EFFECTS OF MAKING CONNECTIONS BETWEEN SCIENCE CONCEPTS AND THE OUTDOORS ON STUDENT COMPREHENSION

by

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A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2011

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July 2011

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ABSTRACT

In this investigation, science concepts were taught in an outdoor setting with the intent of students making connections between the science concepts and the outdoors to determine the effect on student comprehension for three units of study. Lessons became progressively difficult with each unit. Results indicated that lessons lower in difficulty increased student comprehension for all samples, but only higher-achieving students showed an increase in comprehension with increased difficulty. Also, in comparison to lessons taught indoors, results indicate that block class samples benefited most from outdoor lessons, while skinny class (short class period) samples benefited more from instruction inside the classroom.

INTRODUCTION AND BACKGROUND

In conversation with other teachers in the Science Department at Palisade High School, the lack of use of our Outdoor Classroom has been discussed and the middle school in Palisade had their Outdoor Classroom taken away for that reason. This was of concern to me because Palisade High School's Outdoor Classroom is a wonderful resource that is set up specifically for student learning. Throughout the school year, it was brought to my attention that many students didn't know the names of the main features surrounding Grand Junction: The Grand Mesa, the Colorado National Monument, and the Bookcliffs, and some didn't know we lived in the Grand Valley. It is a no-brainer that we need to get these students outside more often.

Because student test scores only appeared average in all science classes, I spent time in Content Tutoring, which is Palisade High School's intervention program, helping students improve their grades in science when I noticed that many students didn't understand the concepts that were taught in class. Students have commented that science is boring most of the time and that we move (to other concepts) too fast. Plus, the freshmen Geophysical Science curriculum is overloaded with concepts for students to learn for their standardized test. Time usually becomes a factor, and I feel like the science teachers, including myself, forget about making science fun so we can cover all concepts no matter what it takes. Along with a better teaching strategy or better lesson plans, I wondered if making science more relevant to the students' lives, by having them make connections between science concepts and the outdoors, would enable them to understand and apply concepts, and therefore attain higher comprehension. Using the outdoors to

make science connections would also enable me to teach students about their surroundings, stray from traditional teaching, and utilize the Outdoor Classroom more often.

General student observations indicate that many have no experiences or inclination of the outside world that is relevant to their lives. Under parental supervision, many students have played in a playground or an organized sport, and a select few are avid hunters and fisherman, but students in our present society seemed to have lost the drive of curiosity to find out why things happen and what is happening in nature. In other words, students lack the nature experience when science is all around us and constantly occurring. The purpose of my research project is to determine the effects of connecting science concepts to the outdoors, and to see the impact on student comprehension. While exploring the outdoors, I also want to find out the following questions:

Focus Question

How will making connections between science concepts and the outdoors affect student comprehension?

Sub Questions

1. How will unequal class lengths affect student comprehension of science concepts in an outdoor setting?
2. What differences in comprehension are there between concepts taught outdoors vs. concepts taught indoors?
3. How will this project affect my pedagogy and professional development as a teacher?

I teach several sections of the Geophysical Science course for freshmen or

students who need an extra science credit. One class is ninety-minutes long (Blocks) and the other two class are fifty-minutes long (Skinny's). Many veteran science teachers comment that Skinny's aren't long enough to teach science and conduct labs effectively. So I want to find out if this is the case, since all of my Geophysical Science courses are general education courses and have similar demographics. Also, there are an abundance of effective indoor-based science lessons, so I want to compare outdoor-lesson results with indoor-lesson results. Finally, the most important question in this research process is finding out how I will change or adapt my teaching because of the process and finding of this research project. I ultimately want to become a better teacher for the benefit of my students and pass my knowledge on to other teachers.

Any research project requires support. I chose three critical friends who are in the education profession, are trustworthy, and will provide constructive feedback. Tori Hellmann is a colleague of mine and a recent MSSE candidate. Tori and I are the two females in the Science Department and have a common plan period. So far, she has provided good insight for effective outdoors lessons and has provided advice on recent assignments. Heather Huntley is a young, innovative second year math teacher who is extremely intelligent and always asks the constructive questions I look for when composing an assignment, and had helped me understand types of statistical analysis. Finally, Fran Stauffer, is a recently retired elementary school teacher and my aunt. She is wise and has helped me through my first couple of teaching years. Anytime confusion sets in, Fran sets issues straight. All critical friends have played a major role in formulating and shaping my action research project.

CONCEPTUAL FRAMEWORK

Technology and safety are the prominent issues as to why our children lack the outdoor experience (Louv, 2008). The first issue Louv (2008) calls the Boogeyman Syndrome. Understandably, parents have the right to fear for their children unsupervised, roaming around outside. It is evident in the news, unfortunately, more often than not. Parents also probably don't want to spend the time in nature with their children catching bugs when there are a dozen other obligations at home. Safety is a huge issue. The other issue as expressed by Louv (2008) is how culture has gone from direct utilitarianism to romantic attachment to electronic detachment. As it is prominent in the classroom, children are attached to electronics including computers, ipods, and cell phones. They are texting and listening to music constantly in the classroom regardless of the rules. Wouldn't it be something to actually have students engaged enough in science that they might forget about their electronics for a given amount of time?

D.W. Butin (2009) believes that outdoor activities allow students opportunity to experience science in a relevant, hands-on aspect of their daily lives. Science instruction should be hands-on and inquiry-based to promote and sustain student interest and enthusiasm in science, with 40 to 80 percent of science education devoted to laboratory time and that investigating and learning can be enhanced in an outdoor setting (Butin, 2009). Laura Wick (2008) conducted an Action Research project which measured that students' ability to develop skills through inquiry on lessons linked to the outdoors, specifically to make observations that stimulated questioning. Her lessons included classroom practice on observations, and then outdoor application. Her results indicated

that with prior knowledge, students were able to increase inquiry abilities when they applied their knowledge in an outdoor setting. Students are more likely to retain the knowledge they gain through hands-on activity and having to make cognitive decisions based on what they learned (Week, 2009). Most students do not get much opportunity to do research and investigation on their own because it is mostly presented as ready-made knowledge. Rutherford (2002) provides some tips for teachers on helping students make real-world connections on their own by accessing and using prior knowledge, using a wide range of strategies to allow students to process and summarize their learning, both inside and outside of the class, and to make learning active.

While it is proven that the inquiry process is effective, Begley (2010) summarized the surprising findings of a study conducted by William Cobern of Western Michigan University (year not known). Cobern randomly selected 180 eighth graders and subjected them to one of either form of direct-instruction or inquiry-based learning. Results showed that as long as students are engaged, both direct-instruction and inquiry-based teaching can be effective. This article was the reason behind my decision to implement a non-treatment of keeping students engaged with indoor-setting lessons, and to compare comprehension of indoor-taught concepts with outdoor-taught concepts based on my treatment.

Since my treatment will occur in an outdoor setting, students will engage in some sort of active learning. In addition to lab work, I found that sketching and making analogies would be effective implementations to my treatment. Hobart (2002) believes that sketching forces the observer to become more aware of the subject matter by paying

close attention to detail. Sketching will be completed on a much smaller scale than Hobart describes, but because many students love doodling, I thought this method can be effective. Analogies allow students to work from a familiar area into a new area of study. Since understanding involved connecting new learning to something already understood, analogies can be readily useful for some learners, especially comparing similarities and differences (Rutherford, 2002).

The research methodologies attained from this research made me realize how important it is to keep students active in class. Science is not the type of subject where students sit in a desk and listen to the teacher talk. Students need to be active and gaining knowledge on their own. The role of the teacher should be “the guide on the side”, not the person who does the most work. While inquiry-based lessons are effective, teaching inquiry is a difficult task, hence the results of Cobern’s study. Professional development is needed to provide students for the best learning opportunities. The research studies have provided insight as to how my own research project should be formulated.

METHODOLOGY

My Action Research project spanned three units in Geophysical Science that occurred between early October 2010 and mid-February 2011. I chose to implement research on my three Geophysical science classes, which is a general education curriculum requirement for all students. The course is divided into two sections: Geophysical Science A, which focuses on physical science, and Geophysical Science B which focuses on earth science. The Mesa County Valley School District 51 Vertical Alignment Team (2009) compiled a list of Geophysical Science Curriculum documents as a resource for teachers that explains concepts for that curriculum, outlines the teaching sequence, and aligns with the Colorado Department of Education Science Standards. All concepts chosen for my treatment come from these documents. Concepts from Unit 1 and Unit 2 were taken from the Geophysical Science A documents, and Unit 3 concepts were taken from the Geophysical Science B documents.

To begin the research process, interviews were conducted to ensure a good treatment and a good research design. Data was collected for both treatment and non-treatment lessons within each of the three units using Pre-Tests and Post-Tests, Focused Listing Classroom Assessment Technique (Appendix A), and Student Interviews. Introductory lessons to new concepts began with the explanation of the concepts inside the classroom, mostly through lecture, a video, or vocabulary. All treatment introduce concepts inside the classroom and then application of the concepts in an outdoor setting whereas the non-treatment included application of the concepts inside the classroom (Appendix B).

In my Action Research experience, I've learned that one must be a master teacher to produce valid, conclusive results. Teacher Interviews (Appendix B) from both master teachers and newer, innovative teachers helped me formulate my treatment. Most suggestions included inquiry, lab-based methods, focusing on students making inferences and figuring out connections between science concepts and nature on their own. Below are quotes from an interview question asking teachers which data collection methods they suggest to implement in the classroom:

> "Really quick formative assessment through direct observation, written reflections, sketching, pre-test and post-test."

> "Rubrics, pre-test and post-test, compare old data to new data."

> "Interviews that focus on goals and objectives, writing, more verbalized assessments, tests, and projects."

I derived lessons for both treatment and non-treatment from veteran science teachers that were used repeatedly because they have been effective in the past and resources explaining effective teaching methods. I measure the term "effective" by assessment results showing that at least eighty percent of students scoring a C or better or achieving an increased percentile growth. Ideally, assessment scores would be a B or better, but from experience, students with accommodations or learning disabilities may only be able to score a C on assignments. In addition, there are students who must take on other responsibilities, such as caring for younger siblings due to poverty situations.

The advice of master teachers was to take precaution before implementing treatment by deriving a set of rules and expectations, including logistics if students are permitted to roam outside with minimum supervision. As suggested by both teachers and students in Teacher Interviews and Focus Group Interviews (Appendix C), respectively, a set of expectations and rules need to be in place for classroom management purposes so I can keep control of the situation at hand and prevent students from becoming diverted from the lesson. Wong (2004) says that effective teachers have classroom management skills, they teach for lesson mastery, and they practice positive expectations. Therefore, before any treatment was implemented students were given clear expectations and instructions, which varied with treatment, before going outside.

Unit 1 begins the first lessons of my research focusing on Physical Properties and States of Matter concepts which spans three ninety-minute class periods because much of this information was presented to the students during eighth grade, which is when physical science is introduced in Mesa County School District 51. These concepts are covered again in Geophysical science as a review and more depth. The three ninety-minute time span includes a pre-test (Appendix F), the implementation of the treatment and non-treatment lessons, the Focused Listing CAT, a test review, and a post-test (Appendix G).

My treatment explores Physical Properties concepts. Several of these words are familiar to students, such as volume, mass, shape, color, and density because we work with these properties often in labs so I decided to focus on the words students didn't know, such as malleability, conductivity, elasticity, and flammability, and noting

differences between hardness and strength. To introduce these concepts, students were given a blank chart in which they list ten given physical properties and were instructed to do vocabulary as a resource for the outdoor activity. Before going outside, students practiced matching objects in the classroom with physical properties by referencing to their vocabulary lists.

The treatment included going outside to explore the school grounds where students can make careful observations and make connections between physical properties and everyday objects that they are familiar with in the outdoors. These objects included items in nature or man-made items with a practical purpose. I felt we didn't need to go to the outdoor classroom for this because the physical properties were more conducive to metals, glass, and other man-made structural objects, including items in nature that existed in most places. The class walked outside together as a group and students were allowed to work in pairs and have conversations with other students so all had the opportunity to fully understand the concepts. The students completed the treatment in one ninety-minute class period.

Unit 1 non-treatment focused on States of Matter concepts. To introduce the concepts, students engaged in a directed reading out of the textbook and completed a fill-in-the-blank worksheet. Indoor application of the concepts included active student participation by mimicking each state of matter in large groups simultaneous to a teacher-led discussion on the textbook reading. The non-treatment lesson was completed in sixty-five minutes.

Unit 2 focuses on Forces and Motion and spans five ninety-minute class periods. This includes a pre-test (Appendix H), implementation of treatment and non-treatment, the Focused Listing CAT, a lesson on Potential and Kinetic Energy concepts which are not included in my research, a test review, and a post-test (Appendix I). Again, many students were introduced these concepts in eighth grade physical science. Geophysical science provides more depth and lab experience to these concepts.

My treatment focuses on Speed and Acceleration. Inside the classroom, students watched a video which compared and contrasted the accelerations of different types of vehicles. In the video, the main character modeled how to produce speed and acceleration graphs. After the video, students spent time learning how to use the speed and acceleration equations by practicing simple problems and then making speed and acceleration graphs. We then went outside to observe physical education classes running the track so I can point out speed vs. acceleration and describe the lab the students will conduct for the treatment.

For the treatment, the students were to design their own lab by choosing a simple activity or sport in which speed can be measured. Some students chose walking or running a section of the track, throwing a baseball or football, and even putting a golf ball. The objective was for students to choose an activity/sport, set a given, reasonable distance and mark off three points within that range, and use a stopwatch to calculate speed values obtained from their specific activity. Speed data was to be collected and graphed, and then acceleration values were to be obtained from the speed vs. time values and graphed as well. Students spent time outside gathering data for their lab, and then

back inside the classroom to calculate values, produce graphs, and write a conclusion describing lab results and improvements. The treatment spanned two and a half ninety-minute class periods.

Unit 2 non-treatment introduced Newton's Laws. To introduce the laws, students were engaged in directed reading from the textbook to figure out the three laws and several examples of each. Indoor application of the laws included student skits modeling one law of choice. The lesson concluded with an internet simulation of the laws which acted as remediation. Because students displayed prior knowledge of Newton's Laws, and these laws were taught extensively in middle school, only one ninety-minute class period was spent on non-treatment. Because forces and motion are a separate branch of physical science, this unit would not be considered more difficult, but due to lab requirements and expectations, this unit would be considered more rigorous than Unit 1.

Unit 3 treatment focuses on Rocks and Minerals and Weathering and Erosion concepts and spans ten ninety-minute class periods. This time span includes a pre-test (Appendix J), implementation of treatment and non-treatment, the Focused Listing CAT, a weathering lab and a video on Landslides, which was not included in my research, a test review, and a post-test (Appendix K). Earth science concepts are introduced to students in Mesa County School District 51 in the sixth grade. While these concepts would not be considered more difficult to learn than concepts from the previous units, the depth of learning would be considered as rigorous as Unit 2 and require more memory skills on behalf of the students.

The treatment focuses on the differences between weathering and erosion and how they work together to produce depositional and erosional landforms formed by streams and glaciers. Students took notes from a Powerpoint explaining the two concepts, and then a different Powerpoint slide show consisting of photographs of the landforms. In their notes, students described how each landform formed and the shape of each landform, which was needed for the outdoor activity.

Treatment included walking to the Outdoor Classroom to make connections between shapes formed from weathering and erosion and shapes of structures or other features around and outside of the Outdoor Classroom. Students were given a worksheet which listed formations in which connections were to be made. Students were instructed to explore the outdoors to find objects or shapes that matched the given formations. Once objects or shapes were found, students had to write what they found next to the appropriate formation and then sketch the general shape of both. Once students made the connection between the terms and objects in the outdoors, they sat in the "classroom area" in the Outdoor Classroom and made analogies between the landforms and other features/objects that are familiar and relevant to their own lives, using both similarities and differences. The treatment spanned two ninety-minute class periods.

Unit 3 non-treatment introduced Rocks and Minerals. Students took notes from two Powerpoint slide shows introducing information on minerals and then rocks. Indoor applications included a hands-on Mineral Identification Lab after the Powerpoint on minerals, and then a Rock ID Lab after the Powerpoint on rocks. Non-treatment spanned three ninety-minute class periods.

Treatment and non-treatment were implemented on a consistent set of students that are categorized into two groups: Block and Skinny. Each group received the same treatment and non-treatment throughout the entire span of research. Block consists of twenty students from my ninety-minute Geophysical Science class, and Skinny consists of twenty-six students from my two fifty-minute Geophysical Science classes. Average scores from Pre-Tests, Focused Listings, and Post-Tests were obtained from students from these two samples and compared and contrasted to fulfill my first sub-question which asks if differences in class length affects student comprehension.

Palisade High School is a Title 9 school which 43% of students are eligible for free or reduced lunch. In this school, 9% of students in this school are Hispanic and 78% of students are Caucasian. Palisade High School is unique because we are an International Baccalaureate (IB) school which means students outside of our zone have the option of School of Choice if accepted into the IB program. The students participating in my research within each sample are general education students who attend school regularly and are able to supply consistent data. Other reasons for not including certain students in my samples include student transfers, frequent suspensions, or severe learning disabilities that require assignment and testing accommodations. In my Block sample, nine students are Hispanic, eleven students are Caucasian, eight have accommodations and/or learning disabilities (SPED), and four are Gifted/Talented (G/T). In my Skinny sample, six are Hispanic, twenty are Caucasian, and nine have accommodations and/or learning disabilities (SPED). In general, the trend of academic performance with general education students is that the higher students exert effort in their work, the mid-level

students are sporadic with effort and mostly care about earning any grade, and lower students are either apathetic or really do struggle but don’t ask for much help. Again, some of these students are obligated to help with responsibilities at home. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

The instrumentation chosen for my research design is displayed in Table 1.

Table 1
Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3	Data Source 4
Primary Question: How will making connections between science concepts and the outdoors affect student comprehension?	Pre-Test & Post-Test	Focused Listing CAT	Lesson Plans	Student Interviews
Secondary Questions:				
1. How will unequal class lengths affect student comprehension of science concepts in an outdoor setting?	Pre-Test & Post-Test	Focused Listing CAT	Lesson Plans	Student Interviews
2. What differences in comprehension are there between concepts taught outdoors vs. concepts taught indoors?	Pre-Test & Post-Test	Focused Listing CAT	Lesson Plans	Student Interviews
3. How will this project affect my pedagogy and professional development as a teacher?	Pre-Test & Post-Test	Focused Listing CAT	Lesson Plans	Student Interviews

To measure student prior knowledge, Pre-Tests were implemented at the beginning of each unit in which two questions focused on the concepts to be measured. Pre-Test questions were made based off of the Geophysical Science Curriculum Essential Learning's contained in the documents.

At the end of unit or lesson, a Focused Listing CAT was administered where students were to list ten words or phrases relevant to the given concept. In addition to a concept from my treatment, a concept from my non-treatment was administered as well for comparison. The idea to use the Focused Listing assessment comes from Cross & Angelo's Classroom Assessment Techniques (1993) which was proven to be an effective and valid formative assessment. As per Cross & Angelo's data analysis suggestion, Focused Listing results from each subject were divided into Relevant vs. Non-Relevant words.

Finally, six Post-Test questions relevant to the concepts being measured were taken and analyzed. Geophysical Science tests are generated from the Prentice Hall Test Generator that corresponds with the textbook used by the students in the Geophysical Science course. All science teachers in District 51 use this test bank to create Geophysical Science summative assessments because it aligns with the course's essential learning's, making this a valid assessment. I decided to compare Pre-Test results with Post-Test results to determine percentile growth and then compare this with the number of relevant Focused Listing words for triangulation. This method was used consistently among my samples throughout both treatment and non-treatment in all three units to collect reliable data sets.

For analysis purposes, I divided my subjects into High, Medium, and Low categories to observe any patterns, trends, or anomalies. Field notes and lesson plans will be used as a qualitative reference. My final instrument for data collection, Student Post-Data Interviews (Appendix M), was given to a random sample of two students per category to build more information for my qualitative analysis. The data collected in each unit for treatment and non-treatment proves both valid and reliable because the instruments used were evaluated by experts in education, including master teachers from my school, for validity and instrumentation was implemented consistently using the same methods each time for reliability. Therefore, all instrumentation chosen for my research design will provide plenty of triangulated data for my focus and sub-questions regarding the effects of making connections between science concepts and the outdoors on student comprehension.

DATA AND ANALYSIS

Data from the treatment and non-treatment from the three units of research were compared in order to determine the effects of learning in an outdoor setting on student comprehension. In each unit, data was triangulated to answer each research question through the use of pre-tests, post-tests, and the focused listing CAT, including student interviews conducted on select samples after each unit. In the analysis, results within each unit were divided into achievement levels and interpreted, focusing on how unequal class lengths affected student comprehension and differences between treatment and non-treatment results within each achievement level. The analysis will conclude with explanations, including how this research has affected my teaching and my pedagogy, and how this could be improved. Prior to the actual data collection process, student Likert surveys were administered to gather baseline data.

Questions from student Likert surveys (N=46) focused on how students felt about science and their preference of having class either outside or inside. Questions were divided into three clusters: Cluster A- Enjoyment of Class, Cluster B- Outside Preference, and Cluster C- Inside Preference. Results between Block and Skinny Student Survey results (Appendix B: Figure 3) were analyzed separately to observe any similarities and differences.

Table 2
Student Likert Survey Results (N=46)

Cluster	Block	%	Skinny	%
A- Enjoyment of Class Questions 1,2 Max Point Value = 12	7.86	65.5%	6.74	56.2%
B- Outside Preference Questions 3, 4, 6, 8, 9 Max Point Value = 24	21.31	88.8%	20.61	85.9%
C- Inside Preference Questions 5, 7, 10 Max Point Value = 18	11.45	63.6%	12.10	67.2%

Results showed that 65.6% of my Block (*N*=20) and 56.2% of my Skinny (*N*=26) determined that enjoying class is important in science. Honestly, my Block sample has an overall better attitude than many subjects in Skinny. This leads to a score of 88.8% of Block having an outside preference, whereas 85.9% of Skinny favors being outside. Those numbers really are close though. Finally, Block scores of 63.6% and Skinny scores of 67.2% show an inside preference. Overall, Block would be more enthusiastic about having class outside. One quote that stood out to me from the skinny sample was, “I like to wear heels a lot so I really hate going outside.” Many freshmen girls with this same predicament have expressed their dislike of the outdoors during treatment. I do believe that the attitude is a factor to take into consideration affecting performance since the data results do show that the treatment was more effective for the block samples, who mostly enjoyed class in the outdoors.

In Unit 1, the treatment measured comprehension of Physical Properties and the non-treatment measured comprehension of States of Matter. Data results from treatment and non-treatment for high-achieving students from Unit 1 are displayed in Table 3.

Table 3
Unit 1 High-Achieving Results/Points Possible

Sample	Treatment				Non-treatment			
	Focused Listing Relevant/ 10	Pre-Test/2	Post-Test/ 6	Percentile Growth From Test	Focused Listing Relevant/ 10	Pre-Test/2	Post-Test/ 6	Percentile Growth From Test
Block High (*N=8*)	9.88	1	5.75	45%	8.63	1.88	4.75	-14.8%
Skinny High (*N=10*)	9.2	0.9	5.1	40%	5.8	1.4	3.5	-11.7%

Table 3 clearly displays that the outdoor lesson proved more effective than the indoor lesson. Focused listing scores for treatment were higher for both block and skinny samples than non-treatment scores. The pattern in these results was that treatment pre-test scores were lower and post-test scores were higher compared to non-treatment scores, thus receiving a higher percentile growth. Scores for non-treatment indicated a negative percentile growth which shows that the students had more prior knowledge about states of matter than physical properties, yet comprehension did not increase as displayed in the lower post-test scores.

Interviews for both samples indicated that although the students found some of the physical property vocabulary difficult, it was helpful to be able to walk around

touching different objects around the school and making the connections. A student quote from the block sample states, “I now understand the difference in the concepts by comparing objects.” A student quote from the skinny samples states, “I didn’t understand physical properties but making connections and going outside helped.”

Since the block sample achieved 45% percentile growth and the skinny sample achieved a 40% percentile growth, there was a slight difference that the block class length had a better effect on student comprehension than the skinny class length. First impressions indicate that this was a successful activity. Since lessons can always be improved, I will make sure to be clearer with my expectations and model sample work inside the classroom. This should make more students successful and be more helpful to others.

Table 4 displays the averages of treatment and non-treatment results from medium-achieving students from unit 1.

Table 4
Unit 1 Medium-Achieving Results/Points Possible

Sample	Treatment				Non-treatment			
	Focused Listing Relevant/ 10	Pre-Test/2	Post-Test/ 6	Percentile Growth from Test	Focused Listing Relevant/ 10	Pre-Test/2	Post-Test/ 6	Percentile Growth from Test
Block Medium (*N=7*)	4.86	1.29	5.14	20.7%	6.43	1.71	4.43	-12.2%
Skinny Medium (*N=10*)	7	0.87	3.51	15%	7	1.08	2.62	-10.3%

These results are comparable to the results from Table 3. Again, the outdoor lesson was proven effective for the medium-achieving students, displaying higher percentile growth than the non-treatment. However, the block sample displays lower focused listing results for the treatment. This could be because there are a few special education (SPED) students in this block sample who have more difficulty recalling memory or because the sample size for block is smaller than the sample size for skinny. Outside of this research, students have commented in class, mostly before taking a test, that accessing memory is difficult for them, but seeing choices on multiple choice exams does help them remember the concepts. Overall, assessment results show that the block sample achieved a 20.7% percentile growth while the skinny sample achieved a 15% percentile growth, again showing that the block class length was more effective than the length of the skinny class. Again, clearer expectations and modeling will be taken into consideration next time to make more students successful.

Table 5 displays the averages of treatment and non-treatment results from low-achieving students from Unit 1.

Table 5
Unit 1 Low-Achieving Results/Points Possible

Sample	Treatment				Non-treatment			
	Focused Listing Relevant/ 10	Pre-Test/ 2	Post-Test/ 6	Percentile Growth from Test	Focused Listing Relevant/ 10	Pre-Test/2	Post-Test/ 6	Percentile Growth from Test
Block Low (*N=7*)	5.5	0.83	4.5	33.5%	4.17	1.67	3.5	-25.2%
Skinny Low (*N=6*)	3.5	0.5	4.75	54.2%	3.67	1.5	3	-25%

Again, Table 5 results are comparable to prior Unit 1 data. The observable pattern is that both block and skinny samples achieved higher percentile growth due to lower pre-test scores and higher post-test scores, again, proving the outdoor lesson more effective than the indoor lesson. The focused listing results were lower for the skinny sample because many of those students are SPED students and find it difficult accessing memory or remembering more difficult concepts. One student from my skinny sample commented, “I like taking notes the best because it helps me remember the most but I still don’t get, like the big words.” When probed to expand on that, the students responded, “Well, when I don’t get them, I can’t remember them. I don’t know how to explain it.” Like the medium achieving students, seeing the choices on multiple choice exams helps them remember concepts. This was found with a quick survey before an exam by asking students to raise their hands if they agree.

The anomaly in this data is that the block sample achieved 33.5% percentile growth while the skinny sample achieved 54.2% percentile growth. One student from my

skinny sample commented, “I had fun going outside and learned at the same time.” The difference in percentile growth could be from lucky guesses on the pre-test by students from the block sample, or just coincidence. The other factor to take into consideration with the data taken from the low-achieving students is that they are absent more often than other students.

Overall, Unit 1 data results proved the outdoor lesson to be more effective than the indoor lesson, with large differences in percentile growth, and that the block class length has a better effect on student comprehension than the skinny class length. Post-test scores can improve with clearer expectations and modeling. Some of these lower-achieving students can also benefit by practicing with cooperative learning groups which may be a strategy to implement, depending on the needs of the students.

In Unit 2, the treatment measured comprehension of Speed/Acceleration and the non-treatment measured comprehension of Newton’s Laws. Data results from treatment and non-treatment for high-achieving students from Unit 2 are displayed in Table 6.

Table 6
Unit 2 High-Achieving Results/Points Possible

Sample	Treatment				Non-treatment			
	Focused Listing Relevant/ 10	Pre-Test/ 2	Post-Test/ 6	Percentile Growth from Test	Focused Listing Relevant/ 10	Pre-Test/2	Post-Test/ 6	Percentile Growth from Test
Block High (*N=8*)	9.88	1.13	4.88	24.8%	8.63	1.5	4.32	3%
Skinny High (*N=10*)	9.6	1.6	5	3.3%	9.9	0.8	5	43.33%

Block data shows a higher focused listing score and higher percentile growth for treatment than non-treatment. The skinny sample shows unusual data. The indoor lesson proved more effective than the outdoor lesson displaying a slightly higher focused listing score and a much higher percentile growth of 43.33%, which is an anomaly. This lab was broken into two class periods for the skinny class and found it difficult to resume the lab the following class period, whereas the block class mostly completed the lab in one period and were able to ask questions while working through the equations, data tables, and graphs. Student interviews from random subjects from the skinny sample indicated that Newton's Laws were much easier to learn. One student stated, "I already knew some about Newton but writing the Laws and seeing the internet thing helped me really understand them."

Therefore, the block class had the advantage of completing a rigorous lab in one class period while the skinny class did not, thus the outdoor lesson proved more effective in attaining student comprehension with a longer class length. Direct instruction, which

was the non-treatment in this unit, was more effective for the shorter class period than a lab. This makes me think about how to modify instructional strategies. Dropping a lab is not an option, so in order to work with my skinny classes more effectively, I will need to set daily lab goals that will not split data tables or graph making since that seems to be the biggest struggle with most students, which will be further discussed with the lower-achieving students.

Table 7 displays the averages of treatment and non-treatment results from medium-achieving students from Unit 2.

Table 7
Unit 2 Medium-Achieving Results/Points Possible

Sample	Treatment				Non-treatment			
	Focused Listing Relevant/ 10	Pre-Test/ 2	Post-Test/ 6	Percentile Growth from Test	Focused Listing Relevant/ 10	Pre-Test/2	Post-Test/ 6	Percentile Growth from Test
Block Medium (*N=7*)	4.86	1.29	4.86	16.5%	6.43	1.71	2.57	-42.7%
Skinny Medium (*N=10*)	9.1	1.5	3.7	-13.3%	9	0.9	4. 3	26.7%

While focused listing scores were higher for non-treatment than treatment for the block sample, assessment results indicate a higher percentile growth for the outdoor lesson. Results were opposite for the skinny sample, again, proving the indoor lesson more effective. Again, student interviews for the skinny sample indicate that Newton's Laws were easier to learn and that they find data tables and graphs confusing. One student quoted, "I had prior knowledge", when asked why then lesson for Newton's Laws

was effective for her. The students in the block class had the advantage of working together and asking questions in the span of one class, whereas the students from the skinny class had to leave their work and return the next class period. Students from the block class also had the advantage of possibly being grouped with a gifted/talented (G/T) student and expressed enjoyment of going outside to use a sport to collect data. One student who used pitching a baseball for his group's lab said, "Throwing a fastball helped me understand acceleration more." Students from the skinny sample complained of being too cold.

Many of these students that expressed their dislike of making graphs would not say anything during the interviews. Probing them to give negative comments was difficult, maybe because the interviews were conducted after the three units of research were completed and students had difficulty remembering their struggles, or they would not admit that they had trouble. It was through my own observations circulating the room during the lab and helping students that students have complained to either me or each other about this issue. While I did hear a few complaints from my block class, most complaining came from my skinny class. One quote that stood out to me from a skinny medium-achieving student about this lab. I asked if this lab helped her learn the concepts. She replied, "I had no idea of concepts so activities like sports help you understand science more." When she was asked in another question if any of the treatment lessons made her like science more or less, she replied, "The speed/acceleration lab helped her like it more." "Why?" I asked. "Cuz I figured out how easy science can be because I never liked science.' But shhhh!!! I still don't like science." This indicates that if she is

putting on a front for other students, then other students may be doing the same thing which tells me that there are much more smarter students out there than they let on and this reason may be why the data appears the way it does for the skinny sample.

Therefore, again, the outdoor lesson proved more effective for the block class, which indicates that outdoor-based labs are more effective when there is time to complete them in one day. Non-treatment, or direct instruction for Unit 2, proved more effective for shorter classes, although this lab may have not been as ineffective as displayed.

Table 8 displays the averages of treatment and non-treatment results from low-achieving students from Unit 2.

Table 8
Unit 2 Low-Achieving Results/Points Possible

Sample	Treatment				Non-treatment			
	Focused Listing Relevant/ 10	Pre-Test/ 2	Post-Test/ 6	Percentile Growth from Test	Focused Listing Relevant/ 10	Pre-Test/2	Post-Test/ 6	Percentile Growth from Test
Block Low (*N=7*)	5.5	0.67	3.17	19.3%	4.17	0.83	3.26	12.8%
Skinny Low (*N=6*)	6.83	1	2.25	-12.5%	8.33	1.25	3	-12.5%

In this set of data, again, the block sample achieved higher comprehension with the outdoor lesson. Both the focused listing and percentile growth score were higher with the treatment than non-treatment, thus proving the outdoor lesson was effective for the block class.

The data result from the skinny sample, however, is an anomaly. The focused listing, pre-test, and post-test scores were all lower for the treatment than non-treatment, however the percentile growth was -12.5% for both. Students in this achievement category did not attain much comprehension of the science concepts in this unit in the skinny class.

The treatment for Unit 2 concepts was more difficult than unit 1 with the implementation of a design-your-own lab. On the second day of school, I implemented a design-your-own lab in the Outdoor Classroom. The students haven't experienced that freedom in a lab in class until the Speed/Acceleration Lab. Block students experienced this lab six weeks into the school year, whereas Skinny experienced this lab thirteen weeks into the school year. When Skinny students were actually given the freedom to make their own choices, it took awhile for the groups to come up with something on their own because they weren't accustomed to that freedom. Also, there are four G/T subjects in Block that went around and helped other students, whereas many Skinny students struggled with making both the Speed graph and the Acceleration graph. I feel like the Block sample had more of an advantage coming into this lab than the Skinny sample, although my subjects did exert some effort in trying to learn by asking questions and paying attention to my models on the whiteboard.

In Unit 3, the treatment measured comprehension of Weathering/Erosion and the non-treatment measured comprehension of Minerals and Rocks. Data results from the treatment and non-treatment for high-achieving students are displayed in Table 9.

Table 9
Unit 3 High-Achieving Results/Points Possible

Sample	Treatment				Non-treatment			
	Focused Listing Relevant/ 10	Pre-Test/ 2	Post-Test/ 6	Percentile Growth from Test	Focused Listing Relevant/ 10	Pre-Test/2	Post-Test/ 6	Percentile Growth from Test
Block High (*N=8*)	9.25	1.33	5.44	24.1%	9.36	1.56	5.44	12.7%
Skinny High (*N=10*)	8.5	0.7	3	15%	8.9	1.7	4.5	-1%

In this set of data, both samples achieved a higher percentile growth with the outdoor lesson due to lower pre-test scores and average post-test scores that are comparable to non-treatment scores. Focused Listing results are only slightly higher for non-treatment from both samples. When asked in interviews in each class, the students interviewed from this level indicated that rocks and minerals were easier to remember because they had more prior knowledge on rocks. However although some of the weathering landforms were difficult to remember, one student claimed that it helped "making comparisons to shapes" which probably helped the focused listing scores.

Overall, the outdoor lesson proved more effective on student comprehension than the indoor lesson. And because the block sample received a higher percentile growth of 24.1% than the value for the skinny results of 15%, the block class length proved more effective on student comprehension than the skinny class length. The post-test scores for the skinny sample could be improved. Because of the demographic of the sample,

students need more consistent practice making connections through analogies to achieve higher comprehension and utilize more help with this through their peers.

Table 10 displays the averages of treatment and non-treatment results from medium-achieving students from Unit 3.

Table 10
Unit 3 Medium-Achieving Results/Points Possible

Sample	Treatment				Non-treatment			
	Focused Listing Relevant/ 10	Pre-Test/ 2	Post-Test/ 6	Percentile Growth from Test	Focused Listing Relevant/ 10	Pre-Test/2	Post-Test/ 6	Percentile Growth from Test
Block Medium (*N=7*)	7.14	1.44	3	-35%	9	1.22	5.22	26%
Skinny Medium (*N=10*)	9	0.8	2.9	8.33%	8.2	1.2	4.5	15%

Both block and skinny data results show that the medium-achievement students attained higher comprehension with the indoor lesson than the outdoor lesson displaying a higher percentile growth. The focused listing score appeared slightly higher for non-treatment with the skinny sample. Although the scores were close, I honestly think these students were able to regurgitate the weathering concepts easier without actually remembering their exact meaning.

A quote from a student stated that, with weathering and erosion, “It helped to visualize everything.”, but again, it was hard probing the students to express anything negative about this lesson to give me hints as to why scores were an average of 50%. Skinny sample responses indicated that the weathering and erosion concepts were harder

and rocks and minerals concepts were easier to remember. “It is just easier to remember stuff about rocks”, one student quoted. Quick random surveys before each post-test, not having to do with this research, indicate that only the higher-level students from my skinny sample actually study for exams, which most likely had a role in the outcome of this data.

Overall, the indoor lesson proved more effective than the outdoor lesson, and since block data displays a higher percentile growth of 26% over skinny data results of 15%, block class lengths have more of a learning advantage over skinny class lengths. To make this treatment more effective, I should have had students become familiar with the concepts by completing some textbook work on this vocabulary, including prior practice on analogies and metaphors to make connections.

Table 11 displays the averages of treatment and non-treatment results from low-achieving students from Unit 3.

Table 11
Unit 3 Low-Achieving Results/Points Possible

Sample	Treatment				Non-treatment			
	Focused Listing Relevant/ 10	Pre-Test/ 2	Post-Test/ 6	Percentile Growth from Test	Focused Listing Relevant/ 10	Pre-Test/2	Post-Test/ 6	Percentile Growth from Test
Block Low (*N=7*)	4	1.29	2.57	-21.67%	4.67	1.57	4.57	76.17%
Skinny Low (*N=6*)	3.6	0.25	2.5	29.2%	4	1.25	3.5	37.53%

Results from the low-achieving students display almost the same pattern as in Table 10, with the students attaining higher comprehension with the indoor lesson, displaying higher percentile growth and focused listing scores for both samples. Again, interviews suggest that many had more prior knowledge on rocks and that the identification labs were helpful because students were able to feel and manipulate the rocks which helped them remember the concepts.

Overall, the indoor lesson, again, proved more effective than outdoor lesson, and the block data results display a 76.17% percentile growth compared to skinny data results of a 37.53% percentile growth showing that block classes have a more positive effect on student comprehension.

Although baseline data suggests that the block classes preferred to learn in an outdoor setting, it didn't necessarily mean that the outdoor lessons would be more effective in attaining student comprehension. The values for outdoor vs. indoor preference were close between students from the block and skinny samples. Breaking down the types of lessons conducted in the treatment (outdoor lesson) and non-treatment (indoor lesson) gives a better explanation of what happened. For treatment, unit 1 was an outdoor inquiry activity, unit 2 was a design-your-own lab, and unit 3 was another outdoor inquiry lesson that involved higher-level thinking skills. For non-treatment, unit 1 and unit 2 were direct instruction, and unit 3 was two hands-on identification labs. The lessons for treatment seem to get progressively more difficult in skill, not so much concept meaning. Lessons for non-treatment were taken from a collaboration with other teachers that have been effective in the past.

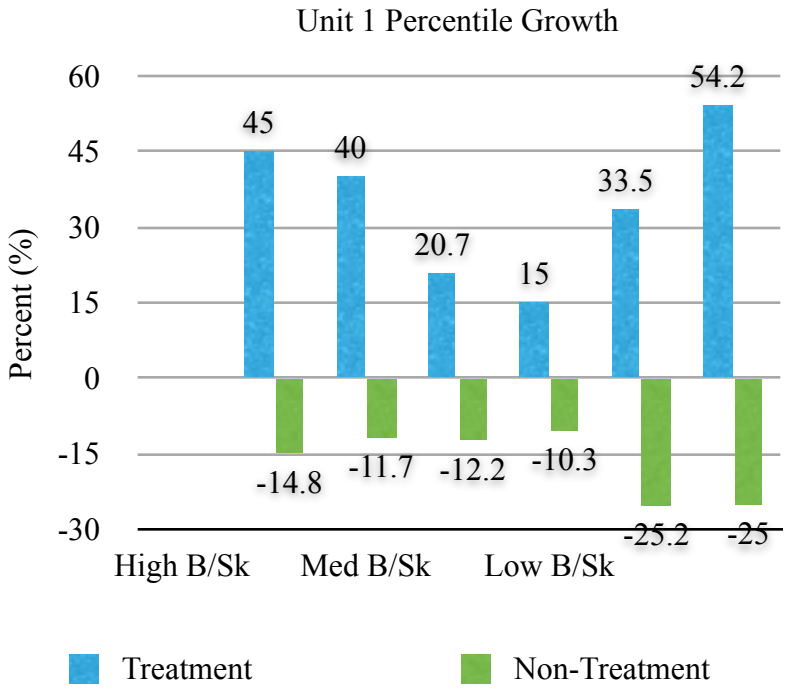

Figure 1. Unit 1 Percentile Growth (*N=46*)

In unit 1, the treatment (outdoor lesson) was by far the most effective for all achievement levels which is displayed in Figure 1. The students enjoyed the outdoor inquiry lesson and found it helpful to walk around and feel objects to make connections with physical properties. Students indicated that most had already learned the states of matter concepts in eighth grade, which also reflect the ninth grade standards, so next year I will spend more time on phase changes and gas laws for a more challenging lesson.

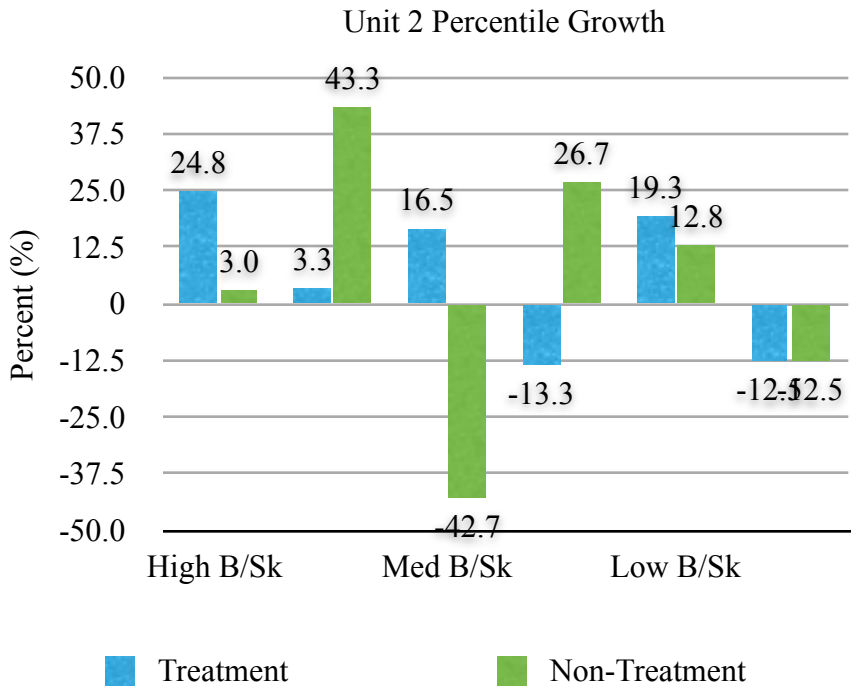

Figure 2. Unit 2 Percentile Growth (*N=46*)

Unit 2 treatment was a step up in skill level by allowing the students to create their own speed/acceleration lab and collect their own data in the outdoors, but many did not understand how to make a data table or create a proper graph. It seemed like, in all classes, there was a large percentage of students who lost time to learn the science concepts because too much time was spent figuring out how to set up a data table, and then how to label the axes on the graphs. Figure 2 displays the percentile growth of treatment and non-treatment for unit 2.

Since the lab grade did focus on creating data tables and graphs, many students scored poorly. Conversely, interviews from select block high-achieving subjects indicate that this lab was easy because they only needed to be reminded of a few things, like the equations for speed and acceleration, because they already knew how to do everything which reflects their percentile growth. The medium and low-achieving students from the

block sample did take the opportunity to socialize while the high-achieving students walked around to help, whereas the students from the skinny sample did not take the time to think of what to do; they wanted to be told what to do and asked me to show them how to do almost everything. This reflects back to the quote from a medium-achieving student regarding the speed/acceleration lab that the lab really did help her like science, but for me not to mention that she actually does enjoy the subject. The big question now is how to interpret this: is the reason weighing more on the skinny sample's disadvantage because of class size or because the students are pretending to be something they are not in front of their peers.

For this unit, the direct instruction method proved to be the most effective for the shorter classes because of an average higher percentile growth for non-treatment, whereas the lab was more effective for the longer class because of an average higher percentile growth for the treatment. Begley (2010) did state that direct instruction can be as equally effective as inquiry-based learning which is interesting to me because of how much inquiry is preached in the world of science education

In class, I need to implement more labs to keep practicing the scientific method, how to set up data tables, and create proper graphs for all students since that skill is integral in standardized testing and passing upper-level science courses. With lower-level students, I could present data table and graph models to start with and gradually transition into labs where students design their own work.

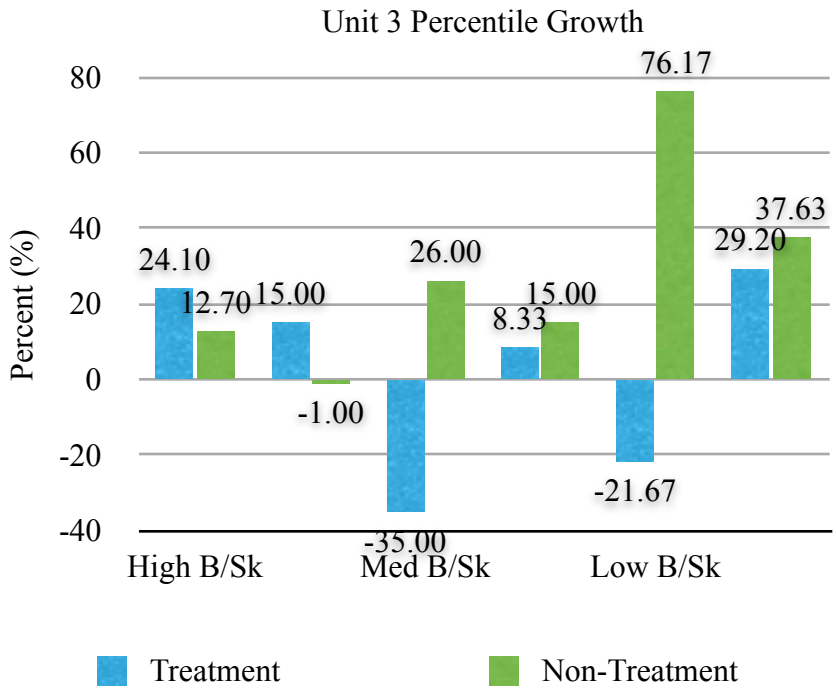

Figure 3. Unit 3 Percentile Growth (*N=46*)

In unit 3, students were presented with higher level thinking skills, which are a step up from graphing skills. Students have not had much practice with this and had trouble making connections by using analogies. While I felt that this lesson could have been more effective than the rock and mineral identification labs, the labs were cut and dry for the students and did not involve much higher level thinking skills. The treatment did seem to work with the higher-achieving students in both samples over the medium and low-achieving samples, which shows that there is a level of thinking involved that many students are not accustomed to. Figure 3 displays the percentile growth for treatment and non-treatment in all achievement levels.

In this scenario, the outdoor inquiry lesson was not effective because I didn't teach the students how to use higher-level thinking skills, however the hands-on labs were effective in helping the students retain concepts and achieve higher comprehension.

I did try to keep the analogies simple and model them. Because the students haven't had much practice, I did design the analogies so that students only need to think of something from their home with a similar shape to the landform and fill in the blank. I do believe that I do need to practice this skill in my classroom more often; however, my observations do indicate that many students didn't want to think.

In order to make every lesson effective, a teacher must display mastery in lesson planning. While any percentile growth is better than none, growth can be improved. Samples that achieved lower percentile growth from the treatment, such as all unit two block samples of 24.8%, 16.5%, and 19.3%, respectively, should be greater and that is a future implication to my pedagogy. Outdoor lessons can be effective if planned correctly and the students are trained and prepared for the task at hand, such as the percentile growth in unit three of 27.4% and 15.0% with the higher-achieving students in the block and skinny samples, respectively. The work ethic of these higher-achieving students prepared them for higher-level thinking. I also learned that direct instruction can be effective as well since this method of non-treatment proved more effective with some samples than some treatment methods, such as unit two non-treatment with 43.4% and 23.7% percentile growth with the high and medium-achieving skinny samples, respectively. Overall, the block students mostly attained higher comprehension than the skinny students because of the longer time span in class to stay focused and take advantage of asking good questions. Because of differences in treatment and non-treatment data results and the fact that block class lengths are more beneficial, I need to adjust instruction and lessons to be a more effective teacher to students in my shorter

classes and learn how to make lesson transitions so students are able to complete longer labs without feeling lost from the day before. I also need to begin to train my students with higher-level thinking skills and lab skills for a more successful high school career.

The process of action research had opened my eyes to what data can say and how quickly lessons can improve year by year. Each year, teachers improve their pedagogy by reviewing lesson plans, identifying improvements, and then making changes. Action research can expedite that process, especially with comments from the students through one-on-one interviews. The feedback obtained shows me the importance of assessment and direct feedback to students. Some of comments that I obtained from students and included in this research weren't exactly supposed to be part of this research. They were the product of data feedback from a quick assessment and me conducting a quick focus group interview with the class, keeping a mental note of the comments, which I never did until I started my action research project. This strategy has been extremely valuable for my professional development so the students can benefit more from instruction, whether they want to or not.

INTERPRETATION AND CONCLUSION

When comparing and contrasting all three units of treatment to form conclusions for the research questions, data suggests through triangulation that making connections to the outdoors by means of outdoor lessons is not always effective. To summarize, unit one treatment was an active learning lesson on physical properties and non-treatment was a direct learning lesson on states of matter. Unit two treatment was an inquiry-based lab on speed and acceleration and non-treatment was a direct learning lesson, including short student skits, on Newton's Laws. Unit three treatment was an active learning lesson, including making connections through analogies and metaphors, on weathering and erosion and non-treatment were two hands-on identification labs on minerals and rocks. Data cited in the conclusion reflects percentile growth unless otherwise stated.

My first sub-question addresses how unequal class lengths affect student comprehension. Since I began teaching at Palisade High School, the department has argued that science classes need to be block length classes, which are ninety minutes, rather than a period length of fifty minutes. Data results indicated that all block samples attained comprehension of concepts for unit one on physical properties, with the high and medium block samples experiencing higher percentile growth than the high and medium skinny samples (5% and 5.5%, respectively). The high, medium, and low-achieving block students for unit two on speed and acceleration attained percentile growths higher than the skinny samples with great differences in data comparison among like-achieving samples (21.8%, 29.8%, and 31.8%, respectively). Only higher-achieving students

attained comprehension for unit three on weathering and erosion with the block sample achieving a 9.1% higher percentile growth over the skinny sample.

Unit two is mostly significant because of the lengthy inquiry-based lab used for the treatment. This unit was completed in one and a half ninety-minute class periods, which means the lesson was under two class periods for the block class, but took three class periods for the skinny classes to complete. Time plays a factor because students can focus on the task at hand for a longer period of time instead of having broken concentration due to shorter classes like the skinny samples experienced and struggled with, which also included lab set up and clean up three times.

Positive results were also evident with the higher-achieving students with the exception of the high-achieving skinny sample in unit two, who displayed in data and expressed in interviews that the non-treatment, direct instruction, was easier to learn than the completion of the treatment, an inquiry-based lab. For example, this sample achieved only a percentile growth of three percent for treatment and a 43.3 percentile growth for non-treatment, thus proving that block class lengths are more beneficial to outdoor active learning instruction than shorter class lengths.

I learned that classroom demographics play a role inside a classroom as well. The block sample has four G/T high-achieving students. During unit two, the G/T students offered assistance with graphing, data tables, and equations to other students in that class which may be why all block samples in the unit 2 treatment attained higher percentile growth than non-treatment. The skinny sample did not have that opportunity and no samples showed comprehension for the treatment.

My second sub-question addressed differences between treatment vs. non-treatment. The treatment involved higher-level thinking skills which increased by unit, which is represented in the data through a progressional decline in percentile growth. All levels of samples attained a high percentile growth for treatment in unit one showing comprehension of the concepts. However, in units two and three, an average decline in performance with some medium and low-level achieving students are evident. For example, the medium-achieving block sample showed a decline in percentile growth as the three units progressed (20.7%, 16.5 %, and -35%, respectively) as did the low-achieving block sample (33.5%, 19.3%, -21.7%, respectively) and the medium-achieving skinny sample (15%, -13.3%, and 8.33% respectively).

Interesting results were derived when comparing treatment versus non-treatment. Again, with lower-level thinking skills, treatment is more effective than non-treatment as shown for all samples in unit one. Conversely, unit three treatment, at a higher-level of thinking, only yielded comprehension with the high-achieving students (block sample: 24.1%; skinny sample 15%) and was found difficult by the medium block (-35%), medium skinny (8.33%), and low-achieving block (-21.7%) samples. This shows that practice and consistency with higher-level thinking skills must be enforced in the classroom. Also, the skinny samples attained higher comprehension with direct instruction (for example, unit two non-treatment percentile growths of 43.3% and 26.7% for high and medium-achieving samples) rather than an inquiry-based lab, probably because this involved lab had to be broken into three class periods, while the direct instruction was easily delivered in one class period (not including the student skits),

showing that in some cases such as shorter class periods, direct instruction can be as beneficial as inquiry.

My final sub-question focuses on pedagogy and professional development. This research opened my eyes to lesson mastery, and I know I could have done things differently for more accurate data results. As a third year teacher always looking to increase my professional development, I continue to find great strategies to help student comprehension in science. While these textbook strategies are proven effective, such as making connection to real-life examples, using analogies and metaphors, and inquiry-based labs, I realized that the students need to practice these strategies consistently. I had the presumption that I can introduce these strategies, list expectations to the students through rubrics or modeling, expect to have to help certain students at first, and then everyone will be fine and work to the best of their abilities. For example, in unit two, since the students had so much practice on the scientific method, I thought they would know how to complete an inquiry-based lab of the sort, including making data tables on the data being collected and a graph. For unit three, I didn't think that making connections between science concepts and shapes around the school, and then thinking of different shapes around the house to produce analogies, would be that hard once I modeled a few. I was wrong with my presumptions. One thing I definitely learned in my past experiences teaching is to guide students enough as to allow them to express their creativity with minimal direct help from the teacher. What I should have recognized before I began my action research is that all students do not always pull through and shine with this method.

The realization that my presumptions were incorrect have affected my teaching. I have a much different perspective on how to deliver science concepts to my students by always beginning with basic learning, or low-level thinking, and then always stepping it up with a higher-level thinking strategy. Unit one results, in which all samples attained higher percentile growth for treatment, showed me that my treatment for all units can be effective and I still believe that connecting science concepts to the outdoors will increase comprehension for all students. I just need to help my students get there. I like the idea of using analogies and metaphors for test reviews so students can get into the habit of making connections to real-life objects or situations. During unit three treatment, this was the first time some students were exposed to analogies and metaphors in science class and my observations of the students showed that they struggled to think of examples because they either were not trained to think in that way or they lacked the practice. This treatment challenged high-achieving students, and they prevailed because they know how to think. For example, in unit three treatment, both block and skinny high-achieving students were the only samples to achieve higher percentile growth for treatment vs. non-treatment (24.1% vs. 12.7% and 15% vs. -1%, respectively).

In addition to the consistent implementation of higher-level thinking skills in my classroom, I learned that I need to modify lessons because of different class lengths. Palisade High School has certain programs, such as the International Baccalaureate program and our SPED program that do not allow subject areas to have consistent block classes. I learned that I always need to take advantage of block classes for extended inquiry-based labs because time permits students to remain focused and to master skills

for a longer period of time. However, something needs to be done to help skinny classes develop and master necessary skills, like graphing and organizing a data table, without taking away those lengthy inquiry-based labs. I recognize that I need to be better with setting daily goals for students to present a narrow focus for a shorter amount of time. Since this was my second time implementing the speed/acceleration lab to skinny classes, I now have a better grasp on the time requirements needed for each section to plan more effectively in the future.

Frequent assessment is vital to obtaining information that will help teachers recognize gray or black areas in student learning. Immediate feedback gives valuable information on what concepts students are struggling with. The Focused Listing CAT was a quick and easy formative assessment that could tell me which concepts the students did or did not completely comprehend due to the amount of relevant or non-relevant words. However, this assessment does not tell me if students actually understood the meaning of the topic. High-achieving students have proven that they can quickly list the words and consistently score well on assessments, especially in block classes. In unit one and unit two, block and skinny samples scored above nine relevant words on their focused listing (9.88 and 9.2, respectively; 9.88 and 9.6 respectively) and above an eighty one percent on their post-test (5.75 and 5.1 out of 6 questions, respectively; 4.88 and 5 out of 6 questions, respectively). This shows me that these students are proficient or advanced in their comprehension of science concepts. With unit three being more difficult, the block sample still performed well with 9.25 relevant words on their focused listing and 5.44 out of six questions on their post-test. This shows that either the block sample of high-

achieving students prevailed with this data because of the G/T population that is not present in the skinny sample, that they better understood how to use higher-level thinking skills will the science concepts, or that block classes are more beneficial class lengths than skinny class lengths.

It's the medium and low-achieving students, whose focused listing data results are difficult to interpret. I'm not sure if they are listing words out of memory, if they saw the word on someone else's paper, or if they actually comprehend the meaning of the word. What proved difficult for me was differentiating between relevant and non-relevant words for medium and low-achieving students for unit two treatment. In terms of speed and acceleration, students began listing words like "a ball", "a car", "running", "fast", and "slow". How does one determine the value of those words? With the medium and low-achieving students, I chose to reflect on my interactions with them in this unit to make the determination. For example, a student I conversed with about throwing a baseball for acceleration did write "throwing a baseball" in his focused listing, so I counted the word as relevant. However, if I felt the word was fluff, I counted it as non-relevant. For SPED students, I counted most words as relevant from my consultation with my co-teacher who is a SPED instructor. I think the Focused Listing CAT can be a useful formative assessment, but expectations need to be set. Next time, I might even introduce a rubric. For example, if students write "a car", students need to know through expectations or a rubric that they need to elaborate on the action of the car and relate it to its rightful vocabulary word.

I found student interviews extremely useful. At first, I was not going to do this and I'm not sure why. Maybe I didn't think I'd get useful information that assessment scores couldn't already tell me. Maybe I felt students would sugar-coat their experiences and the activities and not be completely honest. Or maybe I didn't want to put in the time because my plate was already full. Regardless of these reasons, the interviews provided excellent qualitative data for my quantitative results. After I interviewed several students and saw the significance of their comments, I began asking for student feedback more often, which is how I figured out that mainly my high-achieving students from my skinny sample are the only students that actually study for tests. Outside of this research, I asked a class why they give me hard time with some labs that require them to make their own decisions. A student replied, "Honestly, it's not you, it's because we were always told what we needed to think in our other AP classes. We never were given the opportunity to think for ourselves which is the most frustrating part of these labs, but at the same time, it's nice." This quote itself taught me a lot about my students in that class which taught me a huge lesson on empathy.

VALUE

Action Research has helped me grow into a professional science teacher through assertiveness and perspective. This entire process opened my eyes to new information about my students as individuals and as a class, and that what they have to say can be extremely valuable. I just need to take initiative to find this out, just like initiative is required to gather data to determine percentile growth or for differentiation strategies. When I first began my research, I automatically assumed that going outside was going to be a successful strategy for every student, when in fact, several other factors need to be taken into consideration before I can assume going outside will be successful. It was these factors that taught me a greater lesson beyond the benefits of the outdoors.

I learned that I need to recognize the needs of my students before I make assumptions. How can I expect successful results from an inquiry-based lab when students always seem to struggle with graphing? How can I expect successful results when students struggle with higher-level thinking skills with little to no practice? These questions came to mind during the data analysis, and this tells me that I need to sit down and rethink my lesson plans in the future, such as practicing scaffolding, differentiating instruction, and consistency with higher-level thinking practice for students. To think that I alone can increase the intellect level of a classroom full of individuals is inspiring enough to modify my curricula and to share my findings with my colleagues.

The differences in the data results regarding class length will also change my instructional strategies, and I look forward to presenting this data to my department and administration. Class length brings up two issues at my school. Why can’t the science

department schedule only block classes since data supports longer classes for increased student comprehension and another content area be scheduled skinny classes? Would it be negative for an administrator to be aware of direct instruction occurring more often in skinny classes since implementing twenty-first century skills, which promotes active learning, is highly recommended by the school district? It would be interesting to hear comments from both veteran science teachers and administration regarding these concerns. However, my concern is providing the best instruction for my students using strategies that accommodate to their needs.

The intended audience to which I would like to share these findings is focused toward my colleagues in the science department at Palisade High School. Each science teacher must teach one of the required science classes, which are geophysical science and biology. Five of the six science teachers do teach geophysical science and follow the school district's required curriculum. The presentation of my findings I'm sure will spark questions among my experienced colleagues so that we can sit down to improve the curriculum and make it consistent for all future students. Especially how to differentiate instruction between block and skinny classes.

Future investigation spurs off of improving the geophysical science curriculum for the future because in 2013, school districts will be adopting modified curriculum due to modified science standards released by the Colorado Department of Education. The new ninth grade science standards include less of a content load but delve deeper into fewer topics. I can see the opportunities and benefits of modifying the curriculum now so that when changes do come, we will be ready to take science concepts to a higher level.

Some questions I still wonder include how the implementation of new science standards force more teachers to get out of the textbook and teacher higher-level thinking skills for more success in building student comprehension? To what level of higher level thinking do students need to make the treatment, that didn't prove beneficial, effective, or do students just need to practice learning in the outdoors? Also, if more samples of data are collected that support block classes over skinny classes, how can teachers work together on a modified curriculum that equally benefits skinny classes? My most important concern is the amount of support and cohesiveness my colleagues are willing to offer to make change in their own teaching that will benefit all students because not many people like change. Lastly, can having the knowledge-base enable those students who do not enjoy the outdoors make them find an appreciation for new opportunities to learning? That last question really encompasses the realm of students whom teachers have the opportunity to make a lasting effect.

I feel like I can walk away from this experience knowing that future students will experience well-planned instruction, consistency, fairness, and empathy. I realize that instruction can be differentiated to student need based on assessment results so instruction can focus more on unfamiliar concepts within a unit. I realize that if I want students to be successful with active learning in the outdoors, students need to be prepared through practice and consistency, especially with higher-level thinking strategies and support from my colleagues. I know that if I had prepared students for the treatment, almost all would have benefited or most samples would have increased comprehension on those science concepts. While I feel like my feelings belong on the

negative side for not displaying mastery at my profession during this capstone project, I feel better having come to these realizations that will enable me to grow so that I could become that master science teacher that I've always wanted to be.

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APPENDICES

APPENDIX A

FOCUSED LISTING TEMPLATE

Focused Listing Template

Name: _____ Date: _____

Focused Listing Concept(s): _____

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

APPENDIX B

TREATMENT VS. NON-TREATMENT

Treatment vs Non-Treatment

Unit	Treatment	Non-Treatment
Unit 1	Physical Properties Introduction: Vocabulary lists, Practice Outdoor Application: Make connections between Physical Properties and objects in the outdoors.	States of Matter Introduction: Directed Reading by filling out a worksheet describing the concept. Indoor Application: Models and active student participation further explanations on the concept.
Unit 2	Speed/Acceleration Introduction: Video, Practice with equations and making graphs Outdoor Application: Design-your-own lab connected to an outdoor sport or activity.	Newton's Laws Introduction: Notes on Newton's Laws. Indoor Application: Newton's Law skits, and remediation with an internet site explaining rules and giving examples.
Unit 3	Weathering and Erosion Introduction: Powerpoint notes on differences between the concepts and landforms. Outdoor Application: Explore the Outdoor Classroom to connect shapes objects or features in nature with landforms, sketch the shapes, and make analogies.	Rocks and Minerals Introduction: Two Powerpoint notes on minerals and then rocks. Indoor Application: Mineral ID Lab, and Rock ID Lab.

APPENDIX C

TEACHER INTERVIEW QUESTIONS

Teacher Interview Questions

What are the best practices for optimum student performance that has worked for you in the past?

If you ever took students outside, what worked for you so that all students understood the concept?

What challenges do you think I will face as a teacher if I had class outside?

What strategies do you think I should implement outside to have the most control over a class?

Do you think conducting and linking lessons to nature in the outdoors is a good idea for a research plan? Why or why not?

How might the rules change or ethics be discussed to students for the outdoor classroom?

What is the best advice you can give me from your experiences in which most students attained comprehension of a concept?

What things do you think I need to take into consideration for my research project?

APPENDIX D

STUDENT FOCUS GROUP INTERVIEW QUESTIONS

Student Focus Group Interview Questions

Do you think that you and your friends can achieve higher grades in school? How?

How do you think having class outside and linking lessons to nature will affect your grades?

What challenges do you think I will face as a teacher if I had class outside?

What strategies do you think I should implement outside to have the most control over a class?

Do you think conducting and linking lessons to nature in the outdoors is a good idea for a research plan? Why or why not?

If I was taking your class outside tomorrow for a lesson, what strategies do you think would make the class the most effective? How would you like the class to be structured so that everyone is participating and enjoying the lesson?

APPENDIX E

STUDENT POST-DATA INTERVIEW QUESTIONS

Student Post-Data Interview Questions

Please recall the outdoor lessons: Physical Properties, Speed/Acceleration Lab, and Weathering and Erosion. Did one or all of these lessons help you learn the concepts? How?

(probe based on answer)

Which part of these lessons do you think were most effective for you?

Which parts were least effective?

Can you think of any distractions or anytime you were pulled away from the lessons?

Did any of these lessons make you like science any more or any less??

Do you think your comprehension of these concepts has increased because of the lessons outside? Can you give one specific example?

(probe based on answer)

Do you feel like any of the indoor lessons were effective? (States of Matter, Newton's Laws, Rocks/Mineral ID Lab)

Did you any of those lessons help you learn the science concept better than any outdoor lessons?

(probe based on answer)

APPENDIX F

STUDENT LIKERT SURVEY

Student Likert Survey

Participation is voluntary and participation or non-participation will not affect student's grades or class standing.

On a scale of 1 to 6, with 1 being I strongly disagree, and 6 being I strongly agree, please answer the following questions:

1. Science is one of my favorite subjects in school.

(Strongly Disagree) 1 2 3 4 5 6 (Strongly Agree)

2. If I don't enjoy what we're learning about, I have a hard time paying attention to the

teacher.

(Strongly Disagree) 1 2 3 4 5 6 (Strongly Agree)

3. If I had to choose where classes would be held, I would want to have class outside

more often.

(Strongly Disagree) 1 2 3 4 5 6 (Strongly Agree)

4. When we have class outside, I feel like I am more interested in what is being taught.

(Strongly Disagree) 1 2 3 4 5 6 (Strongly Agree)

5. When we have class inside, I feel like I am more interested in what is being taught.

(Strongly Agree) 6 5 4 3 2 1 (Strongly Disagree)

6. I think that I would understand the material more if the material was related to things outside.

(Strongly Disagree) 1 2 3 4 5 6 (Strongly Agree)

7. When we have class outside, I feel like there are things that distract me.

(Strongly Disagree) 1 2 3 4 5 6 (Strongly Agree)

8. When we have class inside, I feel like there are things that distract me.

(Strongly Agree) 6 5 4 3 2 1 (Strongly Disagree)

9. I feel like I learn more when class is held outside.

(Strongly Disagree) 1 2 3 4 5 6 (Strongly Agree)

10. I feel like I learn more when class is held inside.

(Strongly Agree) 6 5 4 3 2 1 (Strongly Disagree)

In a classroom, which do you think is more important to you- being engaged in a lesson (interested, on task) or comprehension of the material (learning concepts)?

How often would you want class held outside?

Do classes that are held outside generally help you understand what was being taught more so than if it was taught in a classroom? Please explain.

Additional questions/comments/suggestions.

THANK YOU SO MUCH FOR YOUR TIME AND YOUR OPINION!!

APPENDIX G

UNIT 1 PRE-TEST QUESTIONS

Unit 1 (Physical Properties & States of Matter) Pre-Test Questions

1. What is a physical property?

A. any characteristic of a material that can be observed or measured without changing it's composition.

B. When a substance reacts and forms a new substance.

C. When a property of a material changes but its composition stays the same.

3. Which are examples of physical properties??

A. viscosity, conductivity, malleability

B. precipitate, gas, liquid

C. solid, liquid, gas

density, hardness, solid

2. What are the 3 states of matter?

A. viscosity, conductivity, malleability

B. precipitate, gas, liquid

C. solid, liquid, gas

density, hardness, solid

8. Which state of matter do molecules move freely?

A. solid

B. liquid

gas

APPENDIX H

UNIT 1 POST-TEST QUESTIONS

Unit 1 (Physical Properties & States of Matter) Post-Test Questions

1. Which of the following is malleable?
   a) glass
   b) pottery
   c) ice
   d) gold

2. Which of the following has the highest viscosity?
   a) corn syrup
   b) milk
   c) water
   d) orange juice

3. A material that is malleable and conducts electricity is most likely
   a) wood
   b) ice
   c) a metal
   d) motor oil

4. What physical properties of nylon and leather make then good material to use for shoelaces?
   a) high density and low conductivity
   b) durability and flexibility
   c) hardness and durability
   d) low viscosity and flexibility

5. Flammability is a material's ability to burn in the absence of
   a) hydrogen
   b) nitrogen

c) oxygen

d) carbon dioxide

6. A substance that had high reactivity

a) easily combines chemically with other substances.

b) burns in the presence of water.

c) displaces dissolved oxygen.

d) has a high boiling point.

7. A gas has

a) no definite volume but no definite shape

b) b. no definite shape but no definite volume

c) no definite shape or definite volume

d) a definite shape and a definite volume

8. Matter that has a definite volume but no definite shape is a

a) liquid

b) solid

c) glas

d) plasma

9. In which of the substances in Figure-3-1 are the forced of attraction among the particles so weak that they can be ignored under ordinary conditions?

a) Substance A

b) Substance B

c) Substance C

d) all of the above

10. Forces of attraction limit the motion of particles most in

a) a solid

b) a liquid

c) a gas

d) both b and c

11. What type of change occurs when water changes from a solid to a liquid?

a) a phase change

b) a physical change

c) an irreversible change

d) both a and b

12. The phase change that is reverse of condensation is

a) freezing

b) sublimation

c) vaporization

d) melting

APPENDIX I

UNIT 2 PRE-TEST QUESTIONS

Unit 2 (Speed/Acceleration & Newton's Laws) Pre-Test Questions

3. The equation for speed is…

a. $\frac{v2-v1}{t}$

b. Mgh

c. ½ mv2

d. d/t

4. The equation for acceleration is…

a. $\frac{v2-v1}{t}$

b. Mgh

c. ½ mv2

d. d/t

5. Newton's second law is…

a. The Law of Inertia

b. F=ma

c. For every action there is an equal and opposite reaction

d. PE=KE

9. The Law of inertia states…

a. Stored energy = energy in motion

b. F= ma

c. An object in motion stays in motion unless acted upon by an unbalanced force

d. For every action, there is an equal and opposite reaction

APPENDIX J

UNIT 2 POST-TEST QUESTIONS

Unit 2 (Speed/Acceleration & Newton's Laws) Post-Test Questions

1. The slope of a line on a distance-time graph is

a.	distance.	c.	speed.
b.	time.	d.	displacement.

3. What is the speed of a bobsled whose distance-time graph indicates that it traveled 100 m in 25 s?

a.	4 m/s	c.	0.25 mph
b.	2500 m/s	d.	100 m/s

4. The rate at which velocity changes is called

a.	speed.	c.	acceleration.
b.	vectors.	d.	motion.

5. Objects in free fall near the surface of the Earth experience

a.	constant speed.	c.	constant acceleration.
b.	constant velocity.	d.	constant distance.

6. Suppose you increase your walking speed from 1 m/s to 3 m/s in a period of 1 s. What is your acceleration?

a.	2 m/s2	c.	4 m/s2
b.	5 m/s2	d.	3 m/s2

7. The slope of a speed-time graph indicates

a.	direction.	c.	velocity.
b.	acceleration.	d.	speed.

8. The property of matter that resists changes in motion is called

a.	friction.	c.	inertia.
b.	gravity.	d.	weight.

14. An orange might roll off your cafeteria tray when you stop suddenly because of

a.	the balanced forces acting on the orange.
b.	the centripetal force acting on the orange.
c.	the friction forces acting on the orange.
d.	the orange's inertia.

15. According to Newton's second law of motion, the acceleration of an object equals the net force acting on the object divided by the object's

a.	mass.	c.	velocity.
b.	momentum.	d.	weight.

16. If a force of 12 N is applied to an object with a mass of 2 kg, the object will accelerate at

a.	0.17 m/s2.	c.	6 m/s2.
b.	24 m/s2.	d.	12 m/s2.

17. Newton's third law of motion describes

a.	action and reaction forces.	c.	centripetal forces.
b.	balanced forces.	d.	net force.

18. In which of the following are action and reaction forces involved?

a.	when a tennis racket strikes a tennis ball
b.	when stepping from a curb
c.	when rowing a boat
d.	all of the above

APPENDIX K

UNIT 3 PRE-TEST QUESTIONS

Unit 3 (Weathering/Erosion & Rocks/Minerals) Pre-Test Questions

1. The process that wears down and carries away soil is…

A. Weathering

B. Erosion

C. Wind

D. Water.

2. A mineral is…

A. naturally occurring, inorganic solid with a crystalline structure and chemical composition.

B. A combination of minerals that make up one solid.

C. Something man-made that we use for our benefit.

D. The resistance to scratching.

3. An combination of minerals makes up a…

A. crystal

B. really big mineral

C. cleavage

rock.

5. The process of physically breaking rocks down into smaller fragments is…

A. Chemical Weathering

B. Mechanical Weathering

C. Abrasion

D. Erosion

APPENDIX L

UNIT 3 POST-TEST QUESTIONS

Unit 3 (Weathering/Erosion & Rocks/Minerals) Post-Test Questions

1. What is a mineral's hardness?

a. a type of fracture in which a mineral breaks along regular, well-defined planes

b. the resistance of a mineral to scratching

c. the color of a mineral's powder

d. a type of fracture in which a mineral breaks along a curved surface

2. Rocks are classified as

a. sandstone, limestone, or granite

b. organic, intrusive, or clastic

c. igneous, metamorphic, sedimentary

d. sedimentary, intrusive, or metamorphic

3. Intense heat, intense pressure, or reactions with hot water can modify a pre-existing rock to form a(an)

a. metamorphic rock

b. sedimentary rock

c. igneous rock

d. organic rock

5.A series of processes in which rocks are continuously changed from one type to another is called

6.a volcanic eruption

7.the rock cycle

8.geology

9.melting

10.What changes are involved when mud from a lake bottom turns into a sedimentary rock and then into a metamorphic rock?

a. compaction and cementation, and then melting

b. heat and pressure, and then weathering

c. compaction and cementation, and then heat and pressure

d. melting, and then compaction and cementation

11. Which groups of rocks are igneous?
    a. sandstone and shale
    b. granite and pumice
    c. slate and marble
    d. granite and slate

12. Which processes are involved in erosion?
    a. precipitation, evaporation, and condensation
    b. weathering, runoff, and transpiration
    c. weathering, evaporation, and runoff
    d. weathering, the force of gravity, and wind

13. Which of the following is NOT an agent of chemical weathering?
    a. rainwater
    b. oxidation
    c. frost wedging
    d. carbonic acid

14. Meanders, V-shaped valleys, and oxbow lakes are all features formed by
    a. glaciers
    b. surface water erosion
    c. water deposition
    d. groundwater erosion

15. A sediment deposit formed when a stream flows into a lake or the ocean is called a (an)
    a. alluvial fan
    b. delta
    c. meander
    d. natural levee

16.Sediment deposited by a glacier that once existed in a spot is called a

a. cirque
b. moraine
c. horn
d. till

17.What pyramid-shaped glacial formation is a combination of several connected ridges?

a.a horn

b.a U-shaped valley

c.a moraine

d.a cirque