Foss is a HS Language Arts educator with ACS AD and is in his 23rd year of teaching. His experience from his Master of Science in Education and his dedication to our HS English department provide me with insights into difficulties I might come across in my writing and clarity of information. He has been my editor on past work and has stated he would love to help me as I push myself further in my education. He and I share a commonality in trying to create an environment that is safe and nourishing for students, which provides a healthy balance of fun and hard work.

Alba Carollo is the MS Principal at ACS of Abu Dhabi and is a 26 year education veteran. She has an MEd of Educational Leadership and a Superintendent Letter of Eligibility within her education background. Alba has been in principal positions for over a decade and has been a supporter of my life long learning. She has provided me with leadership opportunities in our school and has provided valuable feedback from an administrators point of view.

George Tuthill is my Science Reader and is a Professor Emeritus from Montana State University. He was my instructor for my physics courses in the MSSE program

and has been a key contact throughout the program. George has provided valuable guidance on lesson instruction and in challenging my science misconceptions. He is a trusted advisor that I am lucky to have offer guidance and suggestions for improved data collection and analysis.

Walter Woolbaugh is my Committee Chair and an Adjunct Professor with Montana State University. He was my instructor for my EDCI509- Implementing Action Research in Teaching and Learning class and along with George has been my most reliable source of guidance from Montana State. His leadership throughout the fall semester of 2018 has been invaluable and I appreciate the way he has helped me to prepare my Capstone project.

CONCEPTUAL FRAMEWORK

The middle school science classroom is an ever-changing landscape with evolving education practices and improved modes of learning. Despite these changes, one of the most important obligations from a teacher lies in consistently providing student guidance towards achievable benchmarks. Some classrooms have positioned themselves to offer varied feedback methods that provide multiple avenues for students to receive guidance in order to deepen learning. This opportunity to expand thinking promotes self-efficacy linking to science achievement in the middle school classroom, often defining the academic choices students make (Bandura, 1997).

Susan Brookhart argues that in order to help promote this control over a student's own learning, they need feedback which provides both where they are in their learning and what is next (2017). Research has shown that students that are provided with descriptive feedback are both more motivated and perform better on subsequent tasks than those who are provided with only letter grades or evaluative

feedback (Butler & Nisan, 1986). Despite the positive role feedback provides in helping students gain a belief in their ability to succeed, many students do not receive accurate, detailed, goal-oriented feedback (Ruiz-Primo & Li, 2013). This often leads to poor academic performance, low motivation, or inhibited learning. This is why effective teacher feedback that provides the next steps for students to achieve is essential. Defining where students are in their learning and clarifying what a student needs to understand is essential in helping create clear goals for academic success. (Brookhart, 2017).

In the middle school classroom one of the most important aspects is how an educator connects with his students. When done well, feedback can provide a valuable link between educator and student, as it “encourages students to think and act like learners and results in deeper learning” (Chappuis, 2015, p. 94). However, in order to promote deeper learning, quality feedback must address both cognitive and motivational factors. The combination of these has proven to consistently be more valuable than receiving just grades. Several studies have supported this, like Butler, who found students were more motivated to work when provided with descriptive feedback (1986). Butler found that students that want to understand more and who are willing to work to achieve this are provided with greater opportunities to be a learner. In fact, Elawar and Corno (1985) found that when provided with constructive feedback students indicated a positive attitude towards their subject. The grade 6 teachers in the study were able to make breakthroughs with all levels of learners and found an increase in academic achievement as well as attitudes towards the subject.

Eliminating frustration by providing the guidance to reach an extended level of understanding is crucial. It provides a way of lowering performance anxiety and in

helping students continue the learning process. Too often students are left without feedback and only a low number grade, contributing to little desire to repeat the same work (Butler, 1988). This suggests valid reasoning for why a student might not complete future work, or would have low motivation for receiving similar results. A positive way to help eliminate this is to further extend feedback by adding in pedagogically informed schema further elevating the quality of comments. Teachers that are aware of the most recent shifts in science education are able to provide greater clarity to their comments and therefore students are able to develop better responses. An example is when pedagogically informed feedback was provided to a group of sport science students, there was a shift in their confidence in a variety of areas, in particular when writing scientific laboratory reports (Thomas & Oliver, 2017). In the Thomas & Oliver study, they looked for relationships between feedback perceptions and likelihood of use by analyzing bivariate correlations. Using this type of examination of data provided ample connections to pedagogical feedback and its ability to inform next steps in the learning cycle. Students demonstrated that confidence is a crucial aspect of motivation and has long-term effects on self-efficacy.

Science notebooks and laboratory reports provide two locations where science teachers can provide feedback that guides students to reach academic expectations. The combination of both scientific practices and conceptual understanding that are a part of the Next Generation Science Standards (NGSS) are descriptive categories for a teacher to use as guidelines to give specific feedback and to point out strengths. By providing the guidelines that nurture self-awareness, students are more likely to demonstrate efficacy (Chappuis, 2015). Appropriate

feedback ensures students are able to use these guidelines to set learning goals and criteria for self-assessment, which nourishes academic success, with greater learning achieved (Chueachot, Srisa-ard, & Srihamongkol, 2013). In a study of 300 university students in Auckland, it was found that students reported high academic self-efficacy (ASE) when actively taking up feedback. These students acted on their teacher's guidance and also demonstrate self-regulation in their study attitudes. By believing in how to use the feedback as a guide for their next steps, they were able to find greater academic performance (Brown, Peterson, & Yao, 2016).

However, in order to be successful the comments need to occur during learning and students must be provided with time for remediation before further assessment. In a Nigerian study of 240 junior secondary schools, there were significant differences in mathematical achievement for those that received remediation with their feedback, then those who just received just feedback (James & Foloruns, 2012). The combination of remediation and feedback gives students an opportunity to fix mistakes, clear up misunderstandings, adjust wording for clarity, and add further depth to the learning. As academic achievement is almost always based on a grading scale, having an opportunity to practice what has been guided is an essential element of future success.

In the same sense, if feedback is inaccurate future achievement is negatively influenced. If we think of an athlete that is given faulty guidance it is probable they will demonstrate a skill poorly resulting in an ineffective performance and a lower likelihood of success (Hirst, DiGennaro Reed, & Reed, 2013). Unfortunately this is a common problem for teachers who often find it difficult to find the time necessary to provide both prompt and clear feedback. In one study of 26 teachers and their

students it was found that less than 5% of the comments provided in student science notebooks included appropriate or accurate written feedback for students. It was noted however that it was unknown how much verbal feedback was provided (Ruiz-Primo & Li, 2013). Much of the reason for the low quality written feedback is that notebook responses are time consuming, which is often why teachers do not use them to assess or respond to students (Aschbacher & Alonzo, 2006). This indicates that having strategies to reduce the time it takes to give effective feedback is essential.

Brookhart argues that variance in strategies and content provide opportunities to give timely, quality feedback. Her strategy recommendations include: amounts, timing, mode, and audience (2017). The mode is a key factor, as it looks at the perspective of oral, written, and demonstrative feedback. Teachers are constantly providing oral feedback throughout lessons and during activities, however determining the best time for this is often simply when it feels right. When providing more comprehensive information different modes can also be applied. A Perth, Australia study of 299 first year university students looked at the effect of video feedback on students and on teacher workload. Students contributed high praise for video feedback, with 91% stating it was of greater value than written feedback and many indicating it improved student-staff rapport. In the study the students were provided with an individualized screencast for each of their two assessment items from the study. In the 10 to 20 minute screencasts, their assignments were marked 'live' and the teachers narrated their process of using the assessment rubric and allocating marks on the form. Teachers also recognized they could provide comprehensive feedback that did not impact their workload (West & Turner, 2016).

Varied feedback in this study includes a variety of modes including: written comments, oral comments, and video feedback, as well as peer feedback. Oral feedback is provided immediately to students as they hand in lab activities, while written and video feedback take a day or two to be produced. As I follow the NGSS exclusively, there is usually one scientific practice and/ or crosscutting concept that is focused upon at each feedback stage. The feedback provided is based on their rubric. It comprises of a combination of questions as well as informing criteria from descriptors on the rubric. Questions guide further thoughts or ask for clarification about criteria missing from the rubric.

By providing guiding questions, students are forced to look beyond their own words and seek further detail. The questions also provide next steps as they look to move up the grading continuum or to extend further within their criteria strand. The use of a common rubric throughout the year ensures grading criteria does not change although the topics do. This is a crucial way of setting up metaphorical goal posts that do not move for students, even when the content itself is different. For example during a unit on Cell Structure and Function, students had a formative assessment that focused on three major criteria: Conducting Investigations, Analyzing and Interpreting Data, and Constructing Explanations. During their group investigations, they were provided with feedback that included specific, descriptive comments that directly linked to rubric guidelines and questions about how they might try to accomplish the rubric criteria. These statements provided further thoughts about specific content criteria, as well as questions that help them refine their initial responses. This feedback was the basis of their study and preparation for their summative assessment that required responses in a new, but similar context.

Brookhart suggests that some assignments lend themselves better to specific forms of feedback, but also recognized that certain students benefit from feedback that is best for their learning styles (2017). Brown and Yao found an interesting correlation to these thoughts as they found peer feedback was more useful as a study check-in as opposed to a guide for future success. Students also demonstrated difficulty in finding gaps in their own learning, so the need for feedback from others, in particular teachers, was necessary as it provided more clarity and was felt to be more reliable (2016). A study in Oman found similarities as students looked at recall of information. The study found that students could generally monitor their learning, but required teacher guidance in order to provide appropriate self-assessment (Al-Harthy, 2016).

As can be seen when provided with feedback that occurs at appropriate times, that addresses where students are now in their learning, as well as where they need to get to next, students are able to find academic success. Additionally, students are provided with a greater self-awareness, meaning they can take action and set their own goals. Giving students the guidance necessary to know where they are going and then providing time for remediation and reflection can help with connecting educators to their students and improve student learning.

METHODOLOGY

My classroom research project was focused on one of the most important aspects of student improvement and academic development, feedback. In conversations with parents and students, I often find they have a concern around how to improve a student's abilities in science, as well as how to ensure students know what they need to understand. By making use of a variety of feedback formats, I intended to find the

most effective ways of providing quality feedback to individuals and groups of students in order to elevate their achievement in science.

The action research was conducted from the last week of October 2018 through to the first week of March 2019. In mid October students completed their work with the hydrological cycle. Students had already been introduced to the common rubric continuum (Appendix A) they will be assessed on for the school year and have become familiar with the terminology within the rubric, as well as how the rubric helps to define the elements that characterize higher levels of achievement. Each topic of study has only one or two scientific practice strands from the rubric which students are assessed on for each assessment.

Participants and School Description

The study involved all four grade six classes, three of which had 22 participating students and one had 21 participating students. There were a total of 47 boys and 40 girls with direct heritage from more than 30 different countries, however just over 50% have United States Passports. Between all of the classes, there are 8 students that receive learning support for a variety of learning difficulties. The support services help with Attention Deficit Disorder (ADD), Attention Deficit Hyperactive Disorder (ADHD), English as a Second Language (ESL), undefined reading disabilities, and dyslexia. Each of these students are provided with different accommodations, in particular extended time for written assessments.

ACS AD is an International School in Abu Dhabi that provides an American style curriculum to its nearly 1200 students from KG1-grade 12. It is a non-profit, United States accredited college preparatory school. In grades 11 and 12 students can choose between ACS AD courses, enrolling in the International Baccalaureate (IB)

Programme, or Advanced Placement (AP) courses. There are approximately 80 countries represented in the overall population and about 20% speak another language primarily at home. Despite this diversity, nearly all students are confident, fluent English speakers and writers.

The school has a relatively affluent community. Most families have substantial housing and schooling provided by the company that employs them. In many households, both parents hold graduate degrees, including many PhDs, but have only one working spouse. This provides opportunities for both non-working and working parents to be actively involved in the school and the community. Parents and the Parent Teacher Association (PTA) organize events such as our International Day, grade level activities, social events, recreational events, and fundraising which help to contribute financially to activities and items that enhance opportunities for students on campus.

Treatment

Beginning the first week of November and completing the first week of March, students were taught 4 scientific topics. The first topic focused on Properties of Matter and the Structure of Molecules. This was a Non-Treatment topic, where students were provided with exemplars and rubrics that were highlighted with specific attained criteria for formative work, but with no direct feedback about how to improve their work or questions to help with further reflection on quality of work. The objective of this was to provide a baseline for students as they attempted to reach academic expectations without descriptions about areas of difficulty or strengths, nor suggestions about how to demonstrate higher levels of proficiency in their work. The rubric was the one common tool that would be provided to students during both the

treatment and non-treatment sections. The specific focus of the topic was on developing models using atomic structure of simple molecules. There were two formative assessments they worked through, each developed around one core idea and one or more modelling elements, including: how to accurately label, how to show motion, forces and changes in energy, as well as how to show relationships between components.

The second topic of study, weather, was the first treatment topic. During this topic of study, students were provided with exemplars of proficient or extending proficient work and highlighted rubrics for formative work, as well as written narrative feedback. The feedback described areas that were appropriate to the task or how to improve future work or posed reflective questions that had responses that could be demonstrated on future work. There were two primary formative assessments that took place; each assessment was centered on a core scientific idea and cause and effect relationships found while collecting and analyzing data.

The third topic of study, climate, was our second treatment topic. The three formative assessments for this topic focused on core ideas and the development or use of models describing regional climates. Students were provided with video feedback about their work and samples of other students' responses that showed proficient or extending proficient work. The video feedback described missing components or relationships and showed how to improve future work. It also provided reflective questions that had responses that could be demonstrated on future work. Students used the videos to help them highlighted their own rubrics for their formative work.

The fourth topic of study, global temperature change, was our third and final treatment topic. There were two formative assessments for this topic, with a focus on

asking questions that help address phenomenon which connect to the stability of Earth's global temperatures due to human based activities. Students were provided with exemplars and highlighted their own rubrics for formative work while having one-on-one conferences or small group discussions of the rubrics and exemplars.

Table 1 describes the timetable for the treatment and non-treatment topics of study for the Water and the Environment Unit. The project lasted just over 4 months but also included a three-week winter break. Each topic of study had approximately the same number of lessons.

Table 1
General Treatment Plan and Schedule

Topic 1- Properties of Matter and Molecular Structure Non- Treatment	Topic 2- Weather Treatment 1- Written Narrative Feedback	Topic 3- Climate Treatment 2- Video Feedback	Topic 4- Global Climate Change Treatment 3- Oral One-On-One or Small Group Feedback
Dates: 10/30-11/25 12 lessons, 1 review day and 2 assessment days	Dates: 11/25-01/16 11 lessons, 1 review day and 2 assessment days	Dates: 01/20-02/18 11 lessons, 1 review day and 2 assessment days	Dates: 02/19-03/06 9 lessons, 1 review day and 1 assessment day
-Administer unit pre assessment. -Provide daily learning performances. -Teach daily lessons for topic. -Formatively assess students throughout topic to show understanding of science practices, cross cutting concepts, and core ideas. -Teacher reviews formative assessment responses. -Students are provided with highlighted rubric and proficient and extending proficient samples. -Students complete a next steps checklist. -Administer unit post- assessment.	-Administer unit pre assessment. -Provide daily learning performances. -Teach daily lessons for topic. - Formatively assess students throughout topic to show understanding of science practices, cross cutting concepts, and core ideas. -Teacher reviews formative assessment responses. -Student is provided with highlighted rubric with written narrative feedback on areas of difficulty or strength, including notes about proficient and extending proficient samples. -Students complete a next steps checklist. -Administer unit post- assessment.	-Administer unit pre assessment. -Provide daily learning performances. -Teach daily lessons for topic. - Formatively assess students throughout topic to show understanding of science practices, cross cutting concepts, and core ideas. -Teacher reviews formative assessment responses. -Student is provided with video feedback describing areas of difficulty or strength and how they related to proficient and extending proficient samples. -Students highlight their own rubric and complete a next steps checklist. -Administer unit post- assessment.	-Provide daily learning performances. -Teach daily lessons for topic. -Administer formative as pre-assessment - Formatively assess students throughout topic to show understanding of science practices, cross cutting concepts, and core ideas. -Teacher reviews formative assessment responses -Students meet with teacher to receive feedback on areas of difficulty or strength and discuss proficient and extending proficient samples. -Administer unit post- assessment.

Instrumentation

Data for the non-treatment and treatment portions of the research was collected from the last week of October through to the first week of March. This included the Science, Engineering, Technology and Mathematics (STEM) Semantics survey (Appendix B). It is a 25-item instrument, designed by The Innovative

Technology Experiences for Students and Teachers (IT-EST) program, “created to assess perceptions of Science, Technology, Engineering, and Math (STEM) disciplines and careers” (Christensen, Knezek, Tyler-Wood, 2010, p. 341). The survey was conducted both before the project began as well as after the third treatment was completed. The data from these as well as the Pre- and Post-Treatment Participation Surveys (Appendix C and D), and Post-Treatment Student Interviews (Appendix E) are used to answer the question, “What are the effects of using varied feedback styles on students’ attitudes towards sixth grade science?”

The first STEM Attitude Survey was conducted by all 87 students during the last two weeks of October and the Pre-Treatment Participation Survey was completed by 83 students during the first week of November. There were 39 girls and 44 boys that conducted the survey. Several students were away ill during various parts of November and unfortunately four were unable to find time to complete to complete the survey.

Data was also collected for the Pre and Post Topic 1- Properties of Matter and Molecular Structure Assessment (Appendix F & G). All 87 students completed the assessments with 50 additional minutes provided to all 8 of the learning support students. The results from the three other topic pre and post assessments, including Topic 2- Weather (Appendix H), Topic 3- Climate True/ False (Appendix I), Topic 4- Climate Change (Appendix J) and the Climate Modelling Summative (Appendix K) were combined with results from the Pre- and Post- Treatment Participation Surveys and Post-Treatment Student Interviews to answer the sub question, “What specific forms of feedback might be more effective at enhancing student learning?” and the

focus question, “What are the effects of using varied feedback styles on students’ understanding of sixth grade science concepts?”

In order answer my last sub-question, “What are the effects of using varied feedback styles on my preparation time and teaching methods?” I collected data from daily lessons using the Teacher Daily Reflection survey (Appendix M). Every two to three weeks, I then compiled that information using the Teacher Bi-Weekly Journal Prompts (Appendix N). This combined with observations conducted by my team of colleagues using the Colleague Observation Survey (Appendix L) provided details to help me reflect on how I was implementing feedback, how students were using feedback, and to generate approximate amounts of time it took to provide the feedback to students.

I was able to share an overview of my project with most grade 6 parents during our Back-To-School Night on September 23, 2018 and then sent a detailed email on September 25, 2018 explaining the project to all parents and seeking their permission to use the data from their children. All but one parent approved the collection of their child’s data. IRB approval was also confirmed on October 8, 2018 (Appendix O).

The purpose of this study was to improve student’s understanding and attitudes towards the learning of middle school science concepts and practices. Brookheart’s book, *How to Give Effective Feedback to Students* (2017) provided much of the scaffolding I used to implement feedback. I used key suggestions from her including “effective tone and word choice” that help students to be active participants in their learning. A major focus was to determine criterion-referenced feedback that students could use in future work. My feedback provided words that positively framed

strengths and offered suggestions about weaknesses that were definitive enough for a student to know what their next steps would be or how to further elaborate on concepts or to demonstrate skills.

To further help students visualize their next steps, I worked with my middle school science colleagues to develop a feedback template (Appendix P). Students used this electronic document to write my feedback in their own words to help them prepare for their future assessments. Students were provided with time after summative assessments to look over their graded rubric and to reflect on any additional feedback provided to them from the various assessments in the topic of study. They then filled in the template and were provided with time to refer back to it as they got closer to future summative assessments. I also took time to go over the details of these shared electronic documents to see how students were making use of the template and to see if any students were having difficulty.

For students that had difficulty during various topics or in using the template, I used “Feedback Strategies for Struggling Students” (Brookheart, 2017). I met with students to “check for understanding of feedback” and to help them “select one or two important points for improvement.” After these meetings, students modified their template to help set more appropriate goals for future assessments.

Throughout the study, I had colleagues observe my classroom and talk with students about the feedback they had received and how they were making use of the suggestions and questions I provided in order to develop improved work. The feedback my colleagues provided helped me to modify my approach to providing feedback for students or continued to model successful processes they observed.

This also provided reliable data to help me determine if feedback was effective for students.

I also had my colleagues, principal, science reader, and advisor provide feedback about each of my instruments. They helped me to refine the questions for my surveys, to create consistency between pre and post assessments, as well as to offer suggestions on how to organize my time for delivering various instruments.

In order to validate how students improved their conceptual knowledge and their ability to demonstrate scientific practices, I used test results to determine student growth and grade level successes. I also made use of my student surveys and interviews to help provide enough data to validate student's opinions on their attitudes towards the learning of science. This helped me to gain reliable data that described the form of feedback that was most effective for each student and grade 6 students overall. It also helped ensure I could triangulate the connection between the effect of feedback and assessment results. Below you will find the sources of data collected in order to allow for data triangulation in order to answer the research questions.

Table 2

Data Triangulation Matrix

Research Question	Data Source 1	Data Source 2	Data Source 3
Focus question: What are the effects of using varied feedback styles on students' understanding of sixth grade science concepts?	Pre- and Post-Topic Assessments	Pre and Post Treatment Participation Surveys	Post- Treatment Student Interviews
Sub-question: What are the effects of using varied feedback styles on students' attitudes towards sixth grade science?	Pre and Post Treatment STEM Attitude Surveys	Pre and Post Treatment Participation Surveys	Post- Treatment Student Interviews
Sub-question: What specific forms of feedback might be more effective at enhancing student learning?	Pre- and Post-Topic Assessments	Pre and Post Treatment Participation Surveys	Post- Treatment Student Interviews
Sub-question: What are the effects of using varied feedback styles on my preparation time and teaching methods?	Teacher Daily Reflection Survey	Teacher Bi-Weekly Journal Prompts	Colleague Observations of Teacher

DATA ANALYSIS

What are the effects of using varied feedback styles on students' understanding of sixth grade science concepts?

I used my various sources to attempt to answer my focus question about the effect of using varied feedback styles on students' understanding of sixth grade science concepts? The pre and post assessment results for the Topic 1, Non Treatment: Properties of Matter/ Structure of Molecules modelling skills can be found in Figure 1.

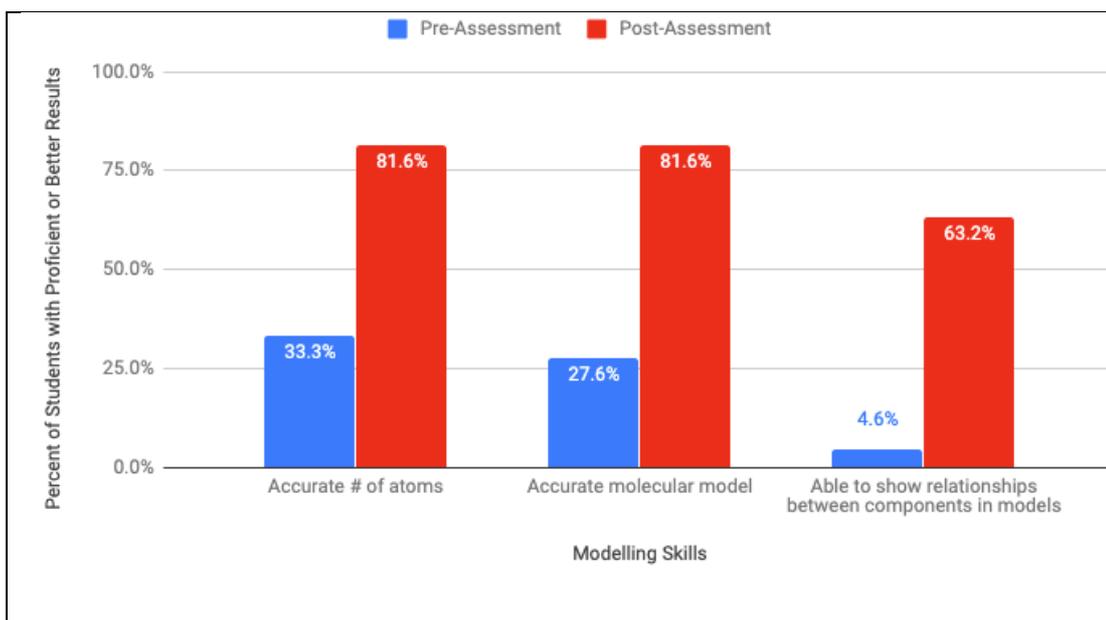


Figure 1. Percent of students with proficient or better results for modeling skills, and atomic structure knowledge, ($N=87$).

This was my non-treatment topic, where students were only guided by a highlighted rubric and other students' exemplars, as well as my daily lessons. Students demonstrated dramatic improvements in their accuracy of molecular model drawings. There was an increase of 54% more accuracy when drawing molecular models and less than 20% of the students missing or omitting minor details. There were three students who drew an accurate simple molecular model in their pre-assessment, but who were unable to draw an accurate simple molecular in the post-assessment. For one of the students they attempted to connect too much new or extraneous content that they were a little unclear about, in particular polarity between atoms, that they were unable to show an accurate structure. For the other two students they mixed up the new content of electron structure within atoms to the more simplistic connection of atoms within molecules.

A common rubric is used for all formative and summative assessments. Students reacted positively to the rubric as a form of feedback and the use of

exemplars. Students mentions things like, “I know what to include” or noted that they “know what to expect.” A few students mentioned they could learn from the examples of other students and couple mentioned having an idea on what to improve on in order to achieve greater results.

Our weather topic was the first treatment topic, where students were provided with written or typed narrative feedback. The assessments involved the organization and analysis of data as evidence. Table 3 below describes the mean, standard deviation and % of students with proficient or emerging proficient results between the formative pre-assessment and summative post assessment.

Table 3

Topic 2, Treatment 1- Weather Pre and Post Assessment Results

	Mean	SD	% of Students with a score of 3 (Proficient) or 4 (Extending Proficient)	% of Students with a score of 1 (Emerging Proficient)
Formative Pre-Assessment (N=85)	2.55	0.55	58	2
Summative Post-Assessment (N=85)	2.65	0.80	54	5

Note. ACS Grading Scale 4=Extending Proficient, 3= Proficient, 2= Approaching Proficient, 1=Emerging Proficient .

The results on this were not surprising. The work for this unit began before our winter holidays and continued after the holidays. Despite the increase in mean results, an increase of about 4%, there was a 5% decrease in students developing proficient analyses or representing their data in an appropriate format. In addition, there was a 3.5% increase in the number of emerging proficient results. It should be noted that during the formative assessment, students were given opportunities to resubmit their work for grading. Only two students chose not to resubmit their work, which were the only two students with an emerging proficient result.

Another note about the drop in scores was found during my interviews. One student noted that sometimes my feedback used complex words that they just didn't understand or was too detailed and they didn't know what to do next. This was also the first treatment topic and the first time they received detailed, written or typed feedback that might have caused confusion and have been why a student noted that, "if I was given a paragraph of things to improve on I would get lost and not know what to improve on."

I also noted in my journal that I found students had difficulty with data collection, and I didn't follow up on it earlier enough to be able to provide the appropriate feedback to help them improve. I was also too rigid in my adherence to the narrative process and should have made more adjustments to provide more oral feedback to guide the process.

I ran a paired t-test to see if there were any noticeable relationships between the two set of assessment results.

Table 4
Topic 2, Treatment 1- Weather Pre and Post Assessment Paired Samples Test

	Paired Differences				t	df	Sig. (2-tailed)	
	Mean	SD	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower				Upper
Post Assessment – Pre Assessment	0.10	0.35	.027	0.030	0.140	-1.209	84	0.230

There was no statistical significance between the pre assessment results ($p=0.230$) and the post assessment results (mean = 2.65, SD, 0.80). The 95% confidence interval for the different is (0.030, 0.140). The means are not due to the amount and type of feedback that was provided to student.

Students who asked questions during the formative assessment process were given guidance and suggestions from me and could discuss their responses with their team before submitting their formative assessment. Although students could use their notes for their summative assessment, they were not able to ask leading questions (questions that could lead to a definitive answer) of me and did not have their group members to discuss answers with before submitting. This would have a positive influence on the formative assessment results, and would seem to be a factor that would influence more positive results for the formative assessment as compared to the summative assessment.

During our third topic, students were assessed on their modeling skills for the third time in the year and the second time in the project. This was also the second treatment topic, where students were provided with video feedback. Students completed a ten-question true/ false assessment to provide data about their understanding of core ideas surrounding how climate is affected by various factors on Earth. The results for the pre and post assessment can be seen in Figure 2 below.

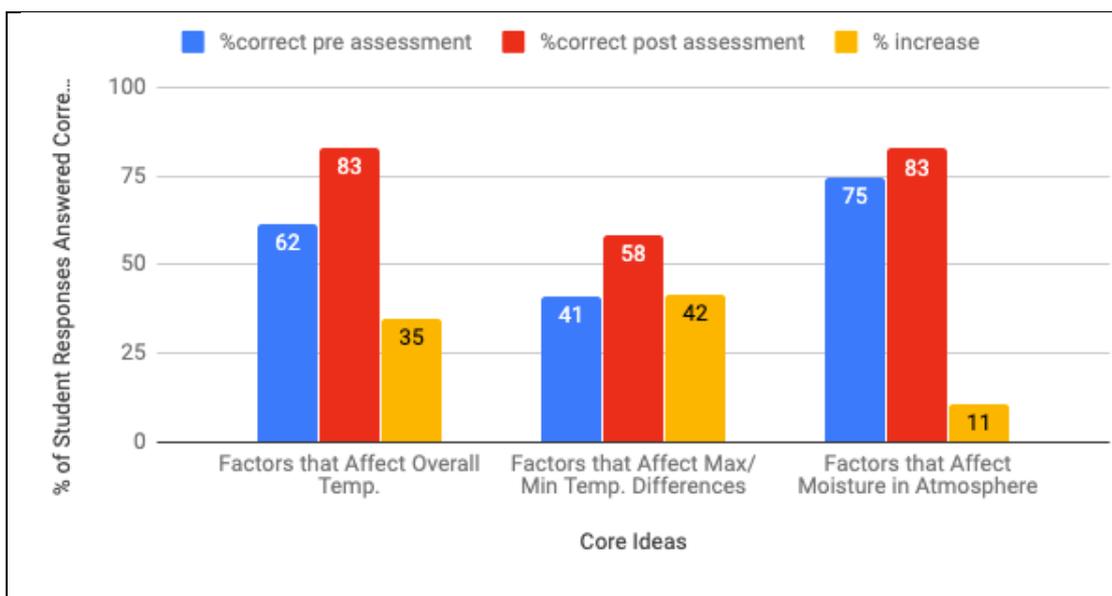


Figure 2. Pre and post assessment accuracy with percent increase, (N=86).

The true and false questions were categorized by three factors: those that affect overall temperature, those that affect differences between maximum and minimum temperature, and those that affect moisture in the atmosphere. Students came in with some previous knowledge from our grade six studies on the hydrological cycle and weather. Nearly 75% of the students were able to state accurately how factors such as proximity to oceans and mountains affect moisture in the air before the treatment. After the treatment, all but one student got at least three of the four questions correct that related to this content. A continued area of difficulty was recognizing factors that affect the difference between maximum and minimum temperature differences especially as they relate to a location that is oceanside versus a landlocked location. Despite this, it was also the area with the greatest percent increase at 42%. Just over 40% of the student's responses were accurate before the treatment and just under 60% were accurate after treatment. Overall students showed an improvement in their content knowledge, increasing from a mean correct average of 66% up to 82%, a percent increase of 24%.

An interesting note for the climate topic was the wide variety of relationships that were studied as compared to the three other topics. The properties of matter topic had only three relationships that students needed to be able to demonstrate. In the weather study there were also three key evidence relationships that students looked at, but there were three other expanded relationships within the topic for them to also address. The climate change unit only identified two major connections, but for the climate study, there were four relationships and extending from each of those relationships there were a total of 15 different conceptual relationships that students were introduced to and provided with opportunities to connect to.

Student proficiency scores from their Non-Treatment Summative assessment and Treatment 2 Summative assessment reveal positive trends in overall ability to develop models, as can be seen in Figure 3.

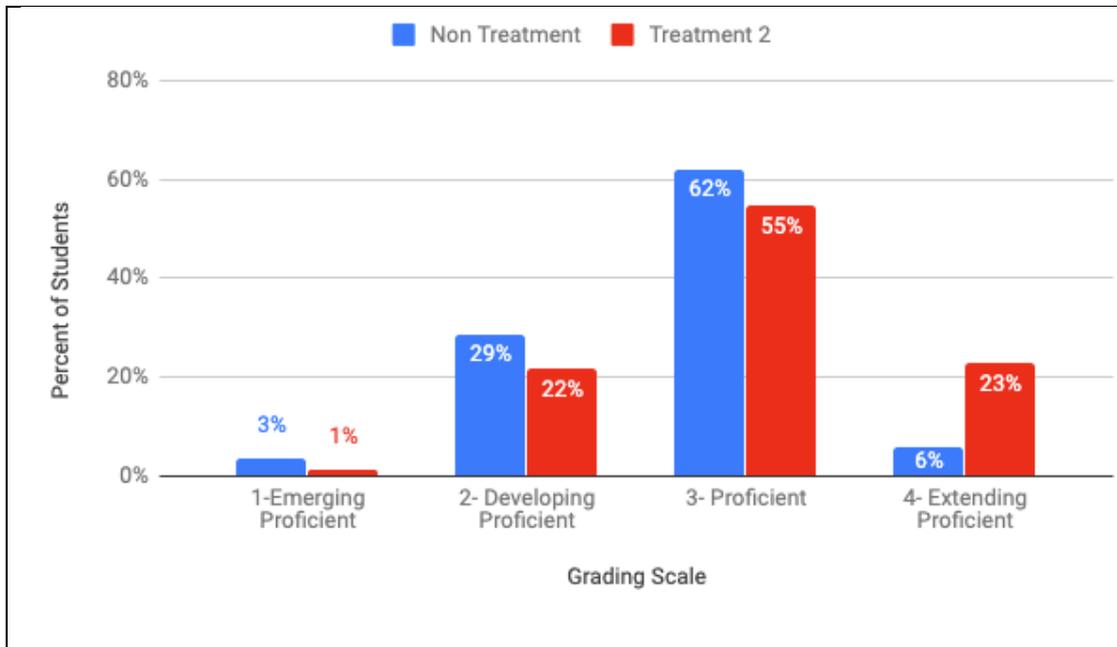


Figure 3. Non treatment and treatment 2- video feedback proficiency percent, ($N=86$).

During the Non-Treatment phase, students had their first opportunity to use exemplars and the rubric to help improve their scientific practices. There was almost 33% of the class that were unable to develop a proficient model, which related to difficulties in showing relationships between components. Only 5 students, 6% were able to provide a strong enough model that there were no questions that needed to be asked about the relationships between the various parts of the model in order to receive an extending proficient result. At the end of Treatment 2, students had experienced rubric grading, narrative written or typed feedback, and video feedback along with student exemplars for proficient or extending proficient work from the formative and summative assessments for each topic. The number of below proficient results dropped from 32% to 23%, a percent decrease of 28%. These models

primarily were either missing labels to describe components or did not show the relationship between components and instead either implied the relationship or described in words. There were four times as many students able to develop extending proficient models. These accurately labeled models showed unquestionable relationships between factors that affect climate, such as latitude, altitude or proximity to the ocean.

Students noted that the video feedback made it easier to learn from because information was “expressed clearly”, that they could hear the feedback more than once, and it provided clear student examples. Seven students noted that they liked that they could compare their work to the video samples and see what they could improve on. On the other hand, those that had difficulty with the video feedback mentioned things like, “I can’t stay totally focused on the information” and “it is too much information at once, I can’t process it all.”

The final topic of study was a chance for students to meet in small groups or one-on-one to conference and discuss areas for improvement. During this phase students completed a pre and post assessment where they needed to choose a testable question and to explain what makes it a testable question that can describe human factors that affect climate change. The results are found in the Figure 4 below.

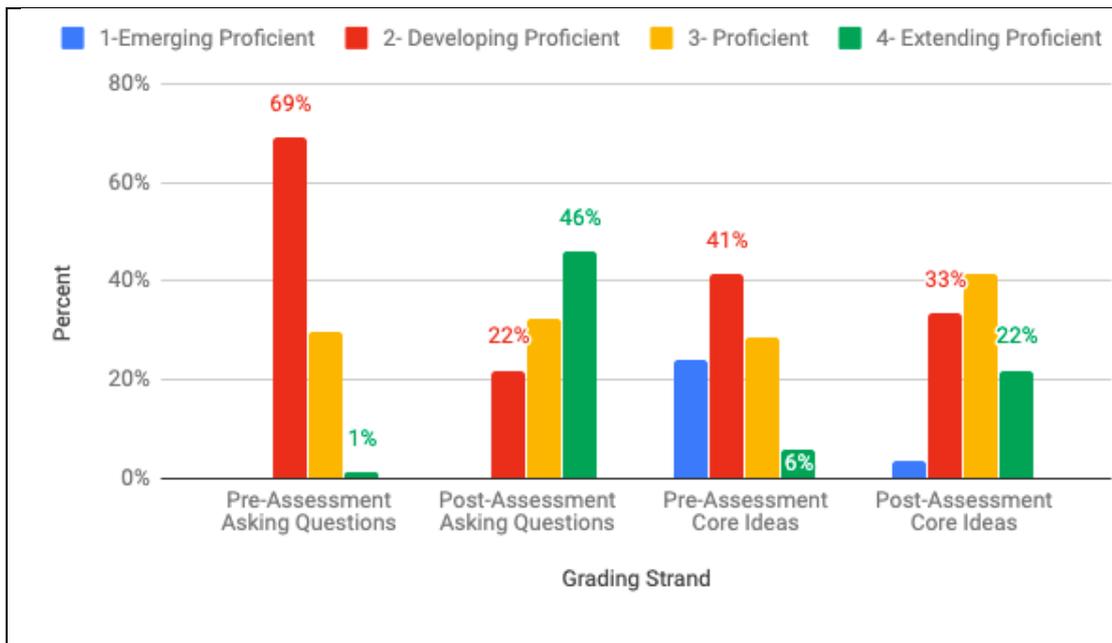


Figure 4. Treatment 3- oral feedback proficiency percents, ($N=87$).

During the Pre-Assessment every student was able to choose an appropriate testable question that described a factor that influences changes in global temperature. Only 31% were able to provide a proficient response where they chose a factor that was a human based activity and could describe at least the dependent or independent variable or examples of evidence that could be collected. One student only was able provide an extending proficient response, which described both variables, as well as examples of evidence. After working through the topic and receiving their feedback, all but 22% were unable to provide a proficient response. More noticeable was the ability for 40 students, a percent increase of 4500% to now provide examples of evidence and accurate variables.

Content is an area that many students struggle with when it comes to assessments. Before the treatment, 65% of the students had difficulty with our core ideas, struggling to provide evidence that would indicate human based activities or natural processes that influence changes in global temperatures. By the end of the treatment session, that number had dropped to only 36%. A couple of students noted

that they forgot many of the things that were discussed during the oral feedback sessions or “when I want to hear it again, where can I go? Google classroom? Veracross?”

On the other hand, the number of proficient responses increased from 29% to 41% and extending proficient responses increased from 6% to 22%. Each of these students provided key evidence that could indicate that humans are influencing changes in global climate change. These students noted things like, “I really like the way Mr. Neurinski lets me share my ideas during conferences and gives me suggestions that help me plan my work” and the majority who highly rated this category or feedback stated they liked that they could ask questions during these sessions.

What are the effects of using varied feedback styles on students’ attitudes towards sixth grade science?

To answer my first sub-question I used the the STEM Attitude Survey, Participation Surveys and Student Interviews to help to provide a picture of students feelings towards grade six science.

The Likert style STEM Semantics Survey had 5 repetitive adjective items used for each of the 4 STEM disciplines and opinions towards a career in a STEM-related field. Table 5 summarizes the average rating and standard deviation for each of the science related perception items before and after treatment.

Table 5
Science Perceptions Means and SD

To Me Science is:	Pre-Treatment Mean Average Rating (N=83)	Standard Deviation	Post-Treatment Mean Average Rating (N=78)	Standard Deviation
1- Fascinating 5-Mundane	2.05	0.97	1.96	0.87
1- Appealing 5-Unappealing	2.06	0.89	2.03	0.81
1- Exciting 5-Unexciting	2.12	0.92	2.00	0.94
1- Means a lot 5-Means Nothing	2.06	0.84	2.01	0.99
1- Interesting 5-Boring	1.88	0.96	1.88	0.93

All five items were more closely associated with the positive adjective term as opposed to the negative adjective term both pre-treatment ($N=83$) as well as post-treatment ($N=78$). Student responses were most closely associated with a neutral response to science being exciting or unexciting than another of the other adjective pairs before beginning the treatment phase of the project. It was six percent closer to a neutral value of three than the least neutral response for the pairs describing science as: interesting or boring. This pair also had the greatest mean change towards positive after treatment, with a three percent increase towards a value of one. All but one other pair of adjectives had a positive mean change after treatment varying from 1.4% to 4.4%.

The pairing that stood out the most was associated with students finding science fascinating as opposed to mundane. It had the second greatest change in mean at 3.1% and the greatest decrease in deviation from the mean with a 10% decrease. This seems to indicate a favourable attraction towards science and its ability to capture a student's interest. In general, it can be stated that students do have positive opinions about science and it is a subject that they show interest in.

Interestingly, the adjective pair with the closest score to a positive value of one remained even at 1.88 and had less deviation from the mean after treatment, decreasing by 3.1%. This was also the only pair of adjectives that had more than 40% of the class choose a value of one before and after the treatment.

One thing of note was how this was the category that had the greatest decrease in female mean scores. Table 6 shows the mean ratings for each category before and after treatment for males and females in the class.

Table 6
Science Perceptions Male and Female Mean Ratings

To Me Science is:	Female Pre-Treatment Mean Average Rating (N=42)	Female Post-Treatment Mean Average Rating (N=35)	Male Pre-Treatment Mean Average Rating (N=40)	Male Post-Treatment Mean Average Rating (N=42)
1- Fascinating 5-Mundane	2.12	2.11	1.98	1.83
1- Appealing 5-Unappealing	2.20	2.17	1.93	1.90
1- Exciting 5-Unexciting	2.17	2.22	2.07	1.81
1- Means a lot 5-Means Nothing	2.05	1.94	2.12	2.07
1- Interesting 5-Boring	1.83	2.00	1.93	1.79
Mean	2.07	2.09	2.00	1.88

Some noticeable comments females stated included, “I am not leaning towards becoming a scientist so this just doesn’t interest me” and “Earth Science doesn’t interest me as much therefore I’m not as excited when it comes to studying.” Many of the other comments leaned towards an interest in biology and the excitement that our future cell structure unit had for them. The overall mean rating for all pairs of adjectives remained near equal for females with an increase of less than 1%, buoyed by a noticeable increase in science having more meaning to females after our treatment.

The male overall mean rating for all pairs of adjectives on the other hand had a percent decrease of nearly 10%, with all five categories showing at least some shift towards the more positive adjective. This was most notable in the 12.5% shift towards how exciting science is for our male students. The adjectives fascinating, exciting, and interesting dominated the ratings and their comments on the survey highlighted things like, “You get to understand why things happen and it gets answered right in front of your face.” Several comments including the recognition that life and the world they live in is connected to science and how it was fun to find the relationships that connect things while doing experiments and looking at data.

The Pre-Treatment Participation Survey provided an opportunity for students to look at their own participation and confidence in science concepts. Figure 5 compares the percent of responses for each of the values on the Likert scale.

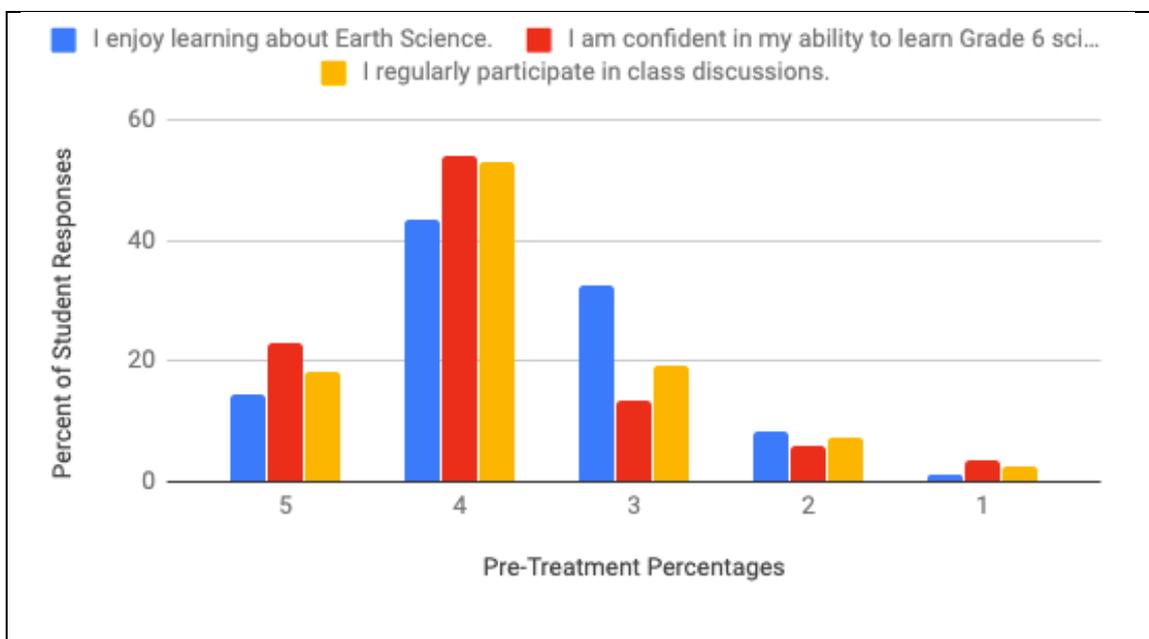


Figure 5. Pre-treatment percentages for Likert scale scores student participation and content perceptions, ($N=83$). *Note.* 5=Strongly Agree, 4= Agree, 3= No opinion, 2=Disagree, 1=Strongly Disagree

The data indicated that only 57.9% of the students enjoyed learning about Earth Science and nearly 10% did not enjoy learning about Earth Science. This meant

almost a third of the class had a neutral feeling towards the topic. For students who were neutral or lower, they indicated things like “plants, animals, and the water cycle lack excitement,” and “I don’t really know a lot of stuff so it makes this too hard and boring”, and “I just don’t find science interesting, especially learning about the earth.” With the number of students with neutral or lower feelings towards Earth Science, it was important to use these as motivation for finding activities that engage a greater numbers of students.

After making our way through our various treatments, students completed a Post-Treatment Participation Survey, results can be seen in Figure 6 below.

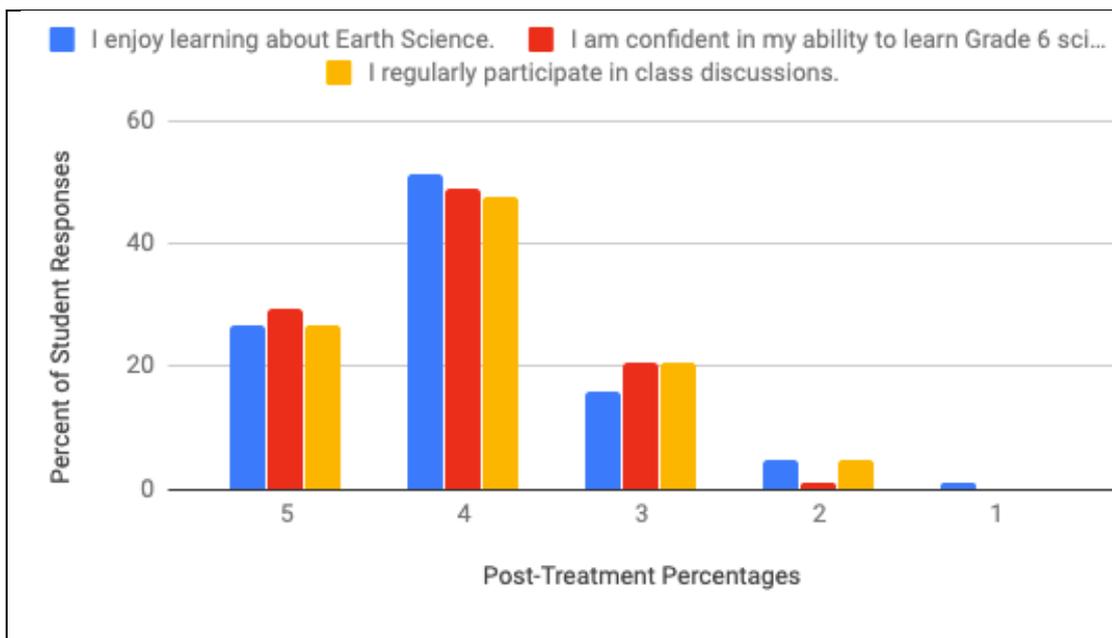


Figure 6. Post-treatment percentages for Likert scale scores student participation and content perceptions, ($N=82$). *Note.* 5=Strongly Agree, 4= Disagree, 3= No opinion, 2=Disagree, 1=Strongly Disagree

The data showed 78% of the students enjoying learning about Earth Science, which was an increase of over 20%. Students who strongly agreed with their enjoyment commenting about their learning being “beneficial for the future” and the lessons being taught in “a very interesting and imaginative way, where we get to act like meteorologists.” Others note that every day they felt like they learned something

new about the planet they live on. One student stated that, “Earth science was hard and boring, then I started trying and suddenly things became more interesting and then I wasn’t bored anymore, and I kept wanting to know and understand more.”

There were only about six percent still indicating they did not enjoy learning about Earth Science, but this was a decrease of 4%. This meant less than half as many students had neutral feelings towards Earth Science as before the treatment program began. For the few students who indicated a lack of enjoyment, they provided valid thoughts such as “not my cup of tea” or “it was fine until we discussed climate change and there was not enough room or time for me to express my negative opinion towards my disbelief in climate change.”

Before the treatment began, almost 10% of the students did not feel confident in their ability to learn grade six science, but by the end of the treatment, only one student still indicated this, providing a rating of two. After the treatment, this student also indicated they were “just are not interested” in Earth Science. Unfortunately, this student did not feel this same way before the project began providing a no opinion response of three for confidence in learning grade 6 science. Although they did not elaborate, before the project they did say “I enjoy science” while rating their feelings towards Earth Science at a four. Despite this one anomaly, there was an increase of student confidence to nearly 30% of the class an increase of over 6%.

During my student interviews (N=11), students were asked how feedback helped them participate in classroom discussion and activities. I used a rubric to sort oral responses into those that felt that the feedback they received was helpful, somewhat helpful, or not helpful in making it easier for them to participate in

discussions. A sample of student responses from each of these categories can be seen in Table 7.

Table 7
Sample Responses from Post Treatment Student Interviews Categorized by Level of Helpfulness

Level of Helpfulness	Sample Student Response to "Did you feel like Mr. Neurinski's feedback made it easier to participate in classroom discussions and activities?"
<i>Helpful</i>	Ya, because you know that now you can do better in class discussion. You are not afraid to be wrong and it makes you want to participate more.
<i>Somewhat Helpful</i>	Some of it, ya. But some of it I get hesitant about. Like sometimes if I get something wrong, I get nervous that if it comes up again, I get nervous to say the answer I think. If I am correct. Sometimes it does give me confidence. Like if I see that I had something wrong, then I want to see if I am now correct.
<i>Not Helpful</i>	The feedback you give us I personally think doesn't affect the conversations, well it depends on the type of conversations, like if you ask us to share about different models. We both do and don't need the feedback.

Nine of the 11 students interviewed stated they felt that feedback helped their confidence in participating and coincidentally all of them rated themselves at or just below strongly agree with how regularly they participate as per the Likert scale from figure 2. Five of those students also indicated an increase on their participation level at the end of the treatment as opposed to before the treatment began. The two students who found the feedback less helpful had no change in their participation level before and after treatment, remaining at four or five on the Likert scale.

In general student's attitudes towards using feedback and their confidence in participation seemed to coincide. Before the treatment began students seemed to be unsure of how feedback might be useful to them. The student participation surveys provided an opportunity for students to express how they felt towards the various feedback treatments. Data from these questions are found in Figure 7.

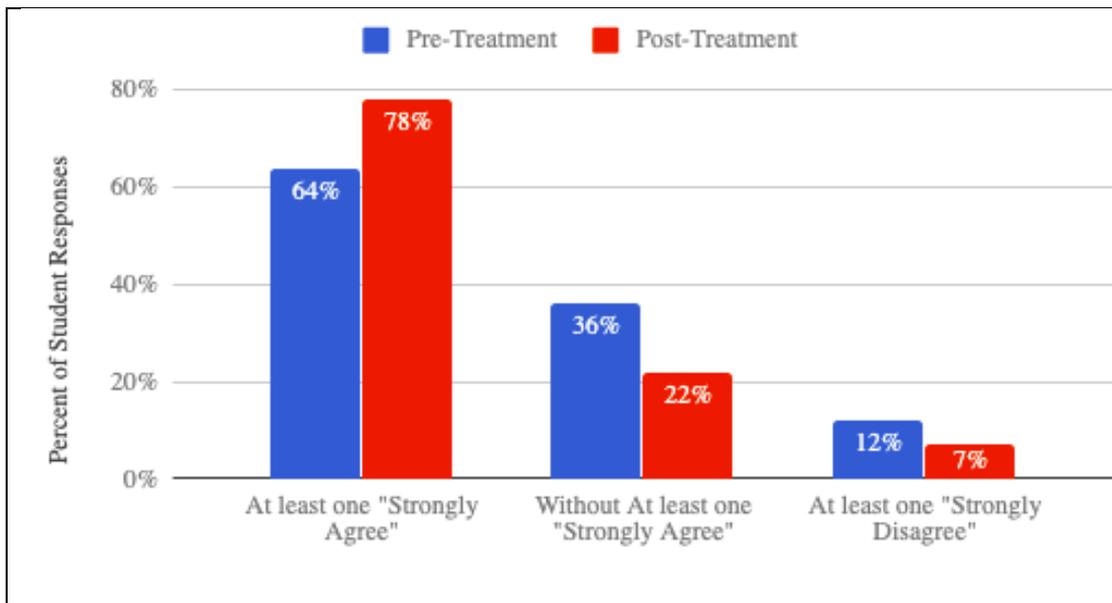


Figure 7. Pre and post-treatment percentages for student perceptions for how feedback helps to improve learning or demonstrate science skills, (Pre $N=83$, Post $N=82$).

Before the project began less than 67% of the students had at least one form of feedback they felt they strongly agreed could help them improve their learning but by the end of the treatment, students had increased this to nearly 80% of the class. On the opposite side, nearly 13% of the class had at least one form they strongly disagreed could help them improve. By the end of treatment this had dropped to just 7% of the class. This could indicate that students were more comfortable with how to use feedback or that they were not familiar with the different forms of feedback. A common statement that came from four students during their interviews was that they find grade six science provides more opportunity to do things their own way, while still demonstrating the same skill or knowledge. They are provided with guidance on “how to do things better by providing feedback” this is different from grade 5, where students were “told what to do and everyone kind of did the same thing.

What specific forms of feedback might be more effective at enhancing student learning?

To answer the second sub question about what type of feedback might be more effective at enhancing student learning, I collected data from student interviews, the pre and post treatment participation surveys, and the pre and post topic assessments. Figure 8 below shows the number of students who were able to demonstrate a proficient or better understanding of our core ideas from each topic of study.

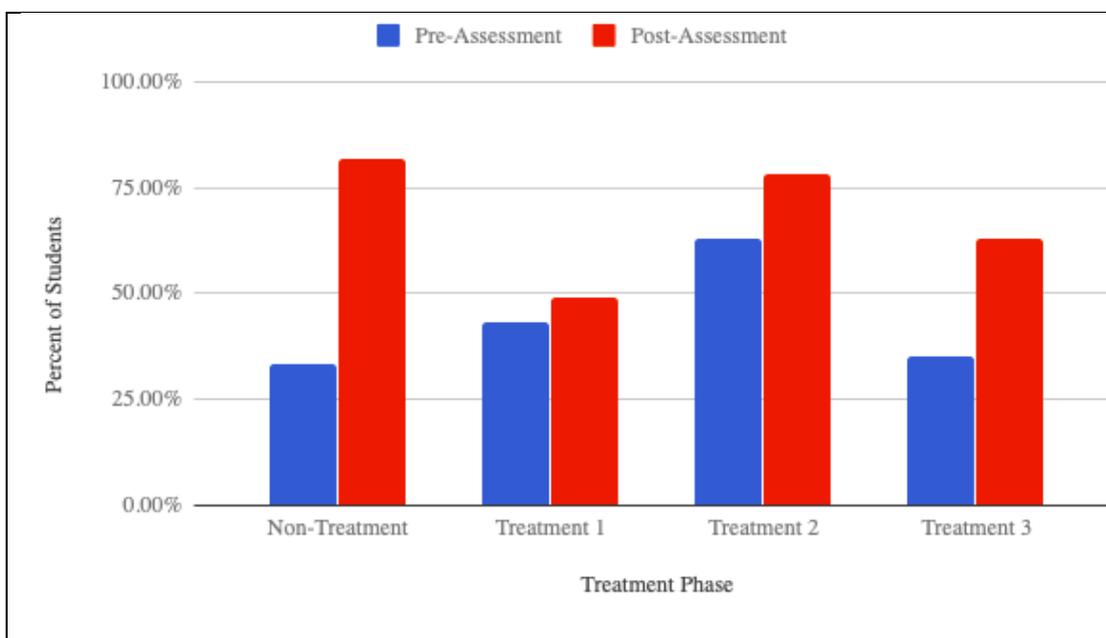


Figure 8. Proficient or better understanding of core ideas, ($N=87$). *Note:* Non Treatment- Rubric Feedback, Treatment 1- Narrative Feedback, Treatment 2- Video Feedback, Treatment 3- Oral Feedback

The results were interesting from this survey, as the non-treatment topic, Properties of Matter and Structure of Molecules, had the greatest amount of improvement for students. A little less than 47% of the class were able to improve to a proficient level of understanding after completing the final assessment. It also had the lowest number of students that began above a proficient level, with just under 67% of the class demonstrating a reasonable understanding of the difference between

an atom and a molecule and relationships between components that describe how atoms form molecules. The topic that had the second lowest number of students who scored below proficient during the pre-assessment, was our third treatment topic, Climate Change. Almost 66% of the class were below proficient in their understanding the human impacts that have influenced changes in the atmosphere. The assessment at the end of the topic had over 61% of the class that were able to demonstrate a proficient of better understanding of our core ideas. The climate topic was the only topic where more students began above a proficient level of understanding than below. Just over 61% of the class understood factors that affect overall temperature, those affect differences in maximum and minimum temperature, and those that affect moisture in the atmosphere. This rose to more than 77% of the class by end of the topic. Some of these factors had been introduced in our weather topic, which had the least amount of improvement demonstrating core ideas. Only 4% of the class improved their ability to describe how the movement of water in the atmosphere influences local weather patterns. The weather topic was also when they were provided with their first detailed feedback. One thing that several students noted during the written or typed feedback from the treatment was they didn't feel they could get an answer to a question. Some students mentioned that the oral feedback option provided opportunities to get a further explanation. Many students commented that by having a video they could see several different ways to improve because the feedback didn't just talk about their own work.

The survey also asked for opinions from students about how they felt about the different types of feedback. Below, in Figure 9, you will find the level of

usefulness that students expressed for each the non-treatment and treatment feedback portions of the project.

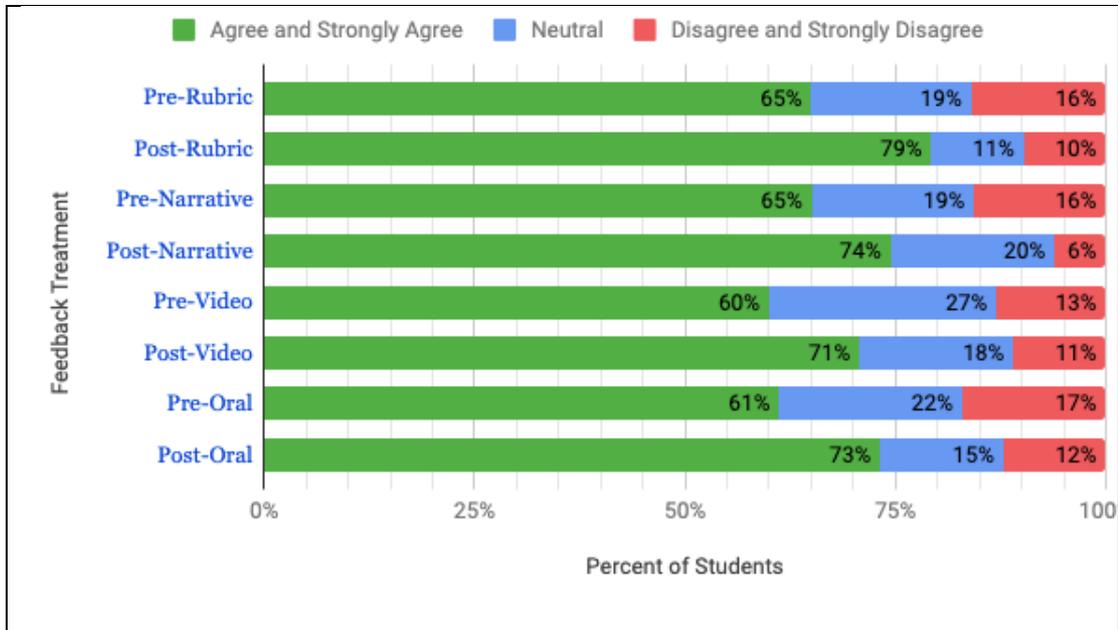


Figure 9. Pre and Post-treatment Percentages for Feedback Usefulness, (Pre $N=83$, Post $N=82$). Note: Non Treatment- Rubric Feedback, Treatment 1- Narrative Feedback, Treatment 2- Video Feedback, 3- Oral Feedback

Before the project began students indicated that they thought oral feedback and video feedback were the least likely to help them improve their learning of grade 6 science concepts and to demonstrate science skills. All forms of feedback had an increase in student agreement that it helped them. Rising from as low as 9% and as much as 14%. Additionally all forms of feedback had a decrease in student disagreement of how it would not help them. The decrease was from as little as 2% to as high as 10%. Oddly before the project began, 17% of students stated they disagreed with how likely oral feedback was to improve their learning, but this dropped by 5% after the project completed. On the other hand, there was a 12% increase in the number of students who agreed with how oral feedback helped them. Disagreeable comments before the project began included: not liking to interact face to face, finding it hard to remember the details or that it takes too much time. In the

post treatment survey, students mentioned they couldn't look back at oral feedback, while others stated if it wasn't a one-on-one conference, they didn't feel as comfortable saying something personal to get further feedback. An important note was that 13% of the students in the class mentioned that they felt uncomfortable discussing their work in group situations because they get embarrassed about having to improve their answers. For students who agreed with how oral feedback helps them, a common theme that 26% of them stated liked that they got specific feedback that is told directly to them. They also noted they felt this meant they could try to fix things immediately. Another common agreement was that students could ask questions which was stated by 28% of the students. This was further supported during my student interviews, where 44% of the students felt that oral feedback was the most effective for them. They like that they could process this information and "go off and talk to a partner about it" or they could "ask questions immediately."

Oral feedback was the second highest increase in usefulness next to the use of a rubric as feedback. There was a 14% increase in the number of students who felt the rubric helped them with their learning and on the opposite side a 6% decrease in the number of students who disagreed with how a rubric helped. A dramatic shift in helpfulness of feedback was the shift from 16% disagreeing with the use of narrative feedback to only 6%. For these five students, each had different reasons they did not find it effective, such as it is too short, while another said it was "too long and too much to read, so I get lost on what to improve on." Before the treatment began a couple of students stated that they simply did not enjoy reading, so this would not be helpful for them.

During my interviews, all of the students said they found each of the feedback styles to be useful, but had preferences that worked for their personalities. Five of the eleven students stated narrative was their preferred form as they felt it provided specific information they could go back to. They also liked that narrative typically described multiple areas to work on. The most common form that was the least effective was video evidence, as 44% of the interviewees indicated. They indicated that they didn't feel it was always specific to their own work or that the videos exemplars focused on common mistakes and how to improve those.

What are the effects of using varied feedback styles on my preparation time and teaching methods?

The third sub question for which I collected data was about my preparation time and teaching methods. This was tricky, because I found I was less fluid in how I would normally share my feedback with students because I was trying to be true to the process of specific feedback for students during each treatment. Throughout the majority of lessons I felt well prepared and took a reasonable amount of time to prepare for the lesson. When I was in my feedback processes however, I did not feel I was taking a reasonable amount of time to prepare for the next lesson in particular for the narrative and video feedback. I found the mean average from my Likert survey in response to my preparation time and teaching methods as seen in Figure 10 below.

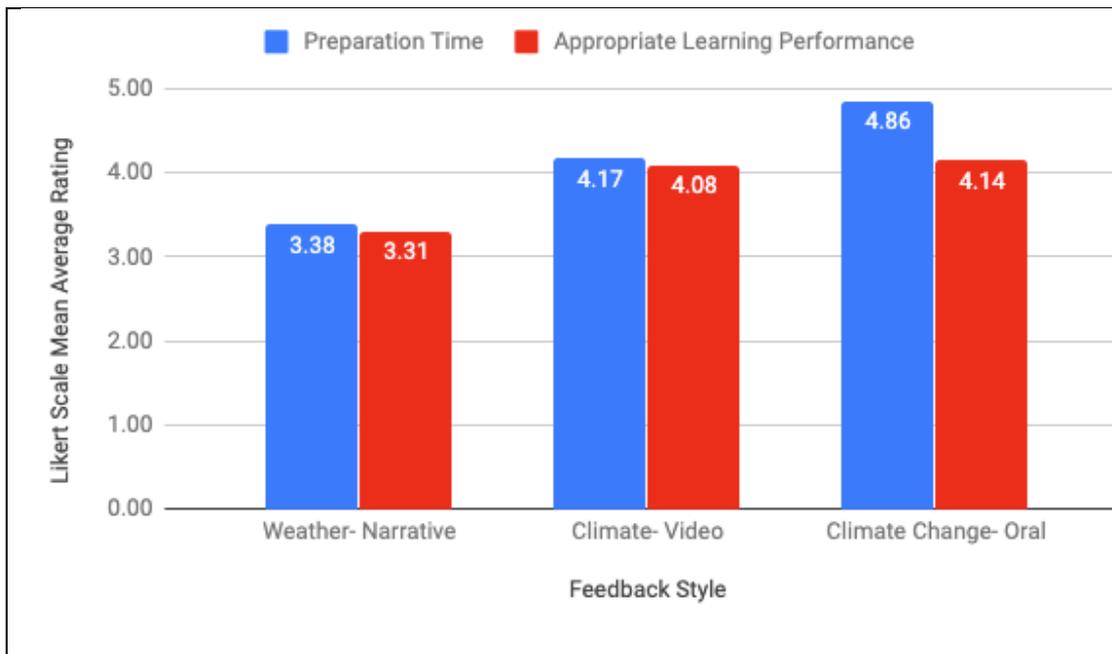


Figure 10. Likert scale results from teacher feedback form for preparation time and appropriate learning performance. (Weather $N=13$, Climate $N=12$, Climate Change $N=7$). *Note.* 5=Strongly Agree, 4= Disagree, 3= No opinion, 2=Disagree, 1=Strongly Disagree

My planning time overall during the first treatment, narrative feedback whether it was typed or hand written was rated 23% lower than the second treatment- video feedback and 44% lower than the third treatment- oral feedback. In my journal I noted that I had one week that spent every evening typing or writing notes during the first treatment. I commented how I asked students to be patient while I provide enough information and appropriate suggestions for them to have it be usable in the future.

During the weather lessons, I also found students had the greatest difficulty with the learning performances. In fact, the rating for the climate unit was 23% greater than the weather unit and the climate change unit was rated 25% greater. My notes indicated that students were not making use of the rubric yet in the first treatment, despite mini-lessons and discussions on how to look at the key terms,

however by the third treatment, many students took out the rubric automatically and started referring to it for each learning performance.

I also looked at how prepared I felt and if I would teach the same lesson. The mean Likert ratings are listed on Figure 11 below for each of the three treatment topics.

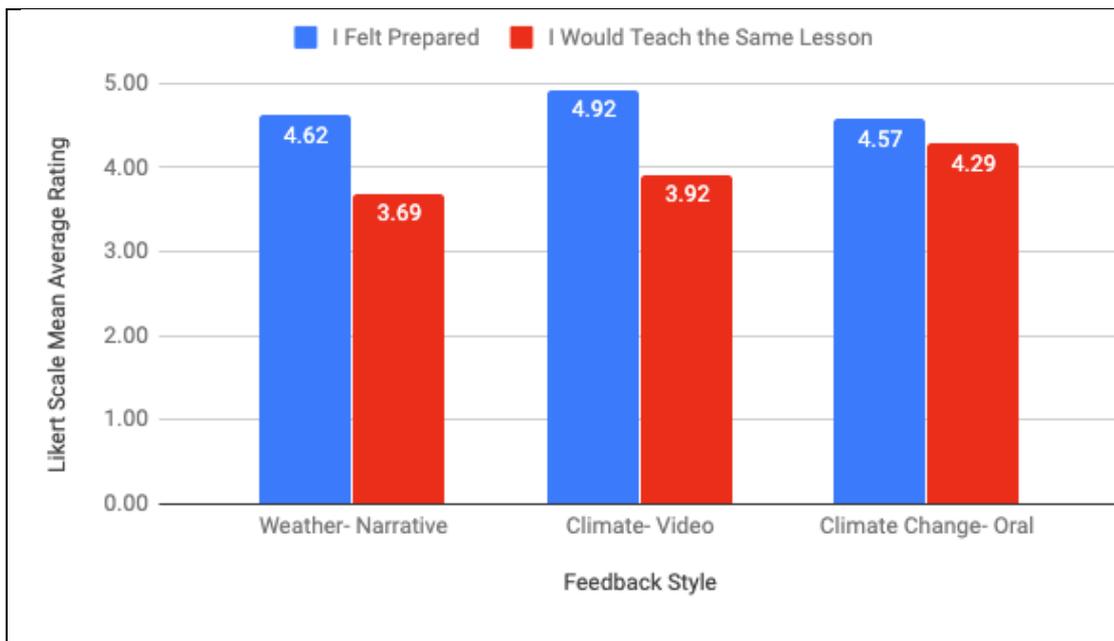


Figure 11. Likert scale results from teacher feedback form for teacher reflection on preparation for lesson and desire to teach same lesson (Weather $N=13$, Climate $N=12$, Climate Change $N=7$). Note. 5=Strongly Agree, 4= Disagree, 3= No opinion, 2=Disagree, 1=Strongly Disagree

On a daily basis I commented that I felt prepared for each lesson, which seems to be a contrast to the appropriateness of the learning performances. Overall I only had 9% of the lesson rate as a 3-No Opinion and 6% at a 4- Agree. This meant that almost 85% of the comments were rated as a 5-Strongly Agree. The climate unit I felt the most comfortable with how I came to class prepared, rating it 6.5% higher than the weather topic and 7.7% higher than the climate change topic.

There were clear differences in modifications of the lessons for each topic. During the climate change, there was the highest ratings on the Likert scale, with a

mean that was 9.4% higher than for the climate topic and 16.3% higher than the weather topic. In fact my ratings for two lessons for the weather topic indicated I would completely change the lesson, as opposed to one in the climate topic and none of the ratings were low enough to indicate any major changes to the lessons for the climate change topic. In my journal I noted my slideshow for one of the weather lessons had too many things on it and although it was step-by-step, numerous students did not seem to know the point of the lesson. For the climate lesson that I suggested by change in the future, I noted that students needed a substantial amount more time to complete this whole activity, instead of just part of it.

I also had colleagues make observations and complete a feedback form for each of the times they visited. They focused on my preparation and interaction with students, as well as how students used feedback or acknowledged the learning performance. Figure 12 below shows the percent of responses for how students responded to the learning performance and how prepared I appeared for the lesson.

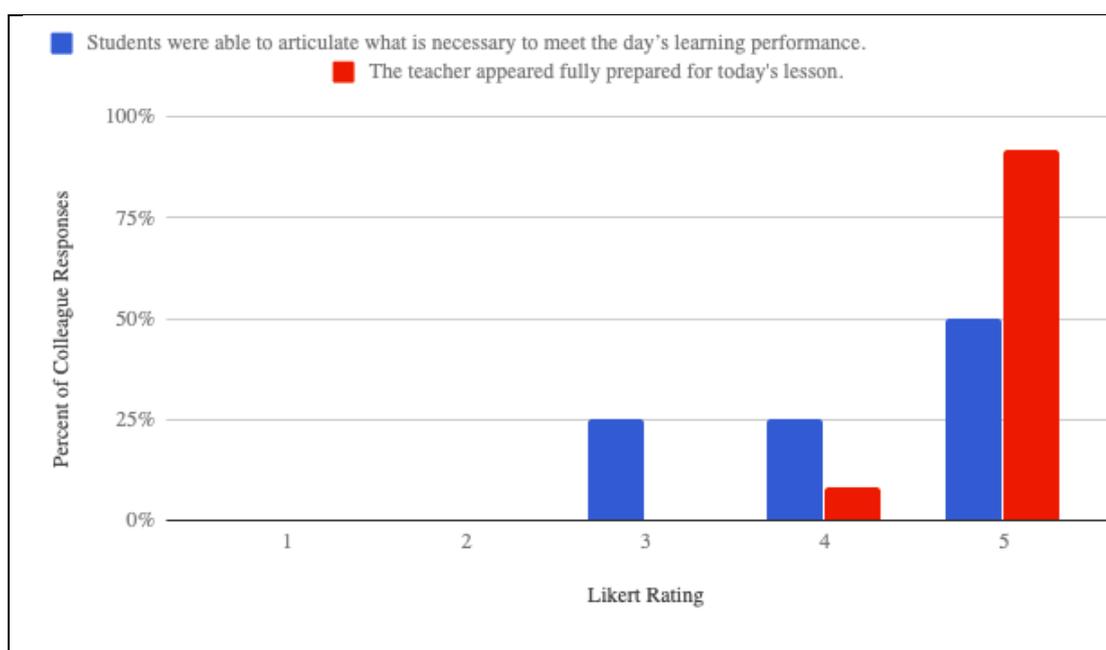


Figure 12. Likert scale results colleague observations of teacher and students, ($N=12$). Note. 5=Strongly Agree, 4= Disagree, 3= No opinion, 2=Disagree, 1=Strongly Disagree

Not unlike my ratings for myself, my colleagues felt my lessons were well prepared, with 92% of their ratings at a strongly agree. The one day that the rating was at a 4-agree level, it was noted that there was a small error on one of the sheets. A few students had to wait an extra couple of minutes for an update version to be electronically input into Google Classroom. Although there were no colleague responses in the disagree category, 25% of the ratings came in as 3-no opinion relating to students ability to articulate the learning performance. It was noted by one teacher that, “some students could articulate the goal, but other students seemed to be discussing data collection instead of model modification which was the focus.” The other two colleagues also noted that in each group they met with there was at least one person who could clearly describe what they needed to do with the learning performance, but the other students either talked in generalities or shrugged their shoulders.

When my colleagues checked in with if student's had feedback readily accessible while working on the day's assignment, there were some noticeable concerns. In Figure 13, you can see the results of their observations.

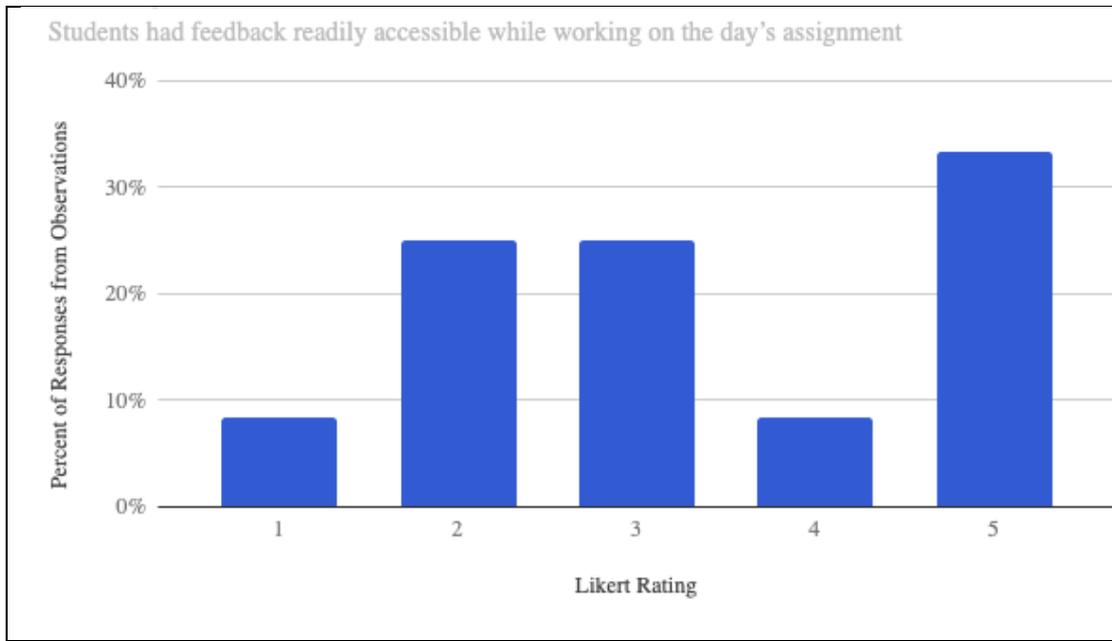


Figure 13. Likert scale results colleague observations of students use of feedback, (N=12). Note. 5=Strongly Agree, 4= Disagree, 3= No opinion, 2=Disagree, 1=Strongly Disagree

Through the discussions that my colleagues had with students, they found that just over 33% of the time, students did not have feedback accessible. However, as noted in three of the observations, there were corrections done for the previous lesson, but not visible feedback.

Although only 41% of the observations had an agreement that feedback was readily accessible, their comments highlighted how feedback had been provided in different forms. One student talked about how they had been guided through a two positive and one thought for improvement exercise that was started by Mr. Neurinski, then the modeled it for a peer. One colleague talked about how Mr. Neurinski was taking individuals or small groups into discussion for oral feedback. Another student

excitedly shared another narrative feedback form where they had been provided a praise, polish, and question form.

INTERPRETATION AND CONCLUSION

When conducting my student interviews and comparing the comments and Likert scale ratings from the students post treatment survey, varied feedback did have a positive impact on student's attitudes towards sixth grade science. This was particularly telling in both the student interviews and the student participation survey. The improved number of positive responses towards participation in class coincided with how the feedback made them feel more confident.

Further evidence was found in the small number of students who did not feel confident in their ability to learn Grade 6 science at the end of the treatment. In fact, only one student still had these feelings as compared to the 10% at the beginning of the project. This was further supported as the number of students who had one form of feedback they felt they did not help them improve learning or to better demonstrate science skills dropped. This seemed to indicate that more of the feedback forms became useful for students as the project proceeded. One thing I found was that as the project proceeded and students became more familiar with how to read the rubric, how to act upon suggestions or to respond to feedback questions immediately, they also became more active in their participation. As I am rarely at the front of the room teaching, I look for students to be proactive in seeking my guidance. At early stages of the year, students often commented that I never answered their questions and would instead often ask questions back of them. During my interviews a couple of students noted that their classmates originally felt like this was me dismissing their questions. As we discussed this and I posed questions, like "why do you think I often

do not give an answer or pose questions?” they responded positively with the fact that my questions are meant to guide them to ways to come to an answer on their own or to build on what they first thought.

Another noticeable improvement was in the number of students who strongly agreed that there was at least one form of feedback that helped them improve learning or to better demonstrate science skills reached near 80%. Students received feedback at least twice during each topic, including various feedback videos about how to improve climate models. The ability to have at least one feedback form that could be relied on to enhance their learning can help a student request the best type of feedback for themselves on future topics and provide the best opportunity for success in their own learning.

The STEM Attitude Survey had mixed results. In general the female population did not show any noticeable difference in their overall perceptions towards science. This is something I have wrestled with for years. I often find that females are very good at science, but for some reason it doesn't seem to capture their interest. One thing that I have noticed is that when I pose questions back to females as opposed to providing an answer, they do tend to get more discouraged than boys do. I also have found that for many girls if they do not get something right in discussions or on their work, they more quickly give up and tend to hide their results from classmates than boys. This frustration with not being right or in not getting the response they want from me, might be one of the reasons their perceptions towards science are lower than boys. In the future I need to be more careful in how I approach my questioning techniques and in how I guide the female population to find an answer. I also will

need to find further ways to encourage the learning process as opposed to the feeling of being right or wrong.

Encouraging most boys on the other hand is not as hard. The male population showed an increase in their perceptions for every science category. Daily I hear comments from boys that they can't wait for science class. Others are waiting for the door to open to the classroom so they can ask what we are going to learn today. Although their overall academic results are lower than their female counterparts, they tend to be happy with a focus on their learning and are encouraged by the fact that they have learning to do. When they are incorrect or have a misunderstanding, they tend to pose more questions that lead to discussions than their female classmates.

If we were to just look at the improvement of the understanding of core ideas for each of the four topics of study, it would appear that no feedback and the use of only a highlighted rubric would be the best way for a student to improve their content knowledge. However, when we look at how many students had difficulty developing a proficient model during the non-treatment phase, not to mention how few understood how to develop an extending proficient model, we can start to see the flaws in just having a rubric to guide a student. Additionally the rubric does not provide any specific ways to guide an improvement of content knowledge connected to our core ideas, as content is always changing. Core ideas are assessed on the accuracy of scientific language and how students make explanations that connect to appropriate theories and laws. This seems to indicate that content is driven by how students gain an understanding from the various lessons that take place throughout the

topic of study and how complex the core ideas tend to be as opposed to guidance from the rubric.

However, since the rubric is the one constant that is always available for them, it can be assumed that this is the one thing they are most comfortable with in providing information they understand. This is clearly seen by its higher rating of usefulness on the Post-Treatment student survey as compared to any of the other feedback forms. Since this is a common document used for all assessments, students know where the goal posts are for the specific scientific practice, and what is required of the core ideas and crosscutting concepts. When looking at student responses, I like how students have been able to use the rubric as a reference for what the other forms of feedback are describing. It also indicated as the one feedback form that has a defined value that can try to continue to working at or to try to grow beyond, which the other forms of feedback do not provide that same level of definability.

Although no feedback form stands out as the most effective, it is encouraging to know that all students have a preferred feedback method. Since every student has at least one form of feedback they agree or strongly agree helps them improve their concept knowledge and skill demonstration, if I can offer a preferred feedback method to each student in the remaining units of the year they would be provided with a method to help them get their best possible future results.

When looking over the data in my teacher journal and my daily reflections, it is interesting that as the topics of study progressed that I found less need to change future lessons. Although my colleagues felt I presented myself as well prepared, and I stated that I felt prepared, the weather topic seemed to still need some changes to better have student accomplish daily tasks. One thing to note, is that my colleagues

did not begin their observations until the last week of the weather topic, when students were preparing for the summative. During this time, students would have had almost two full topics of study in the project to learn routines and expectations.

Although for many of the lessons, colleagues didn't feel that students had feedback readily available, they noticed that students had corrected work available that would have been guided through some form of feedback. What I would like to do in the future is have a specific feedback method ready for each of my topics. I would have colleagues come in on the day that students would be making use of the feedback. This would provide a better idea of how students are making use of the feedback and its effectiveness.

What I am concerned about was how time consuming I found narrative feedback to be. Since only 6% of my students disagree with its effectiveness, it is clear that I will need to find a more efficient method of sharing these types of notes. One thing that a few students mentioned was that the narrative feedback was valuable for their parents, as they could the parent could use it to help their child at home. So perhaps having specific feedback that can be guided by a parent might be a good focus.

Another important note was that I found that by trying to be true to the process of one feedback form per topic of study, I was unable to have a normal flow, where I would improvise based on the moment. The improvisation process is a more natural way of teaching, knowing when to intervene with more dialogue or when to write a note to a student is a skill that I would make more use of in the future. One thing I think I could have done to alleviate this issue is to use the various feedback methods throughout each treatment topic instead of just one.

During all topics of study, except the second topic, our study of weather, there was substantial growth in how students demonstrated the scientific practice that was assessed in the topic, as well as their conceptual knowledge connected to the core ideas. As my journal reflection noted, I would make changes to several lessons and after looking over the pre and post assessments, I would also make significant adjustments. One thing I have noticed is that I focused too much on the organization and potential analyses of the data for the topic instead of the collection of the data. I also tried to intervene with narrative responses, but should have been more flexible in recognizing that some students are not prepared for this type of feedback yet or do not know how to use it without being able to ask further questions.

Student skill development seems to be easier to guide through feedback than content, but I have typically done better at helping to build content knowledge through misconception probes. Some time constraints that were presented by having student complete the pre-assessments, meant I missed this opportunity. Additionally, I could have used the pre-assessments like a misconception probe. Unfortunately, I found myself collecting the data, but not immediately trying to provide opportunities to clear up misconceptions. This was critical flaw on my side and it was highly visible during the weather topic.

Positively, during the third topic, our climate studies, students had another opportunity to look at how atmospheric conditions affect Earth. Although we added in new factors, students were able to transfer their experience from the hydrological studies from the beginning of the year and the weather studies to demonstrate reasonable conceptual knowledge during the pre-assessment and positive growth on the post-assessment. This was also the topic of study that had the widest variety of

relationships for students to address within their various models and the greatest number of distinct connections to make for the factors that affect a system.

Students were also able to show positive growth over time in their modelling skills. It is promising to see so many of the students who were already at a proficient level, push themselves to demonstrate an extending level of achievement. This is encouraging since these students often get the least amount of feedback. I often find there is so much less to provide feedback about, that I am usually asking questions to help them think about ways to improve instead of suggestions. Students that are at this level often find ways to make use of all of the feedback forms instead of one. Many students noted that they could use the video feedback to see several samples at or near their level and then make adjustments on their own models to show how components work together. The adjustments often avoid copying other students' work, and instead helps a student build on their own representation.

VALUE

This has been a rewarding experience and very eye opening as to how I work best as an educator. I know I need flexibility in being able to make adjustments on the fly as I see difficulties students are running into. If I were to do another action research project or if I was to implement something similar next year in my class, I would definitely have a specific plan for what feedback I want to provide instead of trying to provide too much information especially for students who have struggled. One thing I noted was that students with more errors or misunderstandings are the ones I tend to offer a great deal of suggestions to or pose the most questions to. They have noted I give too many detail for them to follow, so I will need to be more cautious of that approach so I don't contribute to their confusion. On the other hand if

I provide the same amount or similar amount of clear, specific information to those that are demonstrating stronger work, I can help them provide examples for other students or encourage them to think of making alternative examples to further demonstrate their understanding.

I find that I am constantly reflecting on my work and try to make immediate adjustments based on those reflections. Although this means I am always trying to improve, I can overwhelm myself with too many things at once. Also if I do not get to something that I want to adjust immediately, I have often not recorded the information or thought somewhere. This means, either I don't get to it or I lose some of the thinking I began with. I would to make better use of a journal for my thoughts and notes and try to act upon things when I can provide ample time.

I also loved the opportunity to try out video feedback, as I had not provided it in the past. Although the videos took some time to create, I can use them in the future and since I am often encouraging my students to make use of video for their peer evaluations, it makes sense that I should also join in.

Each school year, I work with my administration to set a goal for how to improve student achievement, but I have always wanted a more formal way of going through the process. This action research has provided that formality and I know I will use much if not all of the process for my next goal and as I look at possibly getting a paper published in the future.

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APPENDICIES

APPENDIX A

2018 NGSS LEARNING CONTINUUM ACS MIDDLE SCHOOL SCIENCE

2018 NGSS Learning Continuum ACS Middle School Science

NGSS Learning Continuum: Investigation practices				
	Emerging Proficiency (1)	Developing Proficiency (2)	Proficient (3)	Extending Proficiency (4)
Asking Questions	I ask general questions that do not require evidence to answer.	I ask testable questions that require sufficient and relevant evidence to answer.	I ask testable questions that require sufficient and relevant evidence to answer and evaluates the testability of the questions.	I ask testable questions that require sufficient and relevant evidence to answer, evaluate the testability of the questions, and identify the dependent and independent variables as well as control (if appropriate).
Plan the Investigation	I design an investigation that will not produce relevant data and/or evidence to answer the question(s).	I design an investigation that will produce relevant data but with minimal detail about the variables and/or evidence to be used to answer the question(s).	I design an investigation identifying variables (dependent, independent, and controls) that will adequately produce relevant data and/or evidence to answer the question(s).	I design an investigation identifying and explaining the variables (dependent, independent, and controls) that will produce relevant data and/or evidence to answer the question(s).
Conducting Investigations	I use inappropriate scientific methods OR I collect irrelevant data to be used as evidence to answer the question(s).	I use appropriate scientific methods and collects limited relevant data to be used as evidence to answer the question(s).	I use appropriate scientific methods and collects multiple trials (if appropriate) of relevant data to be used as evidence to answer the question(s).	I use appropriate scientific methods and collects multiple trials (if appropriate) of relevant data to be used as evidence to answer the question(s), and evaluate the accuracy of the data collection methods used.

NGSS Learning Continuum: Modeling Practices				
	Emerging Proficiency (1)	Developing Proficiency (2)	Proficient (3)	Extending Proficiency (4)
Develop Models	I constructed models (e.g., 3-d objects, drawings, or diagrams) relevant to the investigation with major conceptual or factual errors or omissions.	I constructed models (e.g., 3-d objects, drawings, or diagrams) to represent the process, system to be investigated, or relationships between components with minor errors or omissions.	I constructed an accurate and labeled models (e.g., 3-d objects, drawings, or diagrams) to represent the process, the system to be investigated, or relationships between components.	I constructed accurate, labeled, and detailed models (e.g., 3-d objects, drawings, or diagrams) to represent the process, the system to be investigated, and provides unquestionable relationships between components, ensuring no further questions need to be asked by my audience.
Use Models	I use the model without evaluating the accuracy or limitations of the model as a representation of the system or process. My discussion of the model includes major errors or omissions.	I use the model and evaluate the accuracy OR limitations of the model as a representation of the system, relationships between components in the system, or process. Discussion of the model includes minor errors.	I use the model and evaluate the accuracy OR limitations of the model as a representation of the system, relationships between components in the system, or process.	I use the model and evaluate the accuracy OR limitations of the model as a representation of the system, relationships between components in the system, or process. I explained how the model might be improved.
Use Mathematics and Computational Thinking	I attempt to apply mathematical concepts or methods (e.g., ratio, rate, percent, basic operations, and simple algebra) relevant to scientific questions or engineering problems, but I apply them with major errors or omissions.	I apply appropriate mathematical concepts or methods (e.g., ratio, rate, percent, basic operations, and simple algebra) relevant to scientific questions or engineering problems, but I apply them with minor errors or omissions.	I accurately apply appropriate mathematical concepts and methods (e.g., ratio, rate, percent, basic operations, and simple algebra) to answer scientific questions or engineering problems.	I accurately apply appropriate mathematical concepts and methods (e.g., ratio, rate, percent, basic operations, and simple algebra) to answer scientific questions or engineering problems AND explain whether the answer "makes sense".

NGSS Learning Continuum: Communicating Information				
	Emerging Proficiency (1)	Approaching Proficiency (2)	Proficient (3)	Extending Proficiency (4)
Represent Data	I constructed spreadsheets, data tables, charts, or graphs that are not accurately labeled or do not display all the data.	I construct accurately labeled spreadsheets, data tables, charts, or graphs to accurately summarize and display data, but do not allow for examining the relationships between variables.	I construct accurately labeled spreadsheets, data tables, charts, or graphs to accurately summarize and display data to examine the relationships between variables.	I construct accurately labeled spreadsheets, data tables, charts, and/or graphs and use more than one of these methods to accurately summarize and display data to examine the relationships between variables.
Analyze data	I analyzed data using inappropriate methods or with major errors or omissions.	I analyzed data using appropriate methods with minor errors or omissions and/ or did not recognize patterns or relationships in the natural world.	I accurately analyzed data using appropriate methods to identify patterns or relationships in the real world.	I accurately analyzed data using appropriate and systematic methods to identify patterns or relationships in the natural world.
Interpret Data	I did not identify the limitations of the data analysis or my attempted limitation analysis (e.g., measurement error, sample selection) had major errors or omissions.	I identified the limitations of the data analysis (e.g., measurement error, sample selection) with minor errors or omissions.	I identified the limitations of the data analysis (e.g., measurement error, sample selection) and identified some implications for the findings.	I evaluated the limitations of the data analysis (e.g., measurement error, sample selection) and explained some implications for the findings.
Obtaining, Evaluating, and Communicating Information	When conducting independent research, I rely on one or two relevant sources, without evaluating their credibility, accuracy, or possible bias.	When conducting independent research, I select a limited number of relevant sources and evaluate the credibility, accuracy, and/or possible bias of one of the sources used.	When conducting independent research, I select multiple relevant scientific sources and evaluate the credibility, accuracy, and/or possible bias of the sources used.	When conducting independent research, I select a variety of relevant, high-quality scientific sources and evaluate the credibility, accuracy, and possible bias of the sources as well as evidence drawn from sources in constructing an argument or explanation.

NGSS Learning Continuum: Core Ideas and Crosscutting Concepts				
	Emerging Proficiency (1)	Approaching Proficiency (2)	Proficient (3)	Extending Proficiency (4)
Cross-Cutting Concepts	I identify or make connections to irrelevant crosscutting concepts OR to relevant crosscutting concepts with major errors or omissions.	I identify or make the connection(s) to relevant crosscutting concepts with minor errors or omissions.	I explain OR make accurate connections to relevant crosscutting concepts.	I explain and make accurate connections to relevant crosscutting concepts.
Constructing Explanations (Claim, Evidence, Reasoning/ Core Ideas)	I struggle to explain my thinking using evidence, but the evidence is inappropriate. I struggle to make connections between my data, model or evidence, and/ or I have major errors or omissions. My attempted explanation uses basic, non-scientific vocabulary and/ or attempts to connect to theories, laws, or core ideas, but with major errors or omissions.	I try to explain my thinking using evidence, but some evidence is inappropriate. I attempt to make connections between my data, model, and evidence and/ or I have minor errors or omissions. My explanation uses mostly basic, non-scientific vocabulary and/ or attempts to connect to appropriate theories, laws, or core ideas, but with minor errors or omissions.	I explain my thinking using appropriate evidence. I make connections between my data, model, and evidence. My explanation uses accurate scientific vocabulary and connects to appropriate theories, laws, or core ideas.	I thoroughly justify my explanation using multiple pieces of evidence. I make clear connections between my data, models, and evidence. My explanation is clear, concise and uses accurate scientific vocabulary and connects to appropriate theories, laws, or core ideas from the topic.

Stanford Center for Assessment, Learning & Equity (SCALE) & Literacy Design Collaborative. (2015). *DRAFT LDC Rubric Dimensions for NGSS Science Integration MIDDLE SCHOOL Grade 6-8*. Stanford, CA: Author.

APPENDIX B

STEM SEMANTICS- STUDENT ATTITUDE SURVEY

STEM Semantics Survey- Student Attitude Survey

This five-part questionnaire is designed to assess your perceptions of scientific disciplines. It should require about 5 minutes of your time. Usually it is best to respond with your first impression, without giving a question much thought. Your answers will remain confidential. This survey has been modified from STEM v. 1.0 by G. Knezek & R. Christensen 4/2008

* Required

Participation in this research interview is voluntary and optional. Your participation does not affect your grade or class standing in any way.

Are you: *

- Male
 Female

What is your student code that you were provided by Mr. Neurinski. *

Your answer _____

1a) To me SCIENCE is: *

	1	2	3	4	5	
Fascinating	<input type="radio"/>	Mundane				

1b) To me SCIENCE is: *

	1	2	3	4	5	
Appealing	<input type="radio"/>	Unappealing				

1c) To me SCIENCE is: *

	1	2	3	4	5	
Exciting	<input type="radio"/>	Unexciting				

1d) To me SCIENCE: *

	1	2	3	4	5	
Means a lot	<input type="radio"/>	Means Nothing				

1e) To me SCIENCE is: *

	1	2	3	4	5	
Interesting	<input type="radio"/>	Boring				

1f) Explain why you have given these types of responses about SCIENCE. *

Your answer _____

3a) To me ENGINEERING is: *

	1	2	3	4	5	
Appealing	<input type="radio"/>	Unappealing				

3b) To me ENGINEERING is: *

	1	2	3	4	5	
Fascinating	<input type="radio"/>	Mundane				

3c) To me ENGINEERING: *

	1	2	3	4	5	
Means a lot	<input type="radio"/>	Means Nothing				

3d) To me ENGINEERING is: *

	1	2	3	4	5	
Exciting	<input type="radio"/>	Unexciting				

3e) To me ENGINEERING is: *

	1	2	3	4	5	
Interesting	<input type="radio"/>	Boring				

3f) Explain why you have given these types of responses about ENGINEERING. *

Your answer _____

4a) To me TECHNOLOGY is: *

	1	2	3	4	5	
Appealing	<input type="radio"/>	Unappealing				

4b) To me TECHNOLOGY: *

	1	2	3	4	5	
Means a lot	<input type="radio"/>	Means Nothing				

4c) To me TECHNOLOGY is: *

	1	2	3	4	5	
Interesting	<input type="radio"/>	Boring				

4d) To me TECHNOLOGY is: *

	1	2	3	4	5	
Exciting	<input type="radio"/>	Unexciting				

4e) To me TECHNOLOGY is: *

	1	2	3	4	5	
Fascinating	<input type="radio"/>	Mundane				

4f) Explain why you have given these types of responses about TECHNOLOGY. *

Your answer _____

<p>2a) To me MATH is: *</p> <p>1 2 3 4 5</p> <p>Interesting <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Boring</p> <p>2b) To me MATH is: *</p> <p>1 2 3 4 5</p> <p>Appealing <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Unappealing</p> <p>2c) To me MATH is: *</p> <p>1 2 3 4 5</p> <p>Fascinating <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Mundane</p> <p>2d) To me MATH is: *</p> <p>1 2 3 4 5</p> <p>Exciting <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Unexciting</p> <p>2e) To me MATH: *</p> <p>1 2 3 4 5</p> <p>Means a lot <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Means Nothing</p> <p>2f) Explain why you have given these types of responses about MATH. *</p> <p>Your answer _____</p>		<p>5a) To me a CAREER in science, technology, engineering, or mathematics: *</p> <p>1 2 3 4 5</p> <p>Means a lot <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Means Nothing</p> <p>5b) To me a CAREER in science, technology, engineering, or mathematics is: *</p> <p>1 2 3 4 5</p> <p>Interesting <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Boring</p> <p>5c) To me a CAREER in science, technology, engineering, or mathematics is: *</p> <p>1 2 3 4 5</p> <p>Exciting <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Unexciting</p> <p>5d) To me a CAREER in science, technology, engineering, or mathematics is: *</p> <p>1 2 3 4 5</p> <p>Fascinating <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Mundane</p> <p>5e) To me a CAREER in science, technology, engineering, or mathematics is: *</p> <p>1 2 3 4 5</p> <p>Appealing <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Unappealing</p> <p>5f) Explain why you have given these types of responses about a CAREER in science, technology, engineering, or mathematics. *</p> <p>Your answer _____</p> <p>SUBMIT</p> <p>Never submit passwords through Google Forms.</p>
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Christensen, R., Knezek, G., Tyler-Wood, T. (2010). Instruments for Assessing Interest in STEM Content and Careers. *Journal of Technology and Teacher Education*, 18 (2), 341-363.

APPENDIX C

STUDENT PARTICIPATION PRE-TREATMENT SURVEY

Student Participation Pre-Treatment Survey

The survey below was modified from Anthony Eugene Altieri's, "THE EFFECTS OF COOPERATIVE LEARNING STRUCTURES ON TRADITIONAL INSTRUCTION IN A MIDDLE SCHOOL SCIENCE CLASSROOM", MSSE Capstone Project, 2016.

Student Participation Pre Treatment Survey

The survey below was modified from Anthony Eugene Altieri's, "THE EFFECTS OF COOPERATIVE LEARNING STRUCTURES ON TRADITIONAL INSTRUCTION IN A MIDDLE SCHOOL SCIENCE CLASSROOM", MSSE Capstone Project, 2016.

* Required

Participation in this research survey is voluntary and optional. Your participation does not affect your grade or class standing in any way.

Please type your student number that Mr. Neurinski gave you in the space below: *

Your answer _____

1 = Strongly Disagree, 2= Disagree, 3= No Opinion, 4= Agree, 5= Strongly Agree

1) I enjoy learning about Earth Science. *

12345

Please explain why you answered the way you did in the above question. *

Your answer _____

2) I am confident in my ability to learn Grade 6 science concepts. *

12345

3) I regularly participate in class discussions. *

12345

4) I think that regular class participation improves my ability to learn grade 6 science concepts and skills. *

12345

Please explain why you answered the way you did in the above question. *

Your answer _____

5) I think that narrative written feedback is a form of feedback that helps me improve my learning of grade 6 science concepts and to demonstrate science skills. *

12345

Please explain why you answered the way you did in the above question. *

Your answer _____

6) I think that video feedback and demonstrations are a form of feedback that helps me improve my learning of grade 6 science concepts and to demonstrate science skills. *

12345

Please explain why you answered the way you did in the above question. *

Your answer _____

7) I think that graded rubrics and other student examples are a form of feedback that helps me improve my learning of grade 6 science concepts and to demonstrate science skills. *

12345

Please explain why you answered the way you did in the above question. *

Your answer _____

8) I think that oral feedback in one on one conferences or in small groups is a form of feedback to help me improve my learning of grade 6 science concepts and to demonstrate science skills. *

12345

Please explain why you answered the way you did in the above question. *

Your answer _____

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Altieri, A.E. (2016). *The Effects of Cooperative Learning on Traditional Instruction in a Middle School Science Classroom* (Unpublished capstone paper). Montana State University, Bozeman, MT.

APPENDIX D
STUDENT PARTICIPATION POST-TREATMENT SURVEY

Student Participation Post-Treatment Survey

The survey below was modified from Anthony Eugene Altieri's, "THE EFFECTS OF COOPERATIVE LEARNING STRUCTURES ON TRADITIONAL INSTRUCTION IN A MIDDLE SCHOOL SCIENCE CLASSROOM", MSSE Capstone Project, 2016.

Student Participation Post Treatment Survey

The survey below was modified from Anthony Eugene Altieri's, "THE EFFECTS OF COOPERATIVE LEARNING STRUCTURES ON TRADITIONAL INSTRUCTION IN A MIDDLE SCHOOL SCIENCE CLASSROOM", MSSE Capstone Project, 2016.

* Required

Participation in this research survey is voluntary and optional. Your participation does not affect your grade or class standing in any way.

Please type your student number that Mr. Neurinski gave you in the space below: *

Your answer _____

1= Strongly Disagree, 2= Disagree, 3= No Opinion, 4= Agree, 5= Strongly Agree

1) I enjoyed learning about Earth Science. *

1 2 3 4 5

○ ○ ○ ○ ○

Please explain why you answered the way you did in the above question. *

Your answer _____

2) I am confident in my ability to learn Grade 6 science concepts. *

1 2 3 4 5

○ ○ ○ ○ ○

3) I regularly participate in class discussions. *

1 2 3 4 5

○ ○ ○ ○ ○

4) I consider regular class participation improves my ability to learn grade 6 science concepts and skills. *

1 2 3 4 5

○ ○ ○ ○ ○

Please explain why you answered the way you did in the above question. *

Your answer _____

5) I consider narrative written feedback as a form of feedback that helps me improve my learning of grade 6 science concepts and to demonstrate science skills. *

1 2 3 4 5

○ ○ ○ ○ ○

Please explain why you answered the way you did in the above question. *

Your answer _____

6) I consider video feedback and demonstrations as a form of feedback that helps me improve my learning of grade 6 science concepts and to demonstrate science skills. *

1 2 3 4 5

○ ○ ○ ○ ○

Please explain why you answered the way you did in the above question. *

Your answer _____

7) I consider graded rubrics and other student examples as a form of feedback that helps me improve my learning of grade 6 science concepts and to demonstrate science skills. *

1 2 3 4 5

○ ○ ○ ○ ○

Please explain why you answered the way you did in the above question. *

Your answer _____

8) I consider oral feedback in one on one conferences or in small groups as a form of feedback that help me improve my learning of grade 6 science concepts and to demonstrate science skills. *

1 2 3 4 5

○ ○ ○ ○ ○

Please explain why you answered the way you did in the above question. *

Your answer _____

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Page 1 of 1

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Altieri, A.E. (2016). *The Effects of Cooperative Learning on Traditional Instruction in a Middle School Science Classroom* (Unpublished capstone paper). Montana State University, Bozeman, MT.

APPENDIX E
STUDENT POST-TREATMENT INTERVIEW SURVEY

Student Post-Treatment Interview Questions

Read Prior to Interview:

Participation in this research interview is voluntary and optional. Your participation does not affect your grade or class standing in any way.

Effective teacher feedback should help provide guidance on what **a student** can improve upon or is doing well. It helps to state what your next steps might be in order to improve your science skills, it validates or questions your connections between models and data to the real world, and confirms or proposes alternative thoughts towards your understanding of core ideas.

1. How would you describe your 6th grade science experience compared to grade 5?
 - Why do you think that is?
 - What have you enjoyed about Grade 6 Science so far? Why?
 - What have you not enjoyed about Grade 6 Science so far? Why?
2. How did you use Mr. Neurinski's feedback to help you develop a model that demonstrates the core ideas of the water cycle?
 - Can you give me an example of how you used Mr. Neurinski's feedback to demonstrate your understanding of a core idea for another graded assignment?
 - In what ways was using feedback valuable to you?
 - What were the benefits of using feedback to prepare for your unit assessment? Why?
 - What were difficult parts of using feedback to prepare for your unit assessment? Why?
3. Did you feel like Mr. Neurinski's feedback made it easier to participate in classroom discussions and activities?
 - Why or why not? Can you give me an example?
4. What form of feedback did you find was the most effective for you? Please provide an example to explain why?
5. What form of feedback did you find was the least effective for you? Please provide an example to explain why?
6. What can I do to make my feedback more effective for you? Give an example to explain why.

APPENDIX F
PRE ASSESSMENT TOPIC 1- PROPERTIES OF MATTER
AND MOLECULAR STRUCTURE

Properties of Matter and Molecular Structure Pre-Assessment
Modified from Measured Progress, Inc. STEM Gauge 2016

Name: _____		Date: _____	
Properties of Matter Pre-Assessment			
Your understanding of molecules and their properties as well as how to develop models that describe the organization of simple molecules will improve throughout the unit as you gain more information and are guided by my feedback. For this assessment, please show me what you know or think you know before we begin our unit.			
Please read the information in the textbox below, then answer the 4 questions at the bottom.			
<p>Matter is anything that has mass and occupies space. There are three different states of matter - solid, liquid, and gas. Matter is made up of many atoms.</p> <p>Ammonia is a compound of nitrogen and hydrogen with the molecular formula NH_3. Ammonia, is a colourless substance with a characteristic pungent smell.</p> <p>It is a common <u>nitrogenous waste</u>, particularly among aquatic organisms, and it contributes significantly to the <u>nutritional</u> needs of terrestrial organisms by serving as an initial substance that then turns to <u>food</u> and <u>fertilizers</u>. Ammonia, either directly or indirectly, is also a building block for the synthesis of many <u>pharmaceutical products</u> and is used in many commercial cleaning products. Although common in nature and in wide use, ammonia is both <u>caustic</u> and <u>hazardous</u> in its concentrated form. It is classified as an <u>extremely hazardous substance</u> in the United States.</p>			
<p>1) How many atoms do you think make up one molecule of Ammonia? Explain why you think this.</p>		<p>2) Make a drawing of the molecule using the same number of atoms you mentioned in question 1.</p>	
<p>3) At room temperature (approx. 23°C) do you think the molecule would be in a gas, solid, or liquid form? Make a drawing to show what you think it would look like in this form.</p>		<p>4) Do you think one molecule of Ammonia (NH_3) would be larger or smaller than one molecule of water (H_2O)? Explain why you think this way and what you could do try to support your answer (be specific as you may be provided the opportunity to explore this option).</p>	

APPENDIX G
POST ASSESSMENT TOPIC 1- PROPERTIES OF MATTER
AND MOLECULAR STRUCTURE

Properties of Matter and Molecular Structure Summative Assessment
Modified from Measured Progress, Inc. STEM Gauge 2016

MS-PS1-1 Develop models to describe the atomic composition of simple molecules and extended structures.

PS1.A: Structure and Properties of Matter

Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.

-Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

Scientific Practices:

-Developing and Using Models
-Engaging in argument from Evidence

Crosscutting Concepts:

-Scale, Proportion, and Quantity

Name: _____

Date: _____

Topic 2- Properties of Matter and Molecular Structure Summative

1) Ammonia is a compound of nitrogen and hydrogen with the molecular formula NH_3 . Ammonia, is a colourless substance with a characteristic pungent smell.

Develop Models

a. Draw a model of one ammonia molecule.

Construct Explanations (CER)/ Core Ideas

b. How many atoms are there in one molecule of Ammonia? Provide evidence from models, use one or more molecules we studied this topic, then explain your reasoning for your response.

Develop Models

c. Using a dropper, a student was given a chance to place some ammonia onto a coin while it was at room temperature (approx. $23^{\circ}C$) do you think ammonia was in a gas, solid, or liquid form? Make a drawing to show what you think it would look like in this form.

Constructing Explanations (CER) / Scale, Proportion and Quantity

d. You have a 100ml jar of liquid Ammonia, (NH_3) and a 100ml jar of liquid water (H_2O), which do you think would have more mass? Provide evidence, then explain why you think this way.

APPENDIX H

PRE AND POST ASSESSMENT TOPIC 2- WEATHER

Weather Data Collection Summative Assessment
 Modified from Measured Progress, Inc. STEM Gauge 2016

Weather Data Collection Assessment

Scientific Practices:

Conducting Investigations

Representing and Analysing Data

-Students will identify, organize and interpret appropriate data that can provide evidence for potential weather conditions.

Crosscutting Concepts:

Cause and Effect

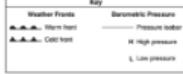
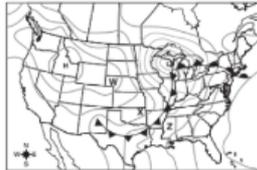
-Explain why evidence supports a cause and effect relationship.

Core Ideas:

Because weather patterns are so complex, it can only be predicted probabilistically.

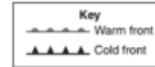
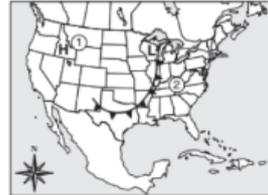
MS-ESS 2-5 Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.

This map shows four locations, W, X, Y, and Z, and weather systems across the United States. Which prediction about the weather is accurate, based on the evidence in the map?

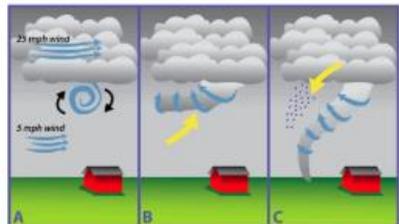


- Location W will have cooler temperatures, because a cold front is moving toward it.
- Location X will have cloudy skies, because it is positioned within a high-pressure system.
- Location Y will be stormy, because it is positioned where a cold front meets a warm front.
- Location Z will be calm, because it is far away from both the high- and low-pressure systems.

The map shows the locations of two cities, 1 and 2, the centers of a high-pressure system and a low-pressure system, and two weather fronts. Which question can be answered using the information shown in the map? 1 point



- Which city is likely to have a blizzard?
- Which city is likely to have a sunny sky?
- Which city recently experienced rain?
- Which city recently experienced a decrease in temperature?

<p>Scientists are monitoring two colliding air masses along a frontal boundary. They are concerned that a tornado may form. Which data collected along the frontal boundary would best alert scientists that the two colliding air masses may cause a tornado?</p>  <p><input type="radio"/> strong gusty winds and overcast skies along the frontal boundary</p> <p><input type="radio"/> air masses of the same temperature and altitude coming together along the frontal boundary</p> <p><input type="radio"/> great differences in temperature, humidity, and air pressure on either side of the frontal boundary</p> <p><input type="radio"/> great differences in the altitude of clouds, percentage of cloud cover, and direction of wind on either side of the frontal boundary</p>	
<p style="text-align: center;">Air Masses</p> 	<p>You are a student that has collected data over several days on two air masses approaching one another. You want to use this data to predict changes in the weather conditions when the two air masses interact.</p> <p>Plan and Carry Out an Investigation</p> <ol style="list-style-type: none"> 1. What are two sets of data you would have collected to understand each of the two air masses and to help you make predictions? 2. Describe two predictions you can make about the interacting air masses, based on the information you identified in part (1). <p>Constructing Explanations (CER) Core Ideas/ Cause and Effect</p> <ol style="list-style-type: none"> 3. Explain why you can use the data and your understanding of how air masses interact to predict how the weather will change.

APPENDIX I

PRE AND POST ASSESSMENT TOPIC 3- CLIMATE TRUE/ FALSE

Pre- and Post-Assessment Topic 3- Climate True/ False

Please put a check in the appropriate box for true or false.		
	True	False
1. Higher altitudes typically cause lower temperatures.		
2. Higher average annual temperatures occur closer to the poles than the tropics.		
3. More direct light can be found at the poles than the equator.		
4. Rising moist air is typically found in wetter climates.		
5. Dry sinking air is typically found in wetter climates.		
6. Land absorbs more solar energy than water.		
7. Land has a more rapid change in temperature than the ocean.		
8. Land near the ocean has a greater difference in maximum and minimum temperature than an area in the center of a landmass.		
9. Earth's rotation circulates oceans and the atmosphere causing regional climate patterns.		
10. Mountains influence climate.		

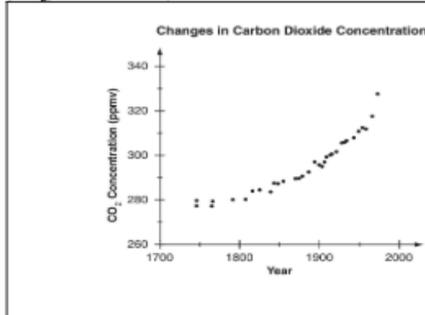
APPENDIX J

PRE AND POST ASSESSMENT TOPIC 4- CLIMATE CHANGE

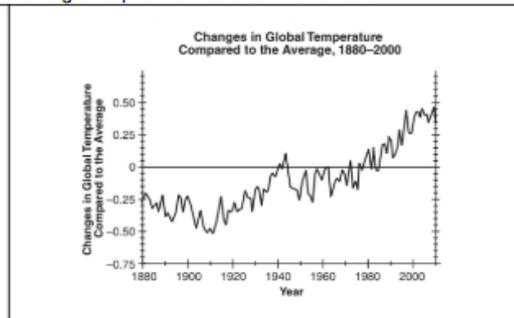
Global Climate Change Pre- and Post- Assessment
Modified from Measured Progress, Inc. STEM Gauge 2016

Global Climate Change

The first graph shows changes in carbon dioxide (CO₂) in the atmosphere from 1740 to 1980.



The second graph shows the changes above or below average temperatures from 1880 to 2010.



Asking Questions

1) Based on these two graphs above, a student claims that humans are causing global temperature change.

Highlight or circle which question, when answered, would support the student's claim?

- a) How does burning fossil fuels affect the amount of CO₂ produced every year?
- b) Is the Greenhouse Effect increasing the amount of CO₂ in the atmosphere?
- c) Do atmospheric temperatures change before or after changes occur in CO₂ levels?
- d) What is the relationship between the amount of CO₂ produced by volcanoes and atmospheric temperature?

Core Ideas, Asking Questions

2) Explain why this is a testable question: Include the dependent and independent variables and examples of evidence that could be collected.

APPENDIX K

TOPIC 3- CLIMATE MODELLING SUMMATIVE ASSESSMENT

Climate Summative Assessment
Modified from Measured Progress, Inc. STEM Gauge 2016

Climate Part 2: Summative Assessment

Scientific Practices:
-Developing and Using Models

Crosscutting Concepts:
-Systems and System Models

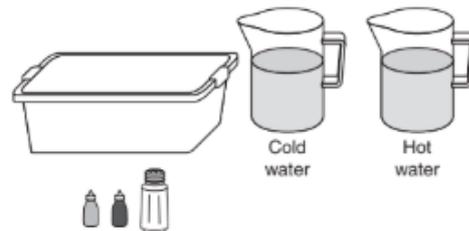
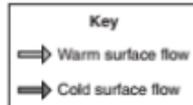
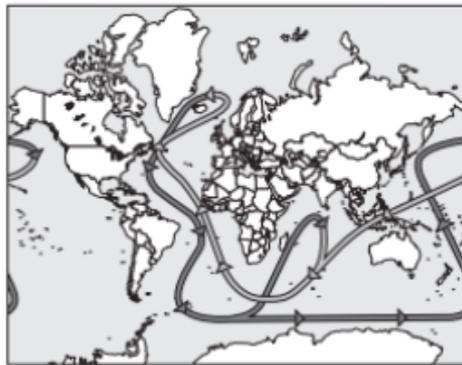
Core Ideas:
MS-ESS2-6 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Use your model and notes to help you answer questions 1 and 2.

1) Clay is deciding on a model to show how the unequal heating of Earth is based on the factors of altitude or latitude.

- a) Create a list of materials he could use to demonstrate these factors.
- b) Draw a model using the materials you listed.
- c) Explain why you chose to use the listed materials (what does each material represent in the real world?)

2) The map shows the global circulation pattern of ocean currents.



A student starts with the following materials to model ocean currents: blue food coloring, red food coloring, a clear tub, a pitcher filled with cold water, a pitcher filled with warm water, and salt.

- a. What additional materials would you use to demonstrate ocean currents?
- b. Write a procedure that uses all of these materials to model how ocean currents form in the ocean and move as a result of differences in density and Earth's uneven heating.
- c. Explain how the model demonstrates the processes given in part (b). Your answer should include the characteristics that drive deep ocean currents and the relationship between ocean currents and Earth's heat.

APPENDIX L
COLLEAGUE OBSERVATION SHEET

Colleague Observation Sheet

Colleague Observation Sheet

Your email address (chrisneurinski@acs.sch.ae) will be recorded when you submit this form. Not you? [Switch account](#)

* Required

Please choose today's date *

Date

yyyy-mm-dd _____

Please choose which period you observed. *

Period 1

Period 2

Period 3

Period 4

Period 5

Period 6

Survey Instructions: Read each statement carefully. Select a number from 1-5 to indicate the degree to which you agree or disagree with each statement below.

1= Strongly Disagree, 2= Disagree, 3= No Opinion/ Not Observed, 4= Agree, 5= Strongly Agree

1a) The Teacher appeared fully prepared for today's lesson. *

1 2 3 4 5

1b) Please explain your response if appropriate. *

Your answer _____

2a) The teacher played the role of coach throughout the majority of the lesson. *

1 2 3 4 5

2b) Please explain your response if appropriate. *

Your answer _____

3a) Students were able to articulate what is necessary to meet the day's learning performance. *

1 2 3 4 5

3b) Please explain your response if appropriate. *

Your answer _____

4a) Students had feedback readily accessible while working on the day's assignment? *

1 2 3 4 5

4b) Please explain your response if appropriate. *

Your answer _____

5a) Students had visible goals set based on previous feedback. Goals had steps that clearly explained what the student felt they needed to do next? *

Your answer _____

5b) Please explain your response if appropriate. *

Your answer _____

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APPENDIX M
TEACHER DAILY REFLECTION

Teacher Daily Reflection

Teacher Daily Reflection

Your email address (chrisneurinski@acs.sch.ae) will be recorded when you submit this form. Not you? [Switch account](#)

* Required

Please choose today's date *

Date

yyyy-mm-dd

Survey Instructions: Read each statement carefully. Select a number from 1-5 to indicate the degree to which you agree or disagree with each statement below.

1= Strongly Disagree, 2= Disagree, 3= No Opinion/ Not Observed, 4= Agree, 5= Strongly Agree

1a) I felt fully prepared for today's lesson. (Preparation Time) *

12345

1b) Please explain your response if appropriate. *

Your answer

2a) I took a reasonable amount of time to prepare for the day's activities. (Preparation Time) *

12345

2b) Please explain your response if appropriate. *

Your answer

3a) I was able to provide high quality discourse throughout each period today. (Feedback) *

12345

3b) Please explain your response if appropriate. *

Your answer

4a) Students I conferenced with left feeling like they knew what they needed to do next. (Feedback) *

12345

4b) Please explain your response if appropriate. *

Your answer

5a) I was able to play the role of coach throughout the majority of the lesson. (Role) *

12345

5b) Please explain your response if appropriate. *

Your answer

6a) The learning performance for the lesson was appropriate and could be followed by most students. (Teaching Methods) *

12345

6b) Please explain your response if appropriate. *

Your answer

7a) I would teach this same lesson in the future with minimal or no alterations. (Teaching Methods) *

12345

7b) Please explain your response if appropriate. *

Your answer

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Scardino, R.M. (2011). *The Effects of Differentiated Instruction on Understanding Middle School Science Concepts* (Unpublished capstone paper). Montana State University, Bozeman, MT.

APPENDIX N

TEACHER BI-WEEKLY JOURNAL PROMPTS

Teacher Bi-Weekly Journal Prompts

Teacher Journal Prompts

- 1) (Preparation Time) Planning for the week's activities did/did not take a reasonable amount of time. Explain
- 2) (Preparation Time) Feedback that I provided for formative assessments did/did not take a reasonable amount of time. Explain
- 3) (Teaching Methods) Based on my daily reflections, on student reflections, and on colleague observations, my teaching methods were/were not effective to help students learn new content. Explain.
- 4) (Role) Based on my daily reflections, on student reflections, and on colleague observations, I was/ was not able to play the role of a coach throughout the week. Explain.
- 5) (Feedback) Based on my daily reflections, on student reflections, and on colleague observations, my feedback to students was/ was not able to help students set goals and determine next steps. Explain

Scardino, R.M. (2011). *The Effects of Differentiated Instruction on Understanding Middle School Science Concepts* (Unpublished capstone paper).
Montana State University, Bozeman, MT.

APPENDIX O
IRB APPROVAL



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 0000165

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 406-994-4706
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MEMORANDUM

TO: Christopher Neurinski and Walter Woolbaugh
FROM: Mark Quinn *Mark Quinn Cj*
 Chair, Institutional Review Board for the Protection of Human Subjects
DATE: October 8, 2018
RE: "The Effect of Varied Feedback on Student Performance in a Middle School Science Classroom" [CN100818-EX]

The above research, described in your submission of October 7, 2018, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX P

STUDENT FEEDBACK REFLECTION AND GOAL SETTING SHEET

Student Feedback Reflection and Goal Setting Sheet

During each topic of study, Mr. Neurinski provides you with directed and indirect feedback through conversations, discussions, written or typed phrases and questions, as well as video responses.

Direct feedback includes one on one conversations, narrative feedback written or typed onto your work, video feedback for you about your own assignment.

Indirect feedback includes group conversations, whole class or small group discussions or videos using other students work as samples for improvement.

It is important for a student to reflect on the feedback that is provided throughout a unit and feedback from previous topics, in order to help them improve and to know their next steps.

For each topic of study, you will be provided with time to reflect and respond to the next steps necessary to improve your understand or scientific practice skills.

Topic 1 Standard: *Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.*

Type your reflection in blue, using Times New Roman, 12 font

Describe Mr. Neurinski's feedback in your own words in the appropriate spaces below.			
	Accurate/ labeled	Process	Relationships between Components
Developing Models			
	Explain thinking using evidence	Connections between data, model, and evidence	Accurate vocabulary and core ideas.
Constructing Explanations Core Ideas			
<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"> <p>What is the most important question that he posed to you in his feedback?</p> </div> <div style="border: 1px solid black; padding: 5px;"> <p>Why do you think it is the most important?</p> </div>			

How will you use this to help you to set a goal and improve your understanding of this scientific practice?

Topic 2 Standard: *Develop models to describe the atomic composition of simple molecules and extended structures.*

Type your reflection in blue, using Times New Roman, 12 font

Describe Mr. Neurinski's feedback in your own words in the appropriate spaces below.

	Accurate/ labeled	Process	Relationships between Components
Developing Models			
	Explain thinking using evidence	Connections between data, model, and evidence	Accurate vocabulary and core ideas.
Constructing Explanations Core Ideas			

What is the most important question that he posed to you in his feedback?

Why do you think it is the most important?

How will you use this to help you to set a goal and improve your understanding of this scientific practice?

Topic 3 Standard: *Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.*

Type your reflection in blue, using Times New Roman, 12 font

Describe Mr. Neurinski's feedback in your own words in the appropriate spaces below.

What are other notes you would make to yourself to continue to improve in these areas?

	Accurate/ labeled	Accurately displayed	Data clearly shows two variables to examine relationship between
Represent Data			
	Accurate analysis	Appropriate methods	Patterns or relationships identified
Analyze Data			
	Explain thinking using evidence	Connections between data, model, and evidence	Accurate vocabulary and core ideas.
Constructing Explanations Core Ideas			

What is the most important question that he posed to you in his feedback?

Why do you think it is the most important?

How will you use this to help you to set a goal and improve your understanding of this scientific practice?

Topic 4 Standard: *Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.*

Type your reflection in blue, using Times New Roman, 12 font

Describe Mr. Neurinski's feedback in your own words in the appropriate spaces below.

	Accurate/ labeled	Process	Relationships between Components
Developing Models			

	Accurate use of model	Evaluate accuracy or limitations	Define improvements
Use Models			
	Explain thinking using evidence	Connections between data, model, and evidence	Accurate vocabulary and core ideas.
Constructing Explanations			
Core Ideas			
<p>What is the most important question that he posed to you in his feedback?</p>			
<p>Why do you think it is the most important?</p>			
<p>How will you use this to help you to set a goal and improve your understanding of this scientific practice?</p>			

Topic 5 Standard: *Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*
 Type your reflection in blue, using Times New Roman, 12 font

Describe Mr. Neurinski’s feedback in your own words in the appropriate spaces below.			
	Testable	Sufficient and relevant evidence	Evaluation of testability
Ask questions			
	Accurate analysis	Appropriate methods	Patterns or relationships identified
Analyze Data			
	Explain thinking using evidence	Connections between data, model, and evidence	Accurate vocabulary and core ideas.
Constructing Explanations			

Core Ideas						
<table border="1"><tr><td data-bbox="304 450 1386 555">What is the most important question that he posed to you in his feedback?</td></tr><tr><td data-bbox="304 555 1386 660">Why do you think it is the most important?</td></tr><tr><td data-bbox="304 660 1386 792">How will you use this to help you to set a goal and improve your understanding of this scientific practice?</td></tr></table>				What is the most important question that he posed to you in his feedback?	Why do you think it is the most important?	How will you use this to help you to set a goal and improve your understanding of this scientific practice?
What is the most important question that he posed to you in his feedback?						
Why do you think it is the most important?						
How will you use this to help you to set a goal and improve your understanding of this scientific practice?						