STORYLINES IN MIDDLE SCHOOL

by

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DEDICATION

To my husband, Bob, for being patient during this process by supporting me and taking on a more duties to help me free up time. To my children, Treyjen and Harlow, for letting mom have her 'homework time' and providing constant love and praise.

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ABSTRACT

The Next Generation Science Standards were presented in a three-dimensional format including science and engineering practice, crosscutting concepts, and disciplinary core ideas. The three-dimensional standards are driven by a real-world phenomenon. With very few resources available, connecting the real-world phenomenon to the three-dimensional standards a disconnect in the units as a whole. Storylines provide a sequence of lessons driven by a students' question about the phenomena. Using a storyline with the Next Generation Science Standards bridge the gap between anchor phenomena and three-dimensional learning. This action research was designed to answer whether or not using storylines can connect phenomena to three-dimensional learning creating an overall deeper understanding of the content. The procedure consisted of two different sections of 6th grade and 7th grade students. Each section alternated between treatment (storyline) units and nontreatment (traditional) units. Pre- post- unit tests and student surveys were given after each unit. The results of this action research were mixed. The pre-post unit tests did not provide strong enough evidence to support the use of storylines to build a deeper understanding. The post-unit student surveys did show marginal differences between students in a treatment versus nontreatment group. Some of the data originally collected was also voided due to the changing of learning models during the COVID-19 pandemic. In conclusion, the data collected did not support or void the use of storylines to connect the phenomenon to three-dimensional learning. Student opinions and attitudes about storylines confirmed the value of this action research within the integrated middle school classroom.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

Context of the Study

The national science standards for science education have evolved due to the implementation of the Next Generation Science Standards (NGSS) created in 2013. Since that time, states and districts have been slowly converting to the performance-based standards. Minnesota followed the lead by adopting a version of these standards that will be fully implemented by the 2023-2024 school year.

This led our district to draft an implementation plan over the course of three years. The middle school was the first to begin the three-year cycle. The first year included the sixth grade converting to an integrated curriculum supported by the NGSS. The following year the sixth and seventh grade had fully integrated curriculum, and the addition of the eighth-grade implementation followed in year three. Phenomena inquiry is at the base of our district wide instruction with an emphasis in three-dimensional learning.

The three-year cycle of implementing the new Minnesota Science Standards based on NGSS occurred at Caledonia Area School District in Minnesota. The implementation process of these standards took place at Caledonia Middle School. Caledonia Area Middle School lies in a rural district with 148 students sixth through eighth grade. Caledonia Area Schools lack in ethnic diversity with 94.4% of students identifying as Caucasian, 3.4% as two or more races, 1.7% Hispanic or Latino, and 0.6%

Black or African American. Caledonia is a one-to-one iPad school with technology being a district initiative (Minnesota Report Card, 2020).

During the 2018-2019 school year, only 24.5% of the students in grades sixth through eighth met the Minnesota Comprehensive Assessments (MCA) science proficiency standards (Minnesota Report Card, 2020). I joined the district three years ago and during this time I have observed the middle school students trying to adjust to a hands-on approach to learning.

The new MN science standards marked the first-time standards were updated in a decade. The new standards in combination with the students' lack of hands-on science experience led to some trial and error as teachers implemented the new Minnesota Science Standards implementation plan. During the designing of the implementation plan, the science team developed curriculum that was based on resources published by NGSS partners. As a department, we took some of these prepared NGSS designed lessons into our classrooms to test with students.

The NGSS phenomena-based lessons led to greater and deeper understanding of the curriculum. The use of science and engineering practices (SEPs) along with crosscutting concepts (CCs) was a difficult transition for the students; however, the depth of knowledge gained was evident. The beginning of each unit would begin with an anchor phenomenon. This was a great way to build interest and connect to real-world situations. The phenomena led into a sequence of lessons. At the end of the unit, I found myself wondering, "where did the anchor phenomenon go?" The path of the lessons did not connect back to the phenomenon, which seemed to make the implementation of the initial phenomena obsolete.

The second concern about the phenomenon-based units were that they required a large amount of trust from the students. I knew that eventually the little lessons would lead them to the bigger picture, but the students did not seem aware of this path. As the Next Generation Science Storylines states, “often the importance of a particular problem or idea is clear to the teacher, but not to the students” (Edwards et al., n.d.). I wanted students to have more ownership in what they were learning. This led me to find the concept of storylines brought to light by Reiser, Novak, and McGill in 2017.

Focus Statement/Question

A storyline “is an instructional unit that is a coherent sequence of lessons, in which each step is driven by students’ questions that arise from their interactions with phenomena” (Edwards et al., n.d., p. 3). The purpose of this study was to create more cohesive units by connecting phenomena-based inquiry to the three-dimensional learning of the NGSS through the implementation of storylines in an integrated middle school classroom. This research will focus on the question, Can storylines create an inherent connection between anchor phenomena and three-dimensional instruction within an integrated science classroom?

My sub-questions include the following:

1. Can storylines connect the phenomena to disciplinary core ideas to produce more authentic learning?
2. Can storylines help students learn to use science and engineering practices by investigating phenomena?

3. Can storylines help students develop a deeper understanding by making connections based on crosscutting concepts?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

International Scope of Science Standards

The United States strives to be the best, but fell short in science education. In 2012, the U.S. average score for fifteen-year-olds on the Program for International Student Assessment fell far below the scores of 15 other OECD (Organization of Economic Ce-operation and Development). This is not an uncommon theme amongst the science education community in the United States. Adolescent students in the United States have been scoring in the middle of the pack or below other countries in science assessments for the past two decades (Program for International Student Assessment, 2014).

The first international study that identified the gap of achievement in science education among developed countries was the Trends in International Mathematics and Science (TIMMS) study conducted in 1999. This study compared the United States to four other countries that outperformed the United States on the 1999 TIMSS assessment. The four countries observed were the Czech Republic, Japan, Australia, and the Netherlands. The TIMSS study took a random sample of 100 lessons conducted in 8^{th} grade science classrooms within the five countries (Roth & Garnier, 2006). The countries outperforming the United States showed patterns in their instruction organization. The Czech Republic stood out in the TIMSS study by exposing their students to rigorous content and expectations. Students were required to share their progress publicly in many formats. The lessons conducted in Japan showed a pattern of using inquiry-based learning with a large emphasis on evidence. Their evidence-based curriculum was the foundation to supporting the outlined science content. The Australian lessons also used a focus of evidence to help support the main ideas of the lessons. However, the Australian lessons used more high-interest activities as well as real-life connections than the lessons conducted in Japan. Finally, the Netherlands placed their focus on learning the science content as a traditional student, through a large amount of textbook use and written homework assignments (Roth & Garnier, 2006). All four countries compared to the United States showed similarity in having a main focus in science content opposed to disconnected lessons. The science lessons conducted within the United States showed a wide range of activities. Many of the lessons showed engaging activities related to real-life content. However, the lessons taught in the United States often lacked a coherent lesson focus or didn't include a lesson goal at all (Roth & Garnier, 2006). The TMISS study concluded that the United States is lacking organization of science content. There is an absence of pattern within the contents of the lessons being conducted. The content of middle school science lessons need to be deepened and strengthened and the activities within the classroom need to be designed around the specific content being taught (Roth & Garnier, 2006).

Creation of New Science Standards

The TMISS study lead to the revising of science education standards in the United States. Within A Framework for K-12 Science Education PART 1: A Vision for K-12 Science Education, there were calls for advancement of K-12 science education standards with a focus on professionals in the science and engineering fields in hopes to keep the

United States competitive with other countries. The TIMSS study along with other previous studies as well as science education projects lead to The Framework for K-12 Education. Based on previous findings it is evident that there is a need to prepare our students for the 21st century, which includes revising the science standards to help students engage in deep and meaningful content-based lessons (National Research Council, 2012).

The Framework for K-12 Education is focused on allowing students to add science and engineering practice skills and to use crosscutting concepts to expand their understandings of traditional science content. This vision allows teachers to focus on a smaller amount of core ideas with the intention of providing a deeper understanding of the core content (National Research Council, 2012).

The Framework for K-12 Education led to the creation of the NGSS (Next Generation Science Standards). The NGSS are organized into three dimensions: (a) disciplinary core ideas, (b) science and engineering practices, and (c) cross-cutting concepts. The disciplinary core ideas overlap each other throughout grade levels to lead to a deeper understanding of content by graduation, which was an area the United States was lacking in the TIMSS study (NGSS Lead States, 2013). For example, DCI Structure and (LS1) Molecules or Organisms is covered in kindergarten, first, third, fourth, fifth, and seventh grade. The science and engineering practices component of the NGSS shows the value of teaching students how to examine the world that surrounds them. As stated in Appendix F of the NGSS,

> showing students to not only 'know' science concepts, but also, students can use their understanding to investigate the natural world through the practice of science inquiry, or solve meaningful problems through the practices of engineering design (NGSS, 2013, p. 1).

This is the largest change within the new NGSS standards compared to previous science standards (NGSS Lead States, 2013).

The crosscutting concepts unite the disciplinary core ideas, thus creating a deeper understanding of the core concepts. The crosscutting concepts also help support the science and engineering practices by giving meaning to why these are being investigated. For example, crosscutting concept patterns helps students observe patterns in data collected during an investigation. These patterns help connect the investigation for the larger disciplinary core idea being taught. This finally leads into the importance of learning the skills needed to investigate the concepts (NGSS Lead States, 2013).

The Framework for K-12 Science Education and the NGSS have laid a new foundation for science education. The NGSS left a lot of room for interpretation and organizational freedom by each school district or state that adopts the standards. This leads to inconsistencies across states and districts and still leaves room to fulfill the "unity" part of the Framework of K-12 Science Education vision (NGSS Lead States, 2013).

Student Driven Science Curriculum

The implementation of the new standards and the freedom they embody can lead to uncertainty when designing curriculum to fit within the three-dimensions. Instead of approaching the uncertainty of the new NGSS as a burden or negative, uncertainty can lead to professional learning and growth as a science teacher. Accepting these uncertainties can lead to teacher change, and better implementation of the three-dimensional components of the NGSS standards (Melville & Pilot, 2014). This approach allows for a new way to look at science instruction. Often times teachers may be aware of why the class is moving from one topic to another within a unit, but it may not be clear to the students until they have fully understood the learning targets of the complete unit. A student driven approach may allow the students to create the path of lessons they follow to meet the learning target of the unit. However, the ability to allow for student driven curriculum requires a teacher's willingness to accept uncertainty and to learn a new strategy to provide instruction for students (Reiser et al., 2017). Storylines are a framework in which a unit is designed to provide a foresight for students to connect the lessons within a unit.

Storylines are a unique way to unite the three-dimensions of the NGSS while putting students in the driver's seat. Storylines provide a logical sequence for a lesson (Appendix G). The lessons are driven by students' questions based on their observed phenomena. This can allow for some positive uncertainty within the classroom by allowing students to drive the instruction based on inquiry (Edwards et al., n.d.). Allowing student driven learning will likely increase students' engagement in their investigations and encourage a deeper understanding of the DCI being taught. Within a storyline format, students are guided on a path to meet learning targets based off of their questions developed from phenomena-based inquiry. Deep content building requires more than designing investigations and collecting data. Student engagement and investment in the classroom requires students to be involved in decision making and ownership of their classroom time (Reiser et al., 2017) (Table 1).

Table 1. Storylines benefits vs. challenges.

Benefits	Challenges
• More student control • Clearview of where the unit is going	• Lack or curriculum • One curriculum does not fit all • Accept uncertainty

Coherent Flow of New Science Standards

A classroom environment the brings about engagement in student knowledge is based on the idea of taking each step of the unit together and allowing choice in which step the class should take next. Creating this classroom culture starts with focusing on five key elements: (a) starting the unit with investigations, (b) motivating the students to drive the next step, (c) using science and engineering practices to figure out the science content, (d) pushing students to go deeper, and (e) helping students make the connections to the disciplinary core ideas and crosscutting concepts (Reiser et al., 2017).

In addition to finding an engaging anchor phenomenon, pushing students to understand that they cannot immediately explain the things that are happening around them every day will help students focus questions around the anchor phenomenon. The phenomenon also needs to be applicable to the students' schema or real-world experiences. Relating phenomenon to the real-world and breaking it down to relevantly fit into their world view can help establish driving questions that coordinate with the phenomenon. This leads to connections between lessons and builds on student curiosity (Nordine et al., 2019). Finally, getting students to verbalize questions and ideas they have about the phenomena will help drive the unit (Reiser et al., 2017).

Motivating students to drive the next step in the unit is considered the more uncertain area of storyline building. As the sequencing is being laid out, teachers need to look forward to the goal of the unit as well as looking backward to connect the dots of the previous lessons, which is rarely straightforward (German, 2017). To do this, performance expectations need to be identified and become the checkpoints of the unit (Nordine et al., 2019). This step is an on-going process where students need to look back to see the progress they have made. At the same time, students need to be able to look forward to identifying new problems to take into the new lesson (Reiser et al., 2017).

At this point in the unit, students need to be able to use science and engineering practices to identify what they are trying to figure out. Before an investigation takes place, students should know why they are using the practice and what questions they are trying to answer. This step leads to further engagement in the investigation. (Reiser et al., 2017). Once the class meets the check points designed into the lesson, it is the teacher's job to encourage students to dive into the concept further. A teacher can lead this dive by pulling our misconceptions or exposing problems with the students' current understandings of the concept. Challenging students to push their mental model or current understandings to new and various situations may create disagreement within the classroom, as mental models and understandings can be unique to each student. This disagreement can open new doors to deeper investigations within the science content (Reiser et al., 2017).

Finally, students need to connect the dots between the disciplinary core ideas and the crosscutting concepts. Small versions of this step should be taking place at each check point of the lesson. This step can be completed in many different forms in which students collected their data and ideas. It is important that the teacher show students how the dots connect across each lesson or model created in order to solidify a deep connection and understanding of the lesson goal (Reiser et al., 2017).

CHAPTER THREE

METHODOLOGY

Treatment

The focus of this action research was to assess if storylines can create an inherent connection between anchor phenomena and three-dimensional instruction within an integrated middle school classroom. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

This action research took place within the 2020-2021 school year, which presented unique and cumbersome circumstances due to the COVID-19 pandemic. Caledonia Public Schools followed the Minnesota Department of Education's Safe Learning Plan. During the time of data collection, the Caledonia Public School System was using a hybrid learning plan for the 7th grade classes. The hybrid setting placed students within the classroom once a week, and required students to complete class online once a week. Within four weeks of hybrid learning, Caledonia Public Schools switched into a fully online learning platform. The second semester of the school year started again in a hybrid schedule. Four weeks into the second semester, Caledonia Public Schools moved back into an in-person learning model for the final data collection.

During the time of data collection for this action research, the 6th grade sections were in the in-person model. This learning model required students to attend the class every other day for an hour and a half. After data collection started, the 6th grade was abruptly moved into a fully online learning model for finish the first semester. The 6th

grade students came back as in-person to start the second semester and remained in-person until the end of the year. Due to a reduction in instruction time, the units used with the non-treatment and treatment groups required a longer time to complete.

The participants in the 7th grade class consisted of two sections with one group named the treatment group and the other as the nontreatment group within the same unit. The first section of 7th grade had a total of 23 students, composed of 70% male students and 30% female students. Only two students in this section had an IEP, and another 17% of students received additional support through our ADSIS program (what is this program?). The second section of the 7th grade class consisted of 25 students, which was composed of 60% male and 40% female students. Sixteen percent of students in this section had an IEP, and an additional eight percent received ADSIS services (T. Fruechte, personal communication, January 5, 2019).

The participants in the 6th grade class consisted of two sections that alternated between treatment and non-treatment groups where both sections remained as a treatment or a nontreatment based on the unit taught. The first section of 6th grade students had a total of 26 students, composed of 42% males and 58% females. None of the students in this section had an IEP, but sixteen percent of students participated in out ADSIS program. The second section of 6th grade students had a total of 27 students. This section was comprised of 37% males and 63% female. Twenty-two percent of students in this section had an IEP, and an additional eleven percent of students were part of our ADSIS program (T. Fruechte, personal communication, January 5, 2019).

The treatment for this capstone consisted of adopting a storyline to lead the direction of the unit. Each treatment unit consisted of a Driving Question Board (DQB) in which students constructed questions after being exposed to a phenomenon (Appendix H). Based on the DQB, the students chose which path they would like to take within the unit. The treatment group also decided which lessons within the unit they would like to spend more time on. The treatment group had this choice throughout the unit as students continued to view the DQB and referred to the anchor phenomenon of the unit.

The 7th grade class had one section representing as the treatment group and one section representing the nontreatment group. The groups switched roles on the consecutive unit. The 6th grade class completed the first unit both as nontreatment groups. The two sections both took on the role of treatment groups for the second unit.

Data Collection Instrument

The students in both treatment and nontreatment groups shared their opinions and thoughts on unit structures by taking a post-unit student survey (Appendix D). The post-unit student survey was written in the form of a Likert survey, a score of 5 represented a student opinion of Strongly Agree, a 4 signified Agree, a 3 signified a Neutral viewpoint, a 2 represented Disagree, and a 1 indicated an opinion of Strongly Disagree. Students also participated in a post-unit questionnaire. Within the questionnaire, students were asked to share their mastery levels of the science and engineering practices and cross-cutting concepts used within the unit (Appendix E). Lastly, misconception probes were used to draw out misconceptions based on the disciplinary core ideas of the unit (Appendix F). Misconception probes were administered at the beginning and end of the unit. Growth amongst the misconception probes were determined based on rubric scores. An overview of data collection methods is located in the table below (Table 2).

Table 2. Planned data collection methods for action research project.

Focus Questions	Data Collection Methods				
	DCI Unit Tests	SEP Performance Assessment	SEP & CCC Student Survey	SEP & CCC Written Survey	Misconception Probes
Can storylines connect the phenomena to disciplinary core ideas to produce more authentic learning?	X	X	X	X	X
Can storylines help students learn to use science and engineering practices by investigating phenomena?	X	X	X	X	
Can storylines help students develop a deeper understanding by making connections based on crosscutting concepts?			X	X	X

CHAPTER 4

DATA AND ANALYSIS

Results Connection Phenomenon to DCI

The Disciplinary Core Ideas (DCI) Tests were presented to students in both the treatment and nontreatment groups. These tests were administered at the beginning at end of each unit. If results show higher gains in performance scores from the pre-test to post - test during the treatment units versus nontreatment units, this should indicate a deeper understanding of the DCI indicating more authentic learning when connecting to phenomena.

The results of the statistical analysis of the 6th grade Weather and Climate (nontreatment) pre-test and post-test showed an increase of 24.3 points (42.1-66.4) from the pre-test to the post-test of the unit in Section 1. Section 2 showed an increase of 29 points (36.8-65.8) from the pre-test to post-test in the Weather and Climate (nontreatment) unit. This was an average increase of 26.7 points from the pre-test to post-test during the nontreatment unit (Figure 1, 2). The normalized gains for the Weather and Climate DCI Unit test was 0.46, which indicated a medium gain (Hake, 1998).

The results of the statistical analysis of the Cells to Organisms (treatment) pre-test and post-test mirrored the results of the nontreatment group with an increase of 40 points (40-80) from the pre-test to the post-test of the unit in Section 1. Section 2 showed an increase of 20 points (46.7 to 66.7) from the pre-test to post-test in the Cells to Organisms (treatment) unit. This was an average increase of 30 points from the pre-test to post-test during the treatment unit. The calculated normalized gains for the Cells to Organisms

DCI Unit Test was 0.54 also indicating a medium gain (Hake, 1998). The lack of contrast between the normalized gains of the nontreatment and treatment units indicated no significant evidence to support a deeper understanding of DCI in the treatment unit versus the nontreatment unit.

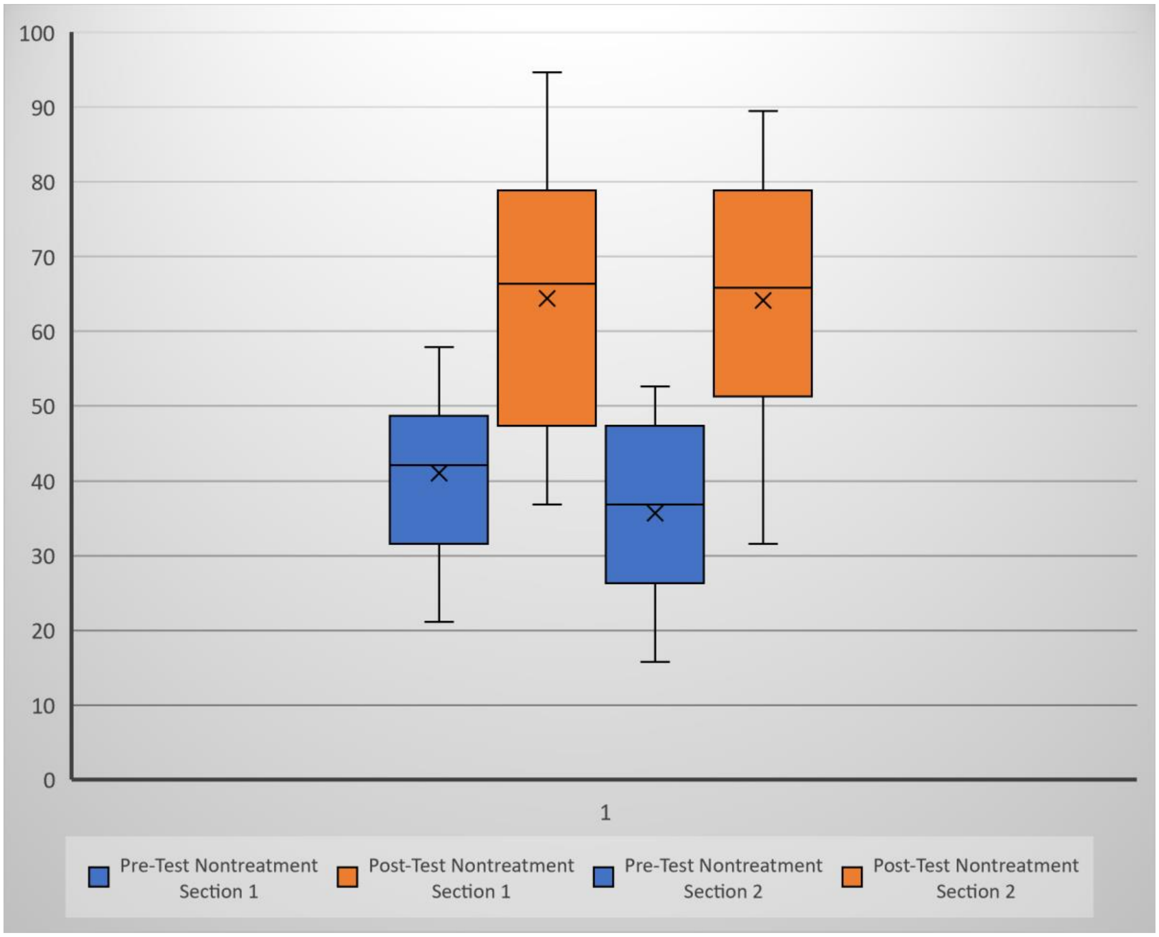

Figure 1. A box plot for the 6th grade Weather and Climate (Nontreatment) DCI Unit Test Section 1: (*N*=26), Section 2: (*N*=22).

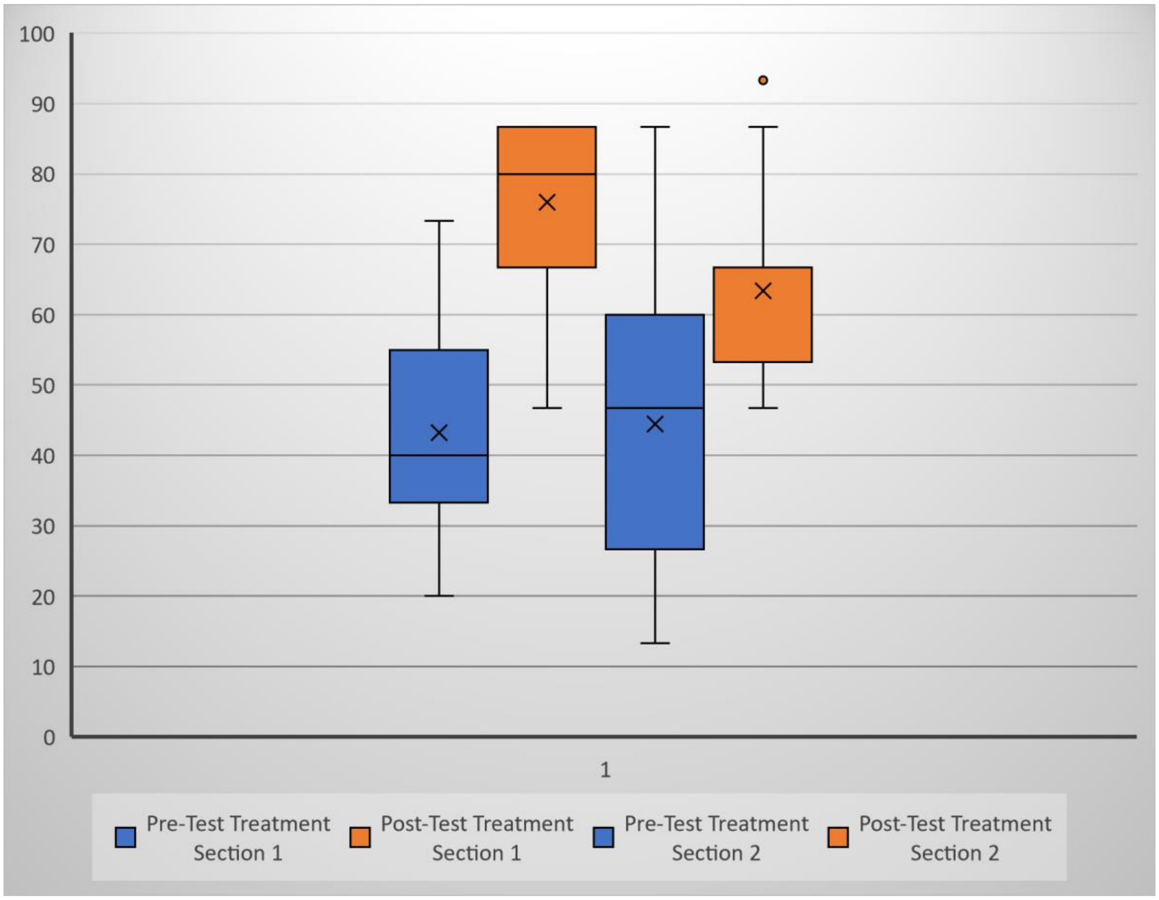

Figure 2. A box plot for the 6th grade Cells to Organisms (Treatment) DCI Unit Test Section 1: (*N*=26), Section (*N*=22).

The DCI Unit Tests were also administered to the 7th grade to gage if the treatment units provided an authentically deeper understanding of the DCI being taught. The statistical analysis of the 7th grade Food and Energy Unit in Section 1 (treatment) showed an increase of 25 points (40-65) from the pre-test to the post-test. In comparison, the statistical analysis of the 7th grade Food and Energy Unit in Section 2 (nontreatment) showed an increase of 40 points (30-70) from the pre-test to post-test (Figure 3). The normalized gain for Section 1 (treatment) Food and Energy DCI Test was 0.43 indicating a medium gain compared to Section 2 (nontreatment) group receiving a normalized gain of 0.5 indicating a stronger medium gain (Hake, 1998).

The statistical analysis of the 7th grade Reproduction Unit in Section 1 (nontreatment) showed an increase of 40 points (30-70) from the pre-test to the post-test. Similarly, to the Food and Energy Unit, the statistical analysis of the 7th grade Reproduction Unit in Section 2 (treatment) showed an increase of 30 points (40-70) from the pre-test to the post-test (Figure 4). The normalized gain for Section 1 (nontreatment) Reproduction DCI Test was 0.53 indicating a medium gain compared to Section 2 (treatment) group received a normalized gain of 0.53 indicating a higher medium gain.

The DCI Unit Tests amongst 7th grade students did not show any significant results support the deeper understanding of DCI in the treatment units vs nontreatment units. The nontreatment units in both Section 1 and Section 2 actually produced a slightly higher normalized gains on the DCI Unit Tests compared to the treatment units.

SEP Performance Assessments administered at the beginning and end of each unit should have also provided an analysis of whether or not storylines provided a deeper connection between phenomenon and DCI. Due to the variety of learning models implemented due to the COVID-19 pandemic, performance assessment data collection was not attainable during the hybrid and distance learning model. The performance assessment data collected during the in-person model was voided.

The comparison of the Misconception Probes carried out and the beginning and end of each unit also had the potential for highlighted patterns between storylines and the ability to deeply understand DCI. This data collection instrument was also removed from the data and analysis section due to the lack of dependable data collected during the distance learning model.

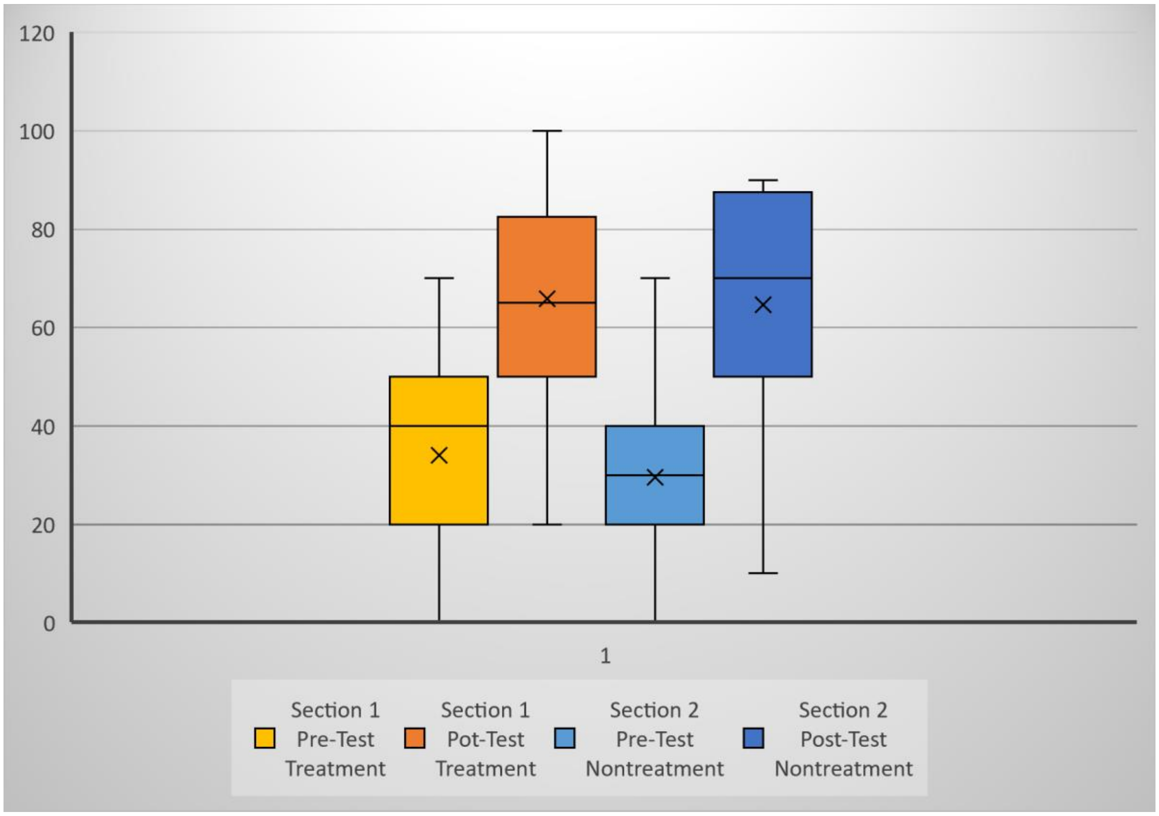

Figure 3. A box plot for the 7th grade Food and Energy DCI Unit Test Section 1: Treatment (*N*=22), Section 2: Nontreatment (*N*=23).

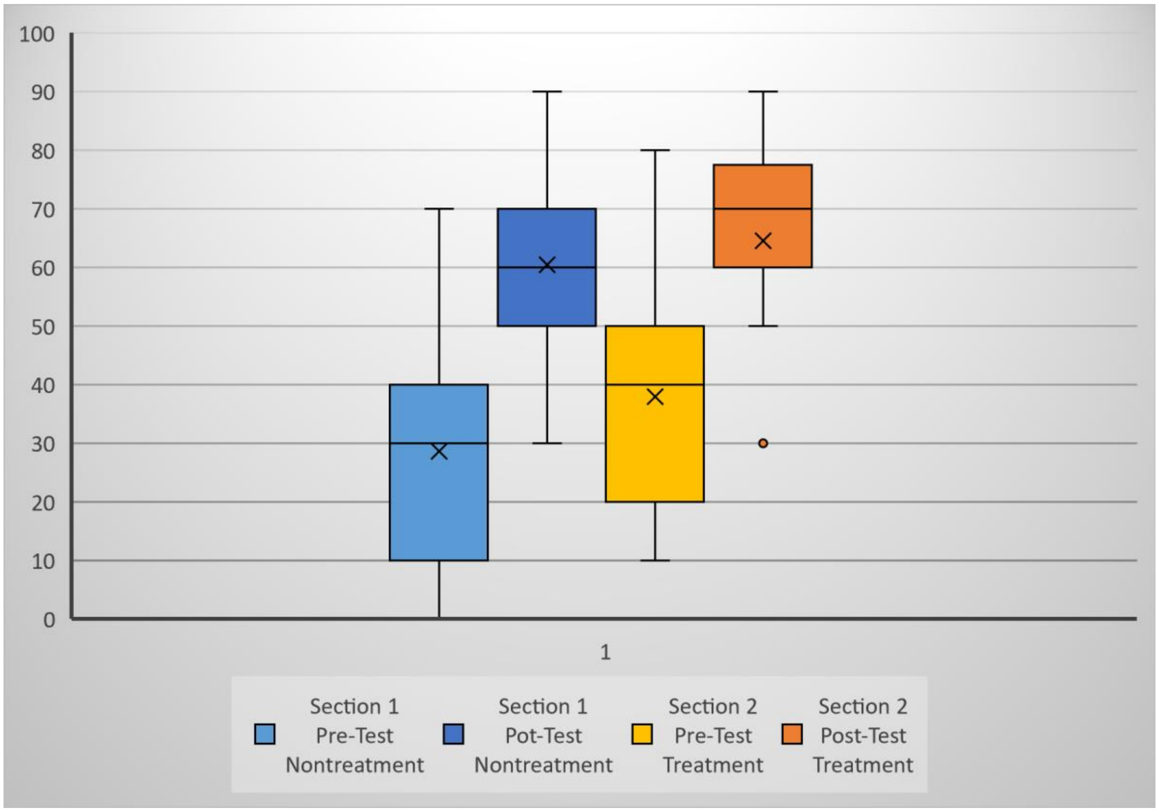

Figure 4. A box plot for the 7th grade Reproduction DCI Unit Test Section 1: Nontreatment (*N*=22), Section 2: Treatment (*N*=23).

Results Connection Phenomenon to SEP and CCC

The data analysis continues with student surveys given at the end of each unit. Questions on the survey were designed to indicate if students were able to grasp SEP by investigating phenomena as well as developing a deeper understanding by making connections using the crosscutting concepts. Higher Likert survey scores reported on treatment post-unit surveys versus nontreatment post-unit surveys would indicate a stronger understanding of SEP and CCC within the treatment units.

The Likert survey scores recorded from the Food and Energy (FE) Post-Unit Survey. The most frequent responses to the statement, “This unit followed a path that allowed me to understand the unit concepts at a deeper level," in the Section 1 (Treatment) FE Post-Unit Survey (*N*= 15) 53% stated they agreed or strongly agreed. The frequency of choosing agree or strongly agree was lowed in the Section 2 (Nontreatment) FE Post-Unit Survey (*N*=19) with 42% (Figure 5, 6).

This trend continues with the statement, "It was clear to see the lessons answering questions posted on our (DQB) board as a class" where 10 (67%) of students chose agree or strongly agree in the FE Post-Unit Survey in Section 1 (Treatment) to only 2 (10%) students choosing agree or strongly agree in the FE Post-Unit Survey in Section 2 (Nontreatment).

The growth in the FE Likert Survey began to slow when looking at the statement, "I feel confident in my understanding of the concepts." Eight (53%) of student agreed or strongly agreed with this statement on the FE Post-Unit Survey for Section 1 (Treatment). This number actually increased on the nontreatment (Section 2) as 11 (58%) on the FE Post-Unit Survey.

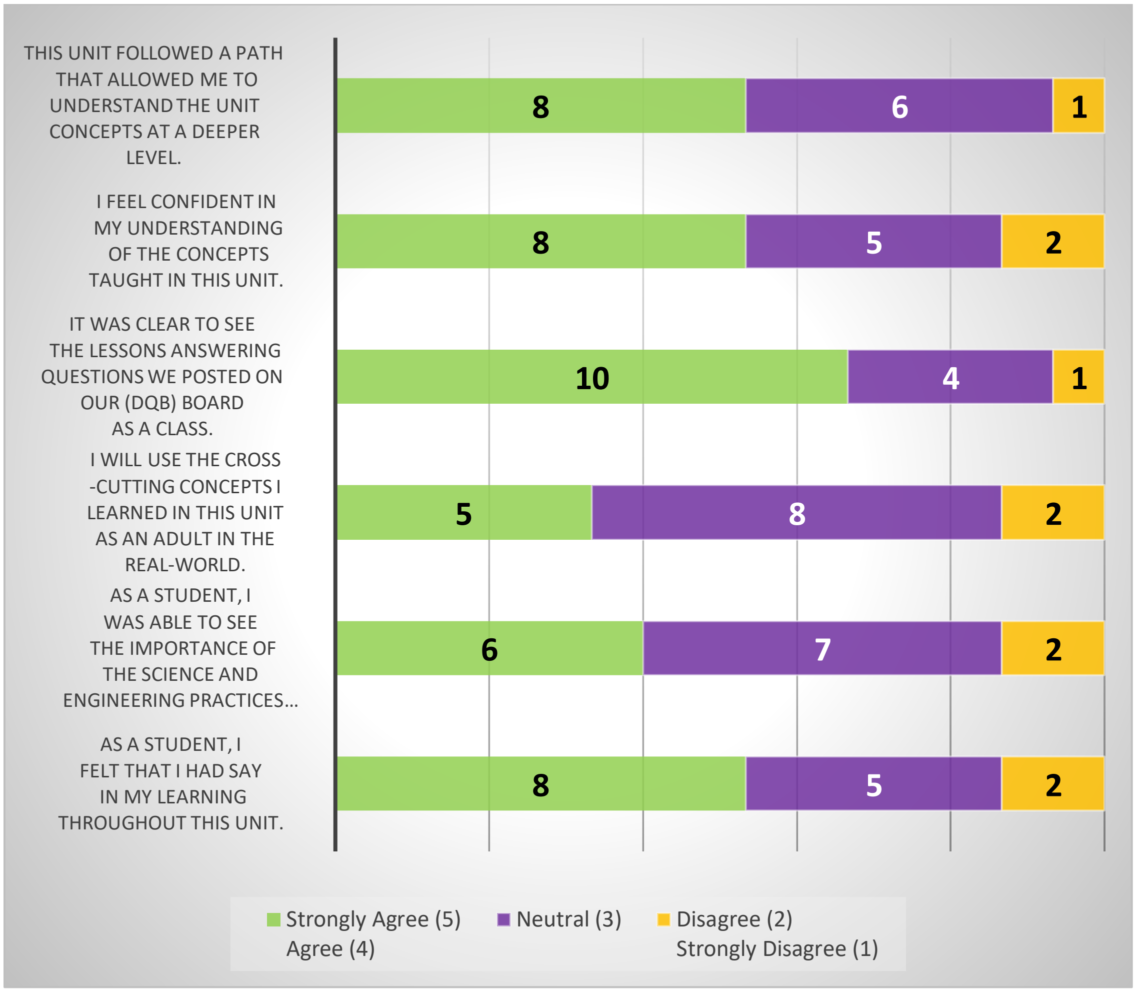

Figure 5. Likert Survey Data from Food and Energy SEP & CCC Student Survey, Section 1 Treatment (*N*=15). This section of the survey was based on "Science and Engineering Practices and Crosscutting Concepts" statements.

Figure 6. Likert Survey Data from Food and Energy SEP & CCC Student Survey, Section 2 Nontreatment (*N*=19). This section of the survey was based on “Science and Engineering Practices and Crosscutting Concepts” statements.

The Likert Survey continued with the Reproduction Post Unit Survey. The most frequent responses to feeling confident in their understanding of crosscutting concepts, in the Reproduction Post-Unit Survey for Section 1 (Nontreatment) was agree with (12) 64% of students choosing either agree or strongly agree. This data improved slightly to the Reproduction Post-Survey for Section 2 (Treatment) where the most frequent response was still agree (16), with 70% of students choosing either agree or strongly agree. (Figure 7; Figure 8).

This trend continues with the statement, “This unit followed a path that allowed me to understand the unit,” where 11 (52%) of students chose agree or strongly agree on the Reproduction Post-Unit Survey for Section 1 (nontreatment) compared to 14 (61%) of student chose agree or strongly agree on the Reproduction Post-Unit Survey for Section 2 (treatment). The students also showed a higher belief in the ability to see the importance of science and engineering practices during the Reproduction Post-Unit Survey Section 2 (treatment) with 61% (14) choosing agree or strongly agree compared to 48% (10) who agreed or strongly agreed for the Reproduction Post-Unit Survey for Section 1 (nontreatment).

The results of the Likert survey amongst 7th grade students were ambiguous in nature. The results indicated the students felt they had a deeper understanding of SEP during treatment units. There was no significant data to support a deeper understanding of crosscutting concepts within a treatment unit.

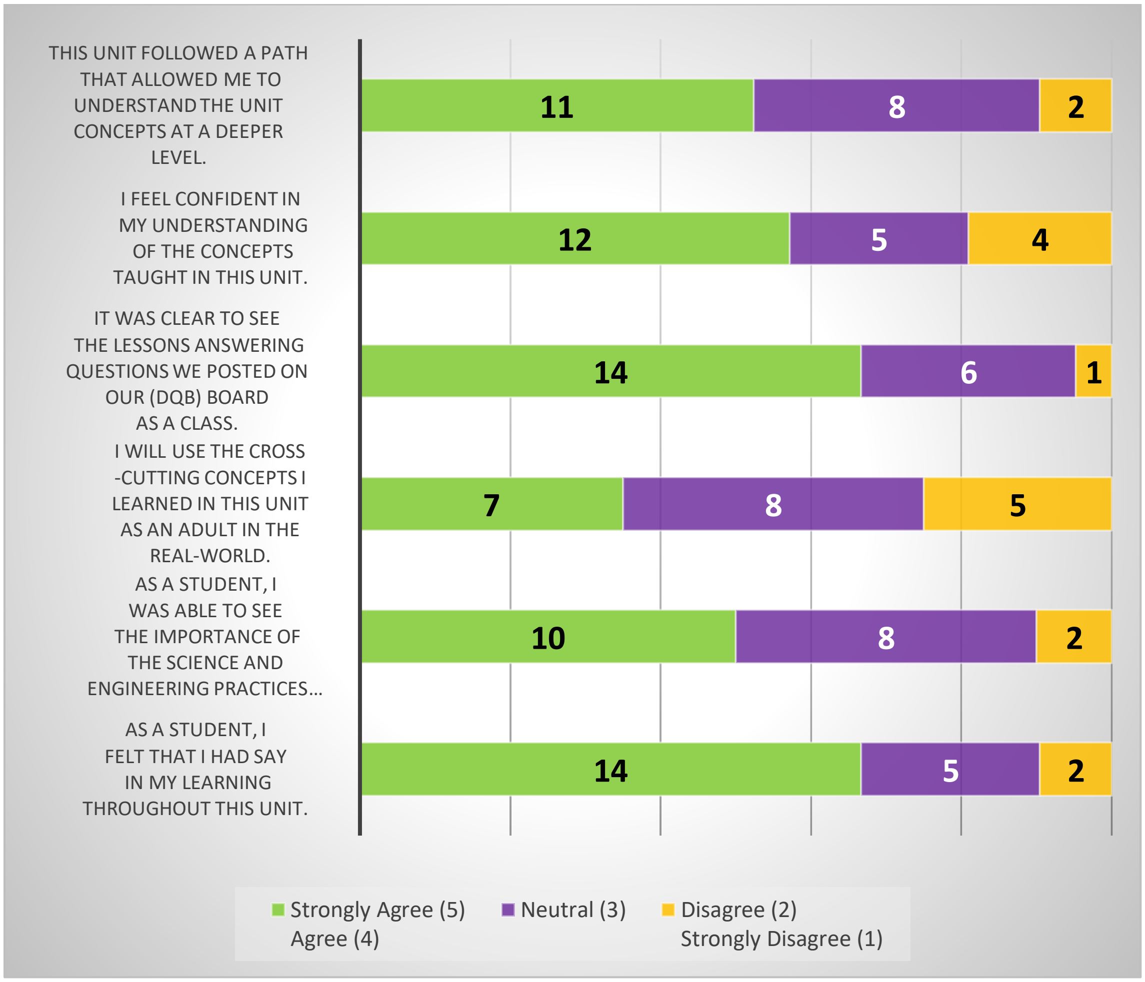

Figure 7. Likert Survey Data from Reproduction SEP & CCC Student Survey, Section 1 Nontreatment (*N*=21). This section of the survey was based on “Science and Engineering Practices and Crosscutting Concepts” statements.

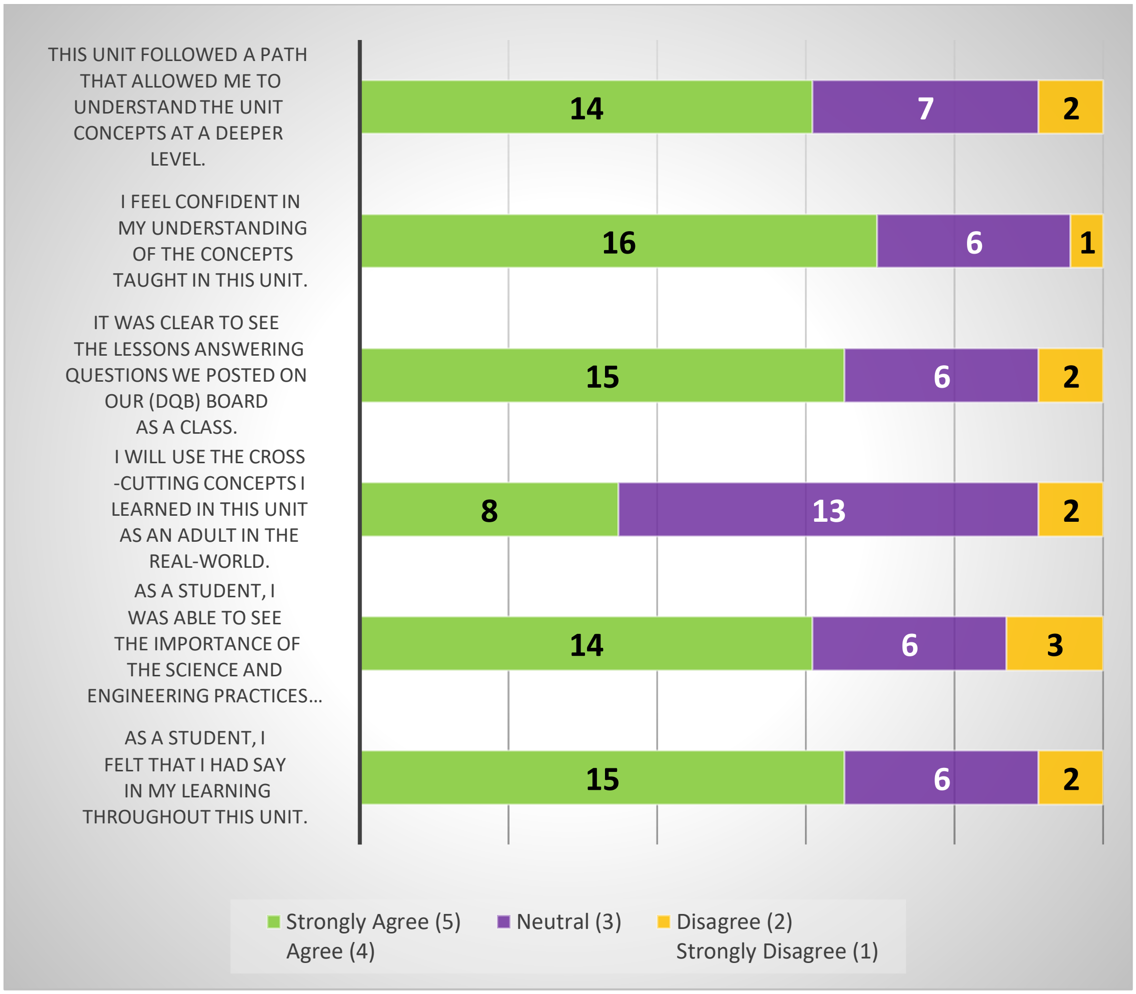

Figure 8. Likert Survey Data from Reproduction SEP & CCC Student Survey, Section 2 Treatment (*N*=23). This section of the survey was based on “Science and Engineering Practices and Crosscutting Concepts” statements.

In accordance to the Likert Survey based on “Science and Engineering Practices and Crosscutting Concepts” statements, the stagnation of growth in the feeling that the unit followed a path that allowed me to understand the concepts at a deep level. The data analysis for the 6th grade Likert scores recorded from the Weather and Climate (WC) Post-Unit Survey (Nontreatment). The most frequent responses to the statement, “This unit followed a path that allowed me to understand the unit concepts at a deeper level,” was agree or strongly agree with 15 (60%) from Section 1 and 15 (57%) from Section 2 (Figure 9, 10). The percentage slightly increased during the (treatment) Cells to Organisms (CO) Post-Unit Survey with 16 (64%) students in Section 1 choosing agree or strongly agree and 17 (65%) in Section 2. The minimal change in scores continued as 17 (68%) students felt they had a say in their learning in Section 1 during the WC Post-Unit Survey and 12 (46%) of Section 2 agreed or strongly agreed. During the CO Post-Unit Survey 18 (72%) of students in Section 1 agreed or strongly agreed to feeling that they had a say in their learning and 15 (60%) of students in Section 2 felt this way (Figure 11, 12).

Figure 9. Likert Survey Data from Weather and Climate SEP & CCC Survey (6th grade), Section 1 Nontreatment (*N*=25). This section of the survey was based on “Science and Engineering Practices and Crosscutting Concepts” statements.

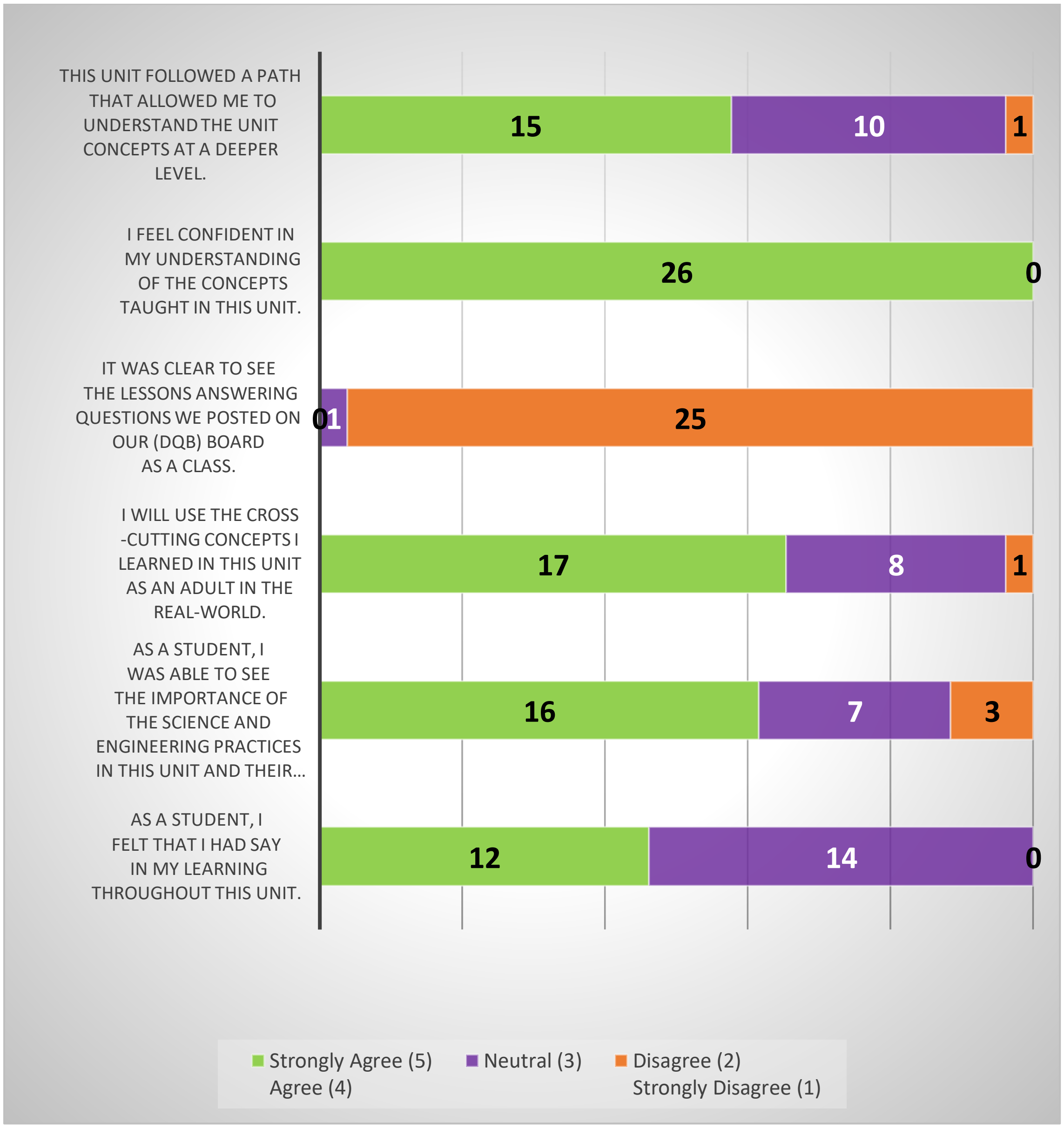

Figure 10. Likert Survey Data from Weather and Climate SEP & CCC Student Survey (6th grade), Section 2 Nontreatment (*N*=26). This section of the survey was based on “Science and Engineering Practices and Crosscutting Concepts” statements.

The trend changes with the statement, “It was clear to see the lessons answering questions we posted on (DQB) board as a class.” Fifteen (60%) chose disagree or strongly disagree in Section 1 and twenty-five (96%) chose disagree or strongly disagree in Section 2 WC (nontreatment) Post-Unit Survey. The statistic dramatically changes on the CO Post-Unit Survey with Section 1 only 3 (12%) chose disagree or strongly disagree and in Section 2 only 4 (15%) of students chose disagree to strongly disagree.

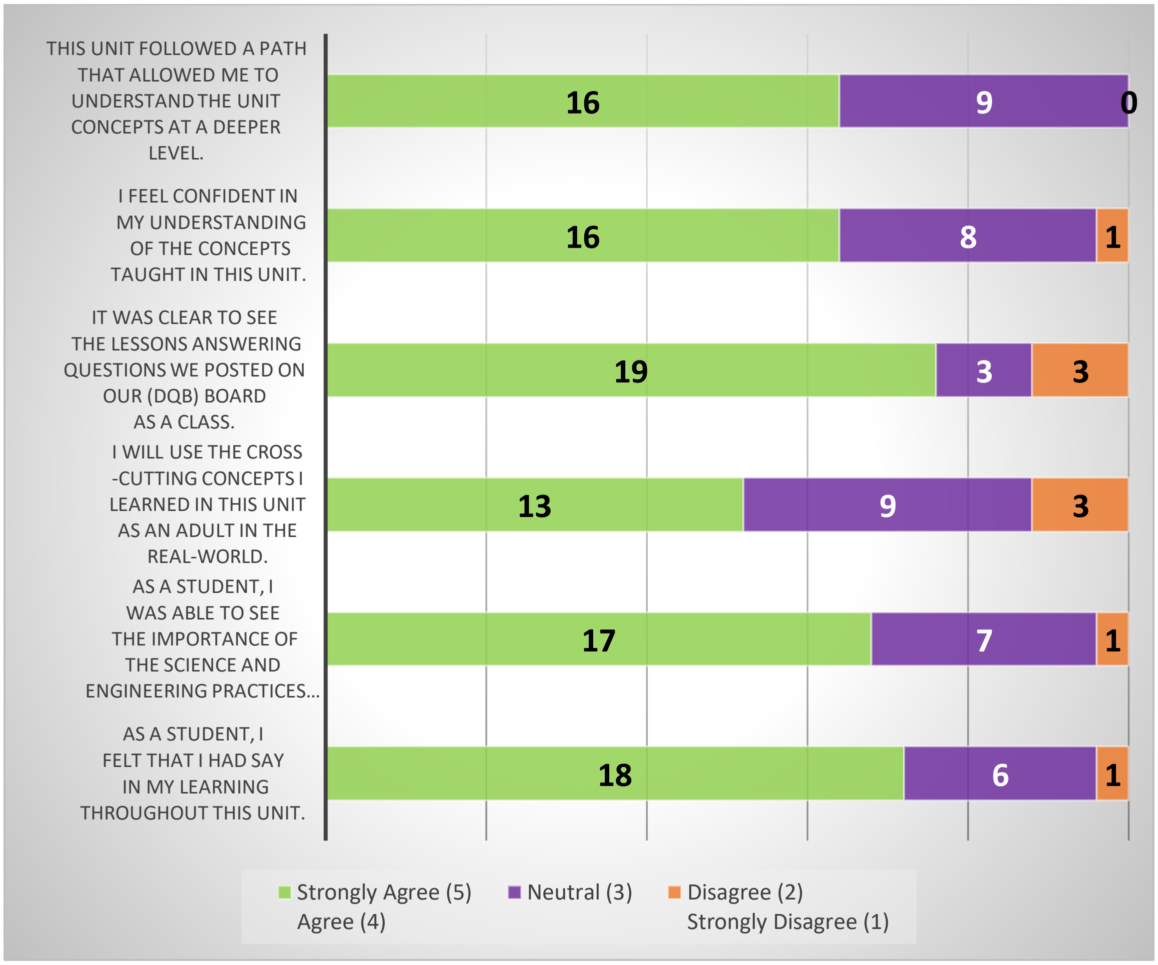

Figure 11. Likert Survey Data from Cells to Organisms SEP & CCC Student Survey (6th grade), Section 1 Treatment (N=25). This section of the survey was based on “Science and Engineering Practices and Crosscutting Concepts” statements.

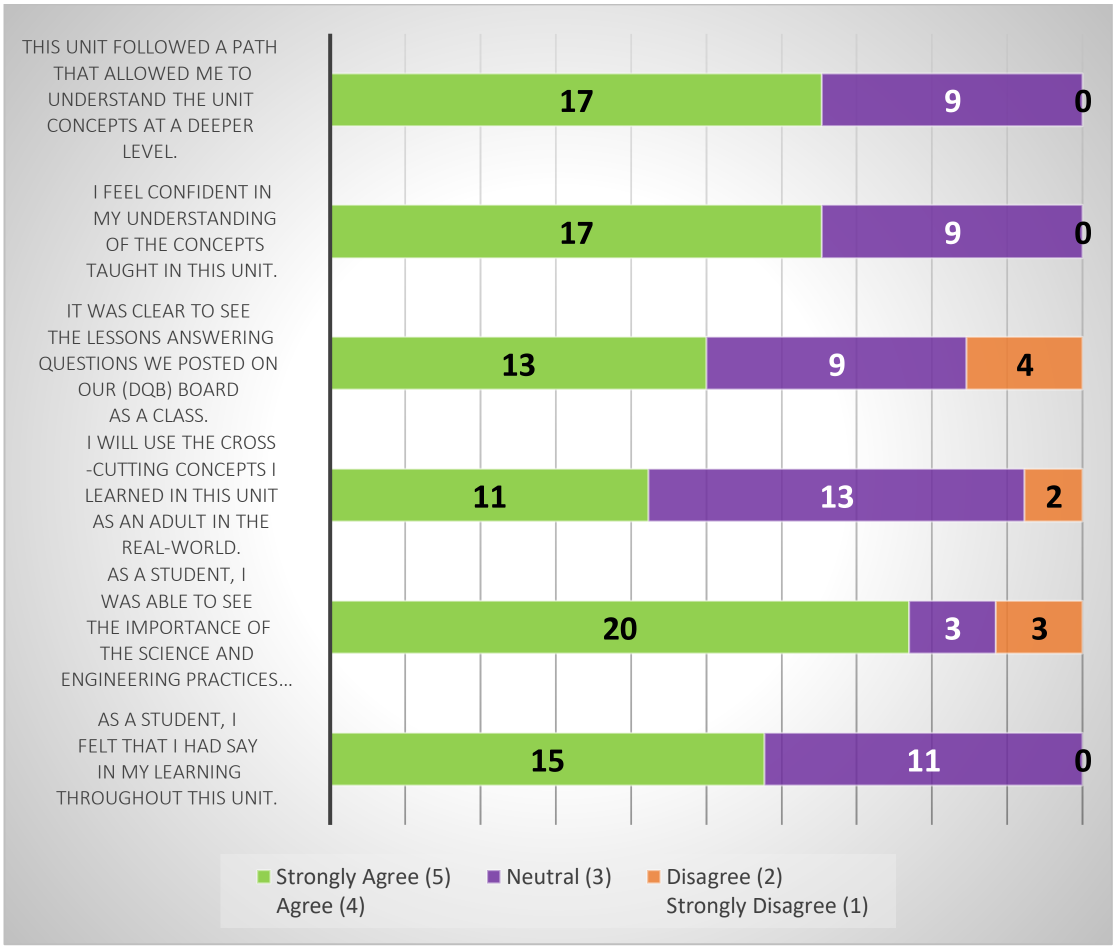

Figure 12. Likert Survey Data from Cells to Organisms SEP & CCC Student Survey (6th grade), Section 2 Treatment (*N*=26). This section of the survey was based on “Science and Engineering Practices and Crosscutting Concepts” statements.

In conclusion the data from the 6th grade Likert survey indicated a stronger confidence of SEP during treatment units, but there remains not indication of evidence to support the deeper connections made through crosscutting concepts. The Likert survey supported a more positive attitude and feeling of confidence towards units that contained a storyline. Students that took part in a treatment unit (62%) felt slightly more confident that the path of the unit lead them to deeper thinking skills compared to the (54%) student in the nontreatment groups. The student quotes such as, “It (storyline) helped me because you're not just thinking about what cells are made of, but what viruses can use the cell for," positively supports the Likert survey results. Student felt a stronger connection to the unit based on student responses such as, "I felt like I was in the shoes of the teacher," and "I was able to see what other students were thinking. Some student thought like I did and others were thinking differently about the same topic."

As stated above, SEP Performance Assessments were eliminated from data collection due to complications with switching learning models during the COVID-19 pandemic. The SEP Performance Assessments had the ability to shine more light on the understanding of SEP by investigating phenomenon. Similarly, the Misconception Probes were designed to evaluate whether a deeper understanding of the concept was reached by making connections through crosscutting concepts. This data collection was also removed from collection due to COVID-19 complications.

Overall, the usable data collected from this action research project provided mixed results.   Reproduction Unit Section 2) pre- post test scores that only increased by an average of 20 points. There is no evidence to support positive growth between the pre-post unit scores in the treatment units. The data remained ambiguous and was not able to provide enough evidence to support or contradict whether storylines create a deep connection between the phenomenon to three-dimensional learning model.

CHAPTER FIVE

CLAIM, EVIDENCE, REASONING

Claims from the Study

This action research project was designed to answer whether storylines could create an inherent connection between an anchor phenomenon and three-dimensional instruction within an integrated science classroom. Within the focus question three claims were created: (a) storylines will connect phenomena to DCI to promote authentic learning, (b) storylines learn SEP by investigating phenomena, and (c) storylines provide a deep understanding by making connections using crosscutting concepts.

The first claim noted in this study was that storylines connect the phenomena to disciplinary core ideas to produce more authentic learning. The DCI Unit Tests did not provide evidence towards this claim. However, the SEP & CCC Student Likert survey showed that students felt they had a greater say in their learning with 69% choosing agree or strongly agree compared to only 56% who chose agree in the nontreatment units. In the short answer part of the survey, a student stated that, “It helped me get more into the unit because it answered things that I wanted to know.” The Likert survey also showed that 65% of students in the treatment groups felt that it was clear to see their questions being answered on the DQB compared to only 30% who felt that way during the nontreatment groups. A student also stated that, “It helped me break down the big topic (phenomenon) and work our way through it, piece by piece, to better under the concept.” Both survey questions laid the groundwork for students entering a deeper level of thinking even if the assessment results do not indicate greater growth.

The second claim of the action research was that storylines help students learn to use science and engineering practices by investigating phenomena. The Likert data showed a slight preference to seeing the importance of using the Science and Engineering Practices in their life outside of school. Sixty-five percent of students chose agree or strongly agree compared to only 60% of students in the nontreatment unit. One student stated, “It helped me learn that I actually need to use evidence when I am giving my answer or opinion,” and another stated, “I learned that we are actually surrounded by models and use them every day.” Based on the evidence and environment of the classroom it was evident that students felt these practices were beneficial for them to use in the future.

Lastly, it was claimed that storylines help students develop a deeper understanding by making connections based on crosscutting concepts. Neither the DCI Unit Test nor the SEP & CCC Student Survey data showed any evidence supporting this claim. A student did state that, “finding patterns in data is something I will use in high school.” It was clear that cross-cutting concepts were a weakness during this study.

Value of the Study and Consideration for Future Research

The value of this study seemed to wavier during the transition of different learning models throughout the year due to COVID-19. Much of the data I collected was not usable, which lead to mixed results in the data analysis. The true value of this researched shined within the environment of the classroom that could not be showing within the statistical data, which was and atmosphere filled with student engagement. As a whole, the 6th grade (Section 1 and 2) completed a nontreatment unit and then completed a treatment unit. During the nontreatment unit, a student asked “Mrs. Burmester, with all do respect, when will this information ever be important to us in the future?” This question was stated during our lessons about the Water Cycle. As a teacher I knew the direction the unit was going and why understanding the components of the water cycle were important, but the student did not. This led to further reflection and realization that this type of question was never asked during the treatment units at any grade level.

During the treatment units the students were provided with a phenomenon based on the real world which immediately grounded and made the unit relevant. The remaining path of the unit was directed or steered by the students. They could answer the “Why are we doing this?” question at all times. That realization validated the importance of this action research within a middle school science classroom.

Impact of Action Research on the Author

This action research project placed my teaching strategies and curriculum under a microscope. The biggest change I will be making as a teacher is relooking at my assessment techniques. Some of the assessment techniques did not allow me to use data for this action research. Other forms of assessments I used for action research didn’t place an emphasis on SEP and CCC standards. In the future, the current assessments being used in my classroom need to better align with the three-dimensional standards in order to better fit the storylines that were presented.

As an educator, I have definitely grown in my content knowledge as well as my ability to modify and develop lessons fluidly. This growth was based on the fact that storylines are every changing and will never be taught the same way between two different sections. The majority of the time I was able to allow student choice while guiding them down a path, but this doesn't always happen. When students are hungry and driven to find answers, it is important to let them do so. This led to the strengthening of my teaching skills as well as being willing to let go of some control and to be vulnerable enough to learn with the students.

Lastly, going through the action research process has allowed myself to grow a deeper respect for action research or research in education. Collecting tangible data on the changing minds of humans is not an easy task. The variables within the walls of a classroom are changing daily. As I use research to continue shaping my classroom, I will not forget the time and diligence it takes to complete an educational study.

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APPENDICES

APPENDIX A

IRB APPROVAL

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STATE UNIVERSITY

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For the Protection of Human Subjects
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MEMORANDUM

TO: Tori Burmester and John Graves

FROM: Mark Quinn Mark Quinn CH
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: November 2, 2020

RE: *"Using Storylines to Connect Phenomena-Based Inquiry to Three-Dimensional Learning" [TB110220-EX]*

The above research, described in your submission of November 2, 2020, 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:

_X_ (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.

_X_ (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; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).

____ (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 B

DCI UNIT TEST EXAMPLE

Question 1 (1 point)

Which one of the following does NOT describe the weather?

- a the amount of water pollution in a lake
- b if it is raining out
- c the force of the wind through the trees
- d the number of clouds there are in the sky

Question 2 (1 point)

Which of the following best describes the difference between weather and climate?

- a Weather can be predicted by climate cannot.
- b Weather includes the wind and rainfall, whereas climate only describes the temperature.
- c Weather happens in your state, and climate happens in your country.
- d Weather describes conditions such as wind and rain at a particular time, whereas climate describes typical seasonal conditions.

Question 3 (1 point)

What is the main cause of deepwater ocean currents?

- a wind, caused by variation in air pressure, blowing on the water.
- b freshwater rivers and streams flowing into the ocean.
- c differences in water density because of variation in water temperature and salt concentration.
- d the Coriolis effect: Earth's rotation causes the water in the oceans to move.

Question 4 (1 point)

What substances make up most of the atmosphere?

- a nothing except sometimes clouds.
- b greenhouse gases such as carbon dioxide and methane
- c tiny particles of pollution from cars and other machines.
- d gases such as nitrogen, oxygen, argon, and water vapor.

APPENDIX C

SEP PERFORMANCE ASSESSMENT EXAMPLE

Performance-Based Assessment
Line Graph & Model Drawing

Area	Specific Requirements	Notes	Check off
Labels	- graph is titled - x-axis and y-axis are properly labeled - key is labeled		☐ Completed ☐ Incomplete
Spacing	- x-axis uses proper intervals - y-axis uses proper intervals - ruler used to provide proper spacing		☐ Completed ☐ Incomplete
Plotting	- data plots are clearly visible and neat - data is plotted correctly - data is connected with lines to show proper trend - lines are color coded to match key		☐ Completed ☐ Incomplete
Model Drawing	- a title and description of the cell is present - model is labeled neatly and clearly - model includes all required terms ▪ cell membrane ▪ cytoplasm ▪ nucleus - model shows flow of liquid in and out of a cell		☐ Completed ☐ Incomplete

APPENDIX D

SEP & CCC STUDENT SURVEY

Please answer questions based on our completed unit.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
As a student, I felt that I had say in my learning throughout this unit.	☐	☐	☐	☐	☐
As a student, I was able to see the importance of the Science and Engineering Practices and their use in my daily life.	☐	☐	☐	☐	☐
I will use the cross-cutting concepts I learned in this unit as an adult in the real-world.	☐	☐	☐	☐	☐
It was clear to see the lessons answering questions we posted on our board as a class.	☐	☐	☐	☐	☐

I feel confident in my understanding of the concepts taught in this unit.	☐	☐	☐	☐	☐
This unit was laid out in a way that allowed me to understand the concepts at a deeper level.	☐	☐	☐	☐	☐

APPENDIX E

SEP & CCC WRITTEN SURVEY

What was the importance of the Science and Engineering Practices used in this unit?

Your answer

Explain how the cross-cutting concepts discussed in this unit connected to the unit anchor phenomenon.

Your answer

How did using a student-driven storyline impact your learning of the concept and performance on the summative assessment?

Your answer

APPENDIX F

MISCONCEPTION PROBE EXAMPLE

MYTHSSION CONTROL

The Mythbusters© T.V. show on the Discovery Channel produced an episode about the science behind car crashes. The scientists on the show crashed two identical cars into a head on collision. Each car was traveling at 50 mph.

At the end of the episode….

Mythbusters said: "The two cars hitting each other at 50 mph is equivalent to one car hitting a wall at a speed of 100 mph."

FANS WHEN CRAZY OVER THIS STATEMENT!

Avery ***(Fan of the Show)*** said: "NO! That statement is incorrect! The two cars hitting each other at 50 mph is equivalent to one car hitting a wall at a speed of 25 mph. When the two cars collide, the other car absorbs some of the impact, thus reducing the speed impact of the crash."

Blake ***(Fan of the Show)*** said: "NO! That statement is absurd! The two cars hitting each other at 50 mph is equivalent to one car hitting a wall at a speed of 50 mph. For every action there is an equal and opposite reaction. That is a simple Law of Motion."

Who do you agree with (Mythbusters, Avery, or Blake)? Provide an explanation for your answer.
____

____

____

____

____

APPENDIX G

STORYLINE EXAMPLE

PHENOMENA, DRIVING QUESTIONS AND STORYLINE

FROM CELLS TO ORGANISMS

This unit explores the anchoring phenomenon: When you look through a microscope, organisms as different as humans, plants, and many microorganisms that make people sick are all made of cells. Examples include cells from various animal tissues like blood cells, plant cells, protozoa, and bacteria, including specific microorganisms that cause certain infectious diseases. Students generate and answer questions such as: How are the cells of various organisms alike? How are they different? How do these similarities and differences relate to the functions of these cells??

Phenomenon	Driving Questions	Guiding Questions	Activities	PE	Storyline/Flow (How an activity leads to subsequent activities)
Some diseases can be spread from person to person.	How did scientists discover that microbes could cause and spread disease?	How do scientists figure out the source of an infectious disease outbreak? (Activity 1)	1, 2, 3, 4 (14, 15)	MS-LS1-1	An infectious disease can be transmitted from person to person.
		What can cause an infectious disease? (Activity 2)			Microscopic living organisms are the cause of some infectious diseases.
		How can tools such as microscopes help scientists provide evidence about living organisms? (Activity 3)			Microscopes provide evidence of organisms at scales too small to be observed by the human eye.
		How did the cell theory lead to the germ theory of disease? (Activity 4)			The idea that all living organisms are made of cells led to the germ theory of disease.
Even though organisms may look different on the outside, their cells have a lot in common.	What structures and functions do living cells have in common?	What evidence can you gather that cells are alive? (Activity 5)	5, 6, 7, 8	MS-LS1-2	Cells are alive and respire.
		How do the structures in animal and plant cells relate to their functions? (Activity 6)			Cells of all organisms have similar structures, and these structures function similarly in each organism.
		What is the function of a cell membrane? (Activity 7)			The cell membrane is an example of a cell structure that functions similarly in different organisms.
		How do the parts of a cell work together? (Activity 8)			Models can be used to demonstrate and describe cell structures and their functions.

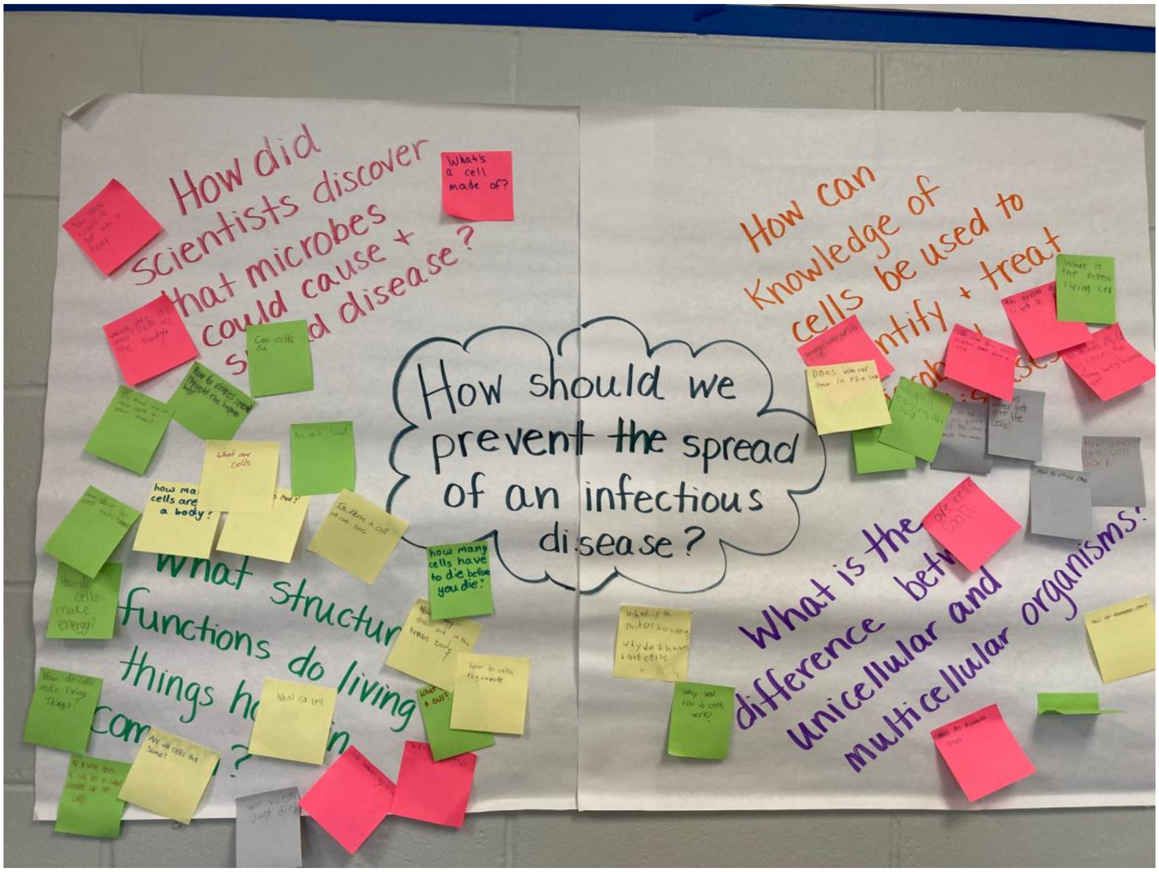
PHENOMENA, DRIVING QUESTIONS AND STORYLINE

FROM CELLS TO ORGANISMS (continued)

Phenomenon	Driving Questions	Guiding Questions	Activities	PE	Storyline/Flow (How an activity leads to subsequent activities)
Some organisms are just one cell, while other organisms have many cells.	What is the difference between unicellular and multicellular organisms?	How do the cells of multicellular organisms compare with the cells of single-celled organisms? (Activity 9)	9, 10	MS-LS1-1 MS-LS1-3	Microscopes provide evidence that living things are made of one or many cells and that cells of different organisms share certain structures.
		What is the relationship between cells, tissues, organs, and organ systems within a multicellular organism? (Activity 10)			Animals and plants have levels of organization, including cells, tissues, organs, organ systems, and organisms.
Living organisms need food to survive.	How do living organisms obtain and use the matter and energy they need to survive?	How does food provide energy and matter for organisms? (Activity 11)	11, 12, 13	MS-LS1-6 MS-LS1-7	Food is rearranged through chemical reactions that support growth and/or release energy for cells.
		What structures in plant cells convert energy from the sun into energy stored in food? (Activity 12)			Plant cells contain structures for photosynthesis, a process that uses sunlight to synthesize food.
		What is the evidence that plants both produce and break down sugars? (Activity 13)			Experiments can provide evidence of photosynthesis and respiration in plants.
Infectious diseases can be diagnosed and treated.	How can knowledge of cells be used to identify and treat microbial diseases?	How can knowledge of cell structure and function be used to treat disease? (Activity 14)	14, 15	MS-LS1-1 MS-LS1-2	Knowledge of cell structure and function has helped scientists develop drugs that treat diseases caused by unicellular organisms.
		What microbe caused the outbreak? (Activity 15)			An understanding of cells and infectious agents can help identify the source and transmission of infectious diseases.

APPENDIX H

DRIVING QUESTION BOARD EXAMPLE


How did Scientists discover that microbes could cause + s[...]d disease?
How can Knowledge of cells be used to [...]ntify + treat
How should we prevent the spread of an infectious disease?
What structur[...] functions do living things h[...]
What is the [...] difference bet[...] unicellular and multicellular organisms?
What's a cell made of?
how many cells have to die before you die?
How do cells make energy?