

THE EARTH IS BEYOND THOSE WALLS!
A LOOK AT OUTDOOR LABS IN EARTH SCIENCE

by

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ABSTRACT

This project measured the effects outdoor labs had on student motivation and achievement. Traditional labs were conducted and compared to field based labs. The data gathered during these labs consisted of observations, pretests and tests, minute papers, interviews, Likert surveys and a teacher journal. The results indicated an increase in student achievement which was greatest at both ends of the academic scale. Student motivation also increased during field based labs.

INTRODUCTION AND BACKGROUND

Project Background and Support

Inspiration

During the past 10 years of my career I have been teaching Earth Science at John S. Burke Catholic High. Since my arrival at Burke, I have had the opportunity to plan and lead several school field trips to Yellowstone National Park. I knew from my own learning experiences while on vacation in Yellowstone that these trips would offer students an invaluable educational opportunity. The trips to Yellowstone have served as my inspiration for this project.

During those field trips, I observed that several of my 10th grade Earth Science students showed increased interest in the field as well as displaying better recall of information. An example of this occurred at Yellowstone; on those trips seemingly average students could enthusiastically recite for me the names and origins of geologic features that were totally new to them, an act of learning that they most likely would not have been able to do in my classroom. However, after we got back into the classroom they seemed to revert back to previous levels of interest and recall. This encouraged me to explore outdoor lessons for my research. As a result, I decided to investigate the effects of being “in the field” during the learning experience. Burke Catholic, which is located in Goshen, NY, has a campus that would provide for field experiences without the costs associated with field trips away from the school. I therefore decided to investigate on campus field activities.

Demographics

Burke Catholic is a private, coed Catholic school located in Orange County about an hour northwest of New York City. While the student population is predominantly white and Catholic, there are minorities and non-Catholics that attend the school. Tuition at the school is approximately \$7500, but there is financial aid available to those students who request and qualify for it. Precise demographic information and information about free and reduced lunch is not available.

There are 61 females and 51 males in my four tenth grade Earth Science sections. One of the sections is an honors class with 24 students in it. The other three sections have four students who have documented learning disabilities. The largest of those three classes has 36 students in it. Class periods for each day are 43 minutes and there is not any time difference in class during days when a lab is given.

Focus Questions

As I strive to be a lifelong learner, my own recent experiences with field classes in the Master of Science in Science Education (MSSE) program and a few vacations have reinforced that learning (in particular in earth science) takes place more readily and at a deeper level when experiences are with tangible items and in context. These experiences have been confirmed and reinforced with my students while on our field trips. With those experiences and observations in mind, I crafted my action research plan and focus questions. My plan was to extend my curriculum beyond my classroom walls into the field and discover how to efficiently engage and educate students there.

That goal led me to my primary research question.

To what degree do on campus field learning experiences influence achievement and enrich learning in earth science?

In addition, the following two sub-questions were examined.

- **To what degree do field experiences affect student attitude and motivation?**
- **What impact has planning, researching and teaching lessons outdoors had on me as a teacher?**

Support Team

I enrolled the assistance of three fellow colleagues from Burke to assist me with my work. Each of these three teachers are people that I have excellent professional relationships with, and I was able to count on them to help me and give unbiased and honest opinions to help improve the quality of my research, professional development and writing. My support team consists of:

John Debold – John S. Burke Catholic High School – Science Teacher

I chose to select John as a part of my support team for two very important factors. The first factor is that John currently conducts field activities with his classes already in Physics and Ecology. His insights and experience in this realm provided invaluable assistance in searching for pitfalls and opportunities as I jumped into field lessons. Second, John is a very experienced educator with over twenty five years of teaching high school science at Burke Catholic.

Melissa Ross - John S. Burke Catholic High School – English Department Chairperson

Melissa has been the one person I have had working with me throughout my MSSE enrollment. As an English teacher I initially asked her to be a proofreader for many of the papers I have written, but she has wound up serving as a sounding board for my ideas and has been able to offer valuable insights setting targets and overcoming obstacles.

Marybeth Kelly Newhard - John S. Burke Catholic High School - Physical Ed. Instructor

While not a science teacher, Kelly fits very well as my non-traditional choice. Kelly is a person whom I have collaborated with so far in searching for ideas for my field lessons.

Kelly has been at Burke for a long time and has provided me with great knowledge about the campus and location ideas for effectively using our field resources. In addition, she is a proponent of field based education and serves as a co-chaperone on our Yellowstone field trip, the impetus for me to study field lessons in the first place. Kelly is also great about volunteering, and she assisted me in taking observations of my class in the field when our schedules allowed.

CONCEPTUAL FRAMEWORK

The NY State Education Department provides teachers with a core curriculum that states, “It should be a goal of the instructor to encourage science process skills that will provide students with a background and curiosity to investigate important issues in the world around them” (NY State Education Department, 1999, p. 4). There is clearly a call to build interest in learning and in the world surrounding the students in the state’s core curriculum. Interestingly, there is no mention of outdoor or place based education in the rest of the document. Field trips and place based education have a significant impact on student attitudes and ideas in science (Zoldosova & Prokop, 2006). Zoldosova and Prokop looked to create field based experience based on real observation and experimentation, an intrinsic experience based on an innate need to understand the world we live in, bridge the gap between theoretical and real phenomenon, and lastly to activate a relationship between the physical and the mental processes. The study revealed that field or informal science experiences cause significant increases in student attitudes towards interest and ideas in science. This conclusion about attitude and interest increasing has been confirmed by other research, particularly when the lessons are planned and executed well (Dillon, 2006), and students are challenged to think by using inductive reasoning (Hourdequin, 2005).

Perhaps the cost associated with such field trips, liability issues, potential problems associated with classroom management, or a true lack of “clearly articulated educational purpose” (Lugg, 1999, p. 25) are the root causes of what appears to be an omission of a call to true authentic earth science experiences. Alternatives to off campus field trips can include on campus investigations that may provide a great majority of the

benefits associated with traditional field trips while minimizing a lot of the problems.

The primary problems that can be avoided by using this on campus approach are ones of time, cost, and liability issues. In addition, close proximity allows for familiar location and the possibility of immediate feedback during campus based field work (Lei, 2010). Finally, in addition to the aforementioned increases in attitude and interest, there have been studies showing measurable gains in cognitive skills to clearly showcase the educational purpose to outdoor lessons (Eaton, 2000). Eaton found that when he measured the cognitive abilities of his 6 classes of 184 students using short answer questions following outdoor ecology lessons, they outperformed his control group which used only traditional lecture based lessons.

The most effective outdoor lessons should be guided by best practice procedures (Dillon, 2006). Dillon mentions potential areas of pitfall to avoid and provides planning steps to make the experience have the maximum effect. Of particular interest was the need to deal with fears on the part of the students as it pertains to health, physical comfort and safety; and having teachers build and maintain their own confidence in fieldwork in order to achieve the greatest benefit. The concerns about student fear and comfort/safety were also addressed from research by another MSSE student Erika Christiansen in her capstone paper (Christiansen, 2010). Christiansen noted that students did not complain about physical (in her instance cold) discomfort when they were prepared mentally and with the correct cold weather gear. She concluded that students would benefit from being in the field even in very cold conditions as long as they were adequately warned and properly prepared.

The motivation for this research was instinctual and based on personal experience. The context in which these investigations were framed was based on research that showed outdoor lessons could be cost effective, and provide improvements in attitude and cognitive abilities. However, Dillon (2006) and Christiansen (2010) do provide some caveats to heed in terms of best practices. It seems that the weather and being able to feel safe outside are items not to be overlooked when planning an outdoor lesson. Getting into the field must be a well planned and executed lesson with both the teacher and the students being prepared to make the most of the experience.

METHODOLOGY

Treatment

My action research project involved a series of treatment labs and lessons that were conducted outdoors, and more traditional classroom based labs for my non-treatment. A particular challenge is that there were no specifically designed outdoor labs in my existing curriculum, so most labs were created from scratch or were modified in some way to bring them into the field. Table 1 indicates the treatment and non-treatment labs and the topics they are associated with.

Table 1
Treatment and Non-Treatment Labs

Topic	Treatment Lab	Non-Treatment Lab	Month
Topography	Mapping Burke Catholic		September
Finding Latitude	Angle To Polaris		October
Minerals/Igneous Rocks		Mineral ID Igneous Rock ID	October
Sedimentary/ Metamorphic Rocks	How did it get here?	Sedimentary Rock ID	November
Sun's Path	Shadow Analysis		December
Mass Movement, Wind, Glaciers		Alpine/Cont Glaciers	December

The premise was really quite simple; treatment labs were conducted outdoors on the campus at Burke Catholic while non-treatment labs were conducted in the classroom. Many topics in the earth science curriculum lend themselves to multiple labs, so the sedimentary/metamorphic rock related labs had both a treatment and non-treatment lab,

while the other topics have only one or the other. Most action research projects and specifically this project took into account that a classroom setting, logistics and other limitations would not enable me to conduct a true scientific study with a treatment and non-treatment lab. In fact, it is assumed during action research that variations from a true scientific study will exist, and that they should be accepted and valued as a part of the project (Mills, 2011). However, in order to make sure that results were as salient as possible great attention was paid to validity, reliability and gaining the maximum sample size. These issues are addressed in more depth in the Sample and Research Methods section of the paper.

From my perspective, the How did it get here lab was the most difficult treatment lab. The reason that I feel it's the most difficult is based on the need to think critically during the lab. I have listed both the treatment and non-treatment labs by order from the most to the least difficult based on that criterion.

Lab Descriptions

Treatment Labs:

- **How did it get here?** (Appendix C) – Students observe several land features or formations and hypothesize about their origins.
- **Angle to Polaris** (Appendix B) – Students construct a simple sextant and measure the angle to the top of the flag pole at varying distances to simulate calculating their latitude based on the angle of Polaris above the horizon.

- **Mapping Burke Catholic** (Appendix A) – Students construct their own topographic map by walking pre-marked trails on undulating terrain. The students recorded altitude data at pre-marked locations and pace off distances to add to the map they construct.
- **Shadow Analysis** – (Appendix D) – Students observe and record the changing position of the shadow of a nail over the course of time. Using the information they collected the students then construct triangles to calculate changes in the angle of the sun above the horizon throughout the day.

Non-Treatment Labs:

- **Mineral ID** – Students use a series of physical and chemical tests and a key to identify a set of unknown minerals.
- **Alpine and Continental Glaciers** – Students construct graphs of ice thickness and motion of alpine and continental glaciers to comprehend the differences between the two.
- **Igneous Rock ID** – Students make a series of observations about a rock and use a key to identify a set of unknown igneous rocks.
- **Sedimentary Rock ID** - Students make a series of observations about a rock and use a key to identify a set of unknown sedimentary rocks.

Classroom Details

The treatment and non-treatment labs were both conducted during the regular forty-three minute class period since there is no separate lab period built into the

schedule. The activity portions of all of the labs were completed in one class period and discussion questions the write-ups were finished for homework. Labs typically follow lecture material that has introduced the students to the topics being investigated, so there was some degree of familiarity with the material. Students were seated alphabetically in the classroom, so labs that require partners are conducted with the students sitting next to them as their assigned partner. Students were able to pick the partner they would work with during non-treatment labs. Students wear a school uniform during the school day that includes a skort (skirt/short combination) for the girls; so on days that any students considered to be cold they were advised to bring appropriate clothes to wear for comfort.

Sample and Research Methods

The sample for my research project contained all 109 of my tenth grade earth science students. It made sense that if I were to conduct outdoor labs it should include all students for the sake of being fair, but more importantly collecting data on students of all abilities would give the largest population from which I could discern trends as well as strengths and weaknesses of these outdoor labs. The sample size varied throughout my research for several reasons. Students have transferred in and out of the school, some students may not have chosen to participate in activities that are not a required part of their classroom assessments, and some students may have been absent on days when labs were conducted making their participation and time on task information invalid when they made up the lab. In addition, I had 13 foreign exchange students spread out amongst those four classes and I chose to leave their data out entirely. The rationale for leaving out their data is that they really struggled with the language barrier causing their behaviors and feedback to be invalid. For example, an overwhelming majority of the

Likert style and open ended questions for all of the self-assessments were left blank. In the end the maximum amount of students observed was ninety-six with most n values being lower than that number for the reasons mentioned. 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.

In order to start collecting data I felt it was important to clarify the goals of my focus questions. The focus questions were as follows:

- To what degree do on campus field learning experiences influence achievement and enrich learning in earth science?
- To what degree do field experiences affect student attitude and motivation?
- What impact has teaching lessons outdoors had on me as a teacher?

In order to achieve that clarity I have defined the important terms of “increased achievement” and “enhanced learning” as detailed in Table 2. Those two terms were both contained in my main focus question. My two other focus questions did not need further clarification so they are not addressed in Table 2.

Table 2
Clarification of AR Targets

Target	How the Target is Measured/Achieved
Increased Achievement	• Improved test scores ○ Pre/Post Test • Minute papers describe lesson objective(s) ○ Student clearly articulates lesson objectives with little or no ambiguity vs. non-treatment • Teacher observes/prompts students articulating lesson objectives ○ Student clearly articulates lesson objectives with little or no ambiguity vs. non-treatment
Enriched Learning	• Student begins to construct their own questions beyond the scope of the lab and can articulate them in the lab report ○ Pre/Post Lab “Extending the concept survey” • Teacher observes/prompts students constructing their own questions

beyond the scope of the lab.

- o Student is clearly able to articulate their own questions beyond the scope of the lab.

With precise aim on the target that I would consider success for my outdoor labs, I was able to construct a plan to measure the impact of those activities. Table 3 is the matrix I constructed to match data collection tools to my research questions.

Table 3
Focus Questions and Data Collection

Focus Questions	Data Collection	Explanation of Methods
To what degree do on campus field learning experiences influence achievement and enrich learning in earth science?	Pre-tests/ tests	Shows changes in student achievement over time.
	Minute Papers, Muddiest Point & Probes	Used to identify misconceptions not clarified by the lessons in order to modify them. They will also be used to unearth effective lessons.
	Observation	Observation can be used to note student achievement and understanding.
To what degree do field experiences affect student attitude and motivation?	Interviews	Interviews can be used to assess attitude changes and initial feeling about field lessons in great depth.
	Multiple Intelligence/ Likert Scale surveys	Surveys can be used to assess attitude changes and initial feeling about field lessons in greater quantity.
	Observation	Observation can be used to note perceived patterns in behavior and participation. Interviews reveal insights about the teacher.
What impact has teaching lessons outdoors had on me as a teacher?	Interviews	Survey and open ended questions assess teacher effectiveness.
	Likert survey	The journal was used to track my view on success and the need to modify lessons based on my comfort level and student success.
	Teacher Journal & Reflection	

To begin my study, baseline information was gathered about the students by having them complete a learning styles survey (Literacyworks, 2001) and a Likert survey that assessed their attitudes with respect to science and nature (Appendix E). The same Likert survey was also administered at the conclusion of the study to gauge changes in attitude. After the initial administration of the Likert survey, open ended follow up questions were added to increase the depth of the information gathered during the second administration.

In order to make the most efficient use of class time, I was able to combine several data collection instruments into one tool. The Earth Science Lab Self Evaluation (Appendix F) was given to my students at the beginning of the class the day after a lab had been conducted. This would also coincide with the students turning in their lab reports. The Earth Science Lab Self Evaluation is a form that collects information on self and peer behavior as well as student interest levels using a Likert scale and includes open ended follow up questions. The instrument also contains a Minute Paper that is used to gauge student comprehension of lesson objectives.

The second tool that contains several data collection instruments is the Student Observation Form (Appendix G). This observation form allowed for the collection of observational data by the teacher relating to behavior, time on task, lesson objective knowledge and student enthusiasm. This form was filled out as much as possible during the administration of the lab and anything not finished was completed at the end of the school day.

The pretest and test data collection tool (Appendix H) was administered just prior to the lab and again on the day the lab reports were turned in. Each pretest or test

consisted of four questions and in order to make comparison more valid the same questions were administered to the students for the pretest and test.

The final two pieces of data collection were student interviews and a teacher journal. The interviews (Appendix I) were recorded and transcribed while they were conducted, and the teacher journal was written at the end of each period or class day depending on time constraints.

In an attempt to assure the validity of the data that was collected, several data collection instruments were employed to answer each research question (Table 3). In addition I used many of the strategies suggested by Cher Hendricks to increase the validity of my data. Of these strategies I found that consulting with my support team through “peer debriefing” (Hendricks, 2009, p. 114), and collecting data accurately and over a long period of time was especially helpful in getting a true picture of what was being observed (Hendricks, 2009). Based on the feedback from these inputs, I was able to revise some methods to make sure that the questions that were being asked were measuring what they were intended to measure.

To address my concerns about reliability, I strived to be consistent in the timing, and format of the instruments I used. For example, pre and post tests always contained the exact same questions; they were delivered at the same times before and after the labs and had the same look to them. This method of timing and familiarity was employed throughout the research whenever possible to best insure the collection of reliable data.

As the researched progressed, I was able to spend a good deal of time observing the successes and setbacks of my students and the lessons that were used during this study. In conjunction with the feedback from the students through their written

instruments and interviews, I gained a good picture of how the treatment and non-treatment labs were affecting the learning process. Personal reflection and collaboration with peers rounded out the ways in which I gained information during this exploration.

DATA AND ANALYSIS

The focus questions for the project will be analyzed using the data gathered from student surveys, pretest and test questions, student self evaluations, teacher observations, interviews, and a teacher journal.

Population and Learning

In order to get some baseline data about the students, a learning styles survey was completed to help assess how the treatment might relate to their learning strengths and weaknesses (Figure 1). The results of the survey were very

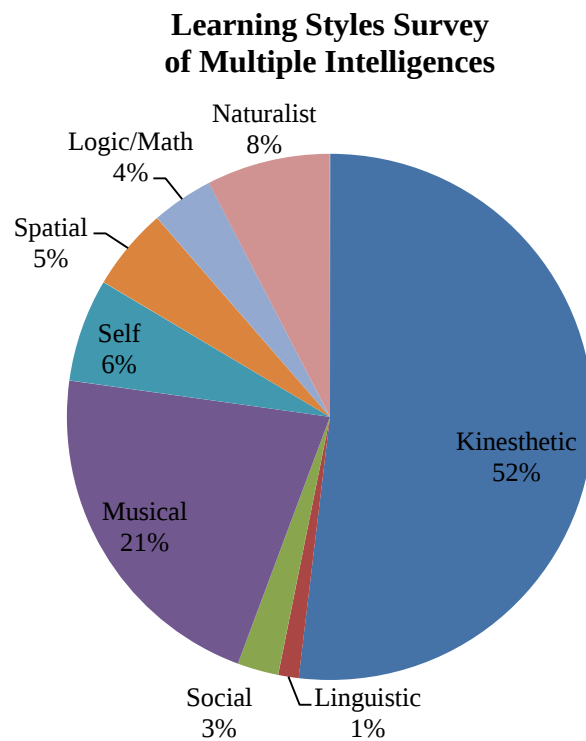


Figure 1. Learning Styles Survey, (N=79).
(Literacyworks, 2001)

interesting. Fifty-two percent of the students displayed a kinesthetic learning style with an additional 8% of the students identified as naturalist learners. Active labs that are

conducted outside seem to be in line with the learning styles of a vast majority of the group. This data was supported by surveys (Appendix E) conducted in September and December that were aimed at evaluating students attitudes towards science. Students clearly displayed a preference for learning in the field when compared to the classroom (Figure 2). Lastly, 13 of the 15 students interviewed indicated that he or she prefers to learn outdoors. When questioned, one student responded, “(I prefer)

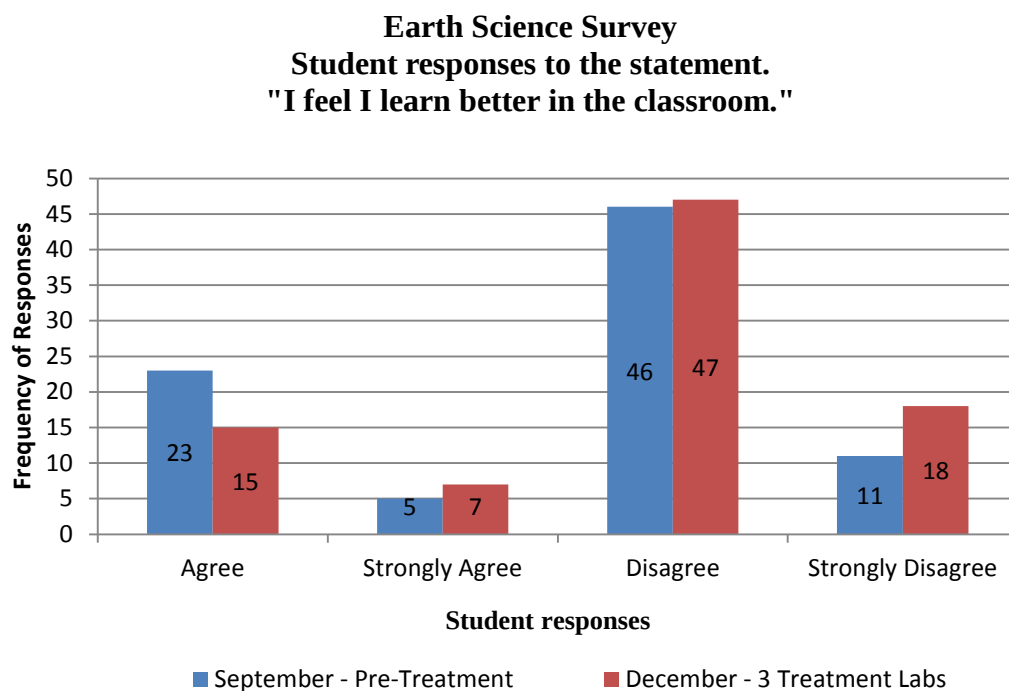


Figure 2. Student opinions about their learning. September Survey, (N=85)
 December Survey, (N=87).

outside because you can see actual examples of rocks instead of just looking at them in a text book and you can see specific examples instead of the general ones in the books.”

In a later interview when questioned further about seeing a rock in the classroom in comparison to seeing a rock out doors, one student explained that it was easier to grasp the explanation when she was seeing “ a larger picture of what was being taught.” The two students that did not prefer to learn outside noted that “it was okay being outside as

long as it was not very cold.” Seven other students when interviewed cited a preference for outdoor lessons being “hands on.” All in all, the student population has a preference towards learning outside the classroom, and it seems that the treatment labs have maintained and not diminished that attitude .

Student Achievement

Student achievement for the labs was measured in a variety of ways, the first of which was a comparison of pretests and tests. Students were given the exact same four-question test before and after the both the treatment and non-treatment labs in order to measure the gains they had made towards the learning objectives for that particular lab. Each of these four questions was then evaluated as either correct or incorrect, so student scores would be the number correct between zero and four.

One of the first ways I tried to look at this data was just by examining and analyzing the average difference between the treatment and non-treatment labs (Table 4).

Table 4

Analysis of the Difference Between Treatment and Non-Treatment Labs for All Students and Trials

Description	Treatment	Non-Treatment
Mean	1.71	1.11
Standard Deviation	1.17	1.17
N Value	328	328
p Value	.001	
t-Statistic	-6.29	
Degrees of Freedom	327	

The results of Table 4 are from a paired t-test. The average for the treatment labs when compared to the non-treatments labs is clearly higher and statistically significant.

However, upon digging a little deeper it becomes clear that not all of these labs were as

equally effective. The average difference between the four treatment labs was not always higher than the four non-treatment labs in every instance (Table 5). The average increase is also varied among the treatment and non-treatment labs.

Table 5
Average Pretest/Test Increase by Lab

Lab	Type	Average Increase	N values
Angle To Polaris	Treatment	2.49	85
Mineral ID	Non-Treatment	1.52	81
Shadow Analysis	Treatment	1.47	85
Mapping Burke Catholic	Treatment	1.46	95
How Did It Get Here	Treatment	1.45	94
Igneous Rock ID	Non-Treatment	1.11	89
Alp/Cont Glaciers	Non-Treatment	1.10	90
Sedimentary Rock ID	Non-Treatment	0.71	83

It is very interesting to note that that the Angle to Polaris Lab was the one that received the greatest percentage increase because I found that this lab was the most difficult and frustrating for me to administer and I was the most dissapointed in my execution of it. The frustration was caused by the fact that when I practiced and did a dry run of this lab with two science inclined members of my support team I did not realize that using a regular protractor could be a problem. When students got outside and needed to measure the angle to Polaris they needed to read their protractor and subtract that reading from 90 in order to arrive at the angle of Polaris above the horizon. Students did not readily understand this at first and upon reflection, in my journal I wrote, “What a disaster! I had to call everyone back together to explain the use of the protractor for this lab and they still did not get it. Next year I have to make a special overlay that will just read the angle above the horizon.” Clearly, in this lab, that issue did not determine the

effectiveness of the lab. I suppose this is because the concept is a difficult one that is more easily understood while actually doing it. Students are able to see the angle change as their angle to the flagpole (Polaris in our analogy) changes. It is also interesting to note that in this instance I was very concerned about how effective the lab would be because it is in essence an analogy. Students are not actually measuring the angle to Polaris and the lab was filled with issues of scale that could be very misleading. In the end, even with the aforementioned issue this lab helped master a difficult topic.

The other two labs that really jump out at me with an explanation are the most and least effective non-treatment labs. The Mineral ID lab is the first hands on lab that is significantly different than anything many of my students have ever done before. I noted “the students were into this lab and very excited” in my reflection at the end of the day. Although this was not an outdoor lab I think the uniqueness of this lab caused it to be particularly effective. I noted earlier that in the interviews students said they liked the outdoor labs because they were “hands on”; I think they saw this lab as being very hands on and unique. We must also not forget that 52% of the students are kinesthetic learners (Figure 1) who would do well with a hands on lab apart from of the setting. The lowest scoring lab, the Sedimentary Rock ID lab was just the opposite of the mineral lab. This lab was the fourth in a series of labs just like the Mineral ID Lab. One student commented to me in an interview that “it was really boring because it was just like the (mineral and) rock labs we had already done.” He later conceded to just rushing through it in order to “just finish.” The two anecdotes serve as a caveat that just looking at the overall numbers for these labs could be somewhat misleading.

However, I was hoping to figure out a little more than just if there was an overall improvement. I wanted to know if there were significant differences in the gains between treatment and non-treatment based on ability. In order to achieve this goal, I would need to look beyond just simply analyzing the difference between the pretest and test. If I had looked only at data from the difference between those two, there would be a bias against the higher achieving students since they would not be able to achieve high average gains since their pretest scores were close to four. For example, if “A” students had an initial pretest score of 3.8 out of 4 the largest average gain they could achieve would have been .2. I realized this when I first analyzed my data and realized that all of my outliers were my top students with very high pretest scores.

In order to compensate for this limitation, I decided to look at what percentage of the possible improvement between the pretest and test did the students actually make at each academic ability level. While preparing this data, I assigned students an “Academic Ability” level of either A, B, C, or D/F based on their end of the year 9th grade NY State Biology Regents Exam test grade. In the event that students did not have test scores I assigned them in a group based on their current class average and my own judgment. The calculation of the “Potential Increase Achieved” would be derived by calculating the average pretest score for a group and subtracting that average from four in order to get the potential increase for an academic ability level. I would then calculate the “average increase” by subtracting the average test score from the average pretest score. The final calculation would be:

$$\text{Potential Increase Achieved} = \frac{\text{Average Increase}}{\text{Potential Increase}} \times 100$$

The results of calculating the gains made by students in this fashion showed that the lowest achieving students actually benefitted most from field lessons (Figure 3).

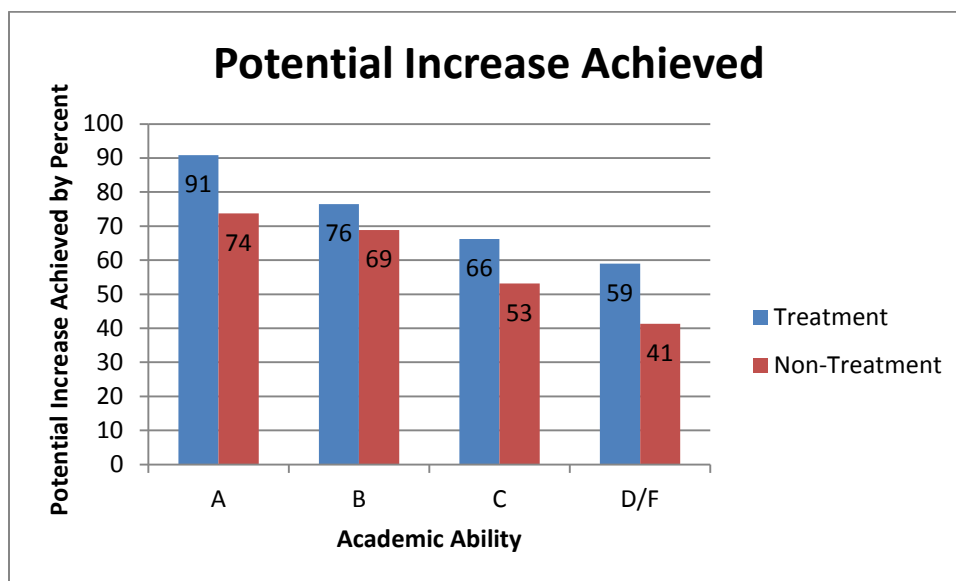


Figure 3. Student Achievement by Academic Ability, (N=96).
 Note. A (N=7), B (N=47), C (N=32), D/F (N=10).

The D/F students showed a greater potential increase achieved of 59% compared to 41% for the non-treatment labs; this is a difference of 17.6 which is the highest of all the academic ability groups. The “A” students realized a difference of 17.1 the “B” students realized a difference of 7.6 and the “C” students realized a gain of 13.1 in comparison to the traditional classroom based labs.

The results were not exactly the same, but the observations taken during the labs themselves showed a similar trend (Table 6). These results were taken when I would ask students questions about what was going on during the lab. These results were arrived at by asking four students per lab section in each of my four sections about the lesson objectives, so a total of 16 students were evaluated during each treatment and non-

treatment lab. Students in each ability level were selected randomly prior to each class period. These results are just a strict percentage since there was no “pre” for comparison like there was with the pretest and test.

Table 6

Observed Percentage of Student Understanding by Academic Ability (N=16)

Treatment			
	Clearly Understands Lab	Understands With Misconceptions	Does Not Understand
A	100	0	0
B	78	19	3
C	60	27	13
D/F	70	20	10
Non-Treatment			
	Clearly Understands Lab	Understands With Misconceptions	Does Not Understand
A	75	25	0
B	61	31	8
C	40	40	20
D/F	60	30	10

As Table 6 shows all students performed better on the treatment labs; but the D/F students actually performed at or near the level of the B and C students. This may be due to the fact that it was possible for further probing questions when students were observed. The D/F students have a 30% population of documented Individualized Education Plans (IEPs) or building IEPs (which are an IEP in the process of being documented). These students would benefit most from probing and verbal questions compared to the rest of the student population since it was not possible to read questions or provide extended

time when the students were filling out the post lab tests. In addition, the D/F students were observed to be on task more frequently during all labs (treatment and non-treatment) in comparison to the B and C students. I had only coded in my observations three times when any of the D/F students ($N=10$) were off task during the actual performance of the eight labs compared to 33 ($N=79$) times for the B and C students. In my journal I also noted that many times, during the non-treatment labs, students were off task during the introduction/directions portion of the lab. This could prove to be critical for those students who are not performing well on the labs since it would be easy to be lost with the needed background information or instructions. This was confirmed by the results from the “Muddiest Point” feedback with seven of those 33 off task students reporting in one form or another that they did not understand the lab or found it difficult.

Enriched Learning

In addition to student achievement the concept of how field labs enriched learning was to be investigated. The measure of enriched learning would be defined as: “The student begins to construct their own questions beyond the scope of the lab and can articulate them.” The Earth Science Lab Self Evaluation (Appendix F) contained a lab specific question to measure enrichment for each lab. Each of these was graded ($N=96$) according to the following scale: 2= Clearly articulates an ability to form deeper questions or extend the concept. 1= Articulates an ability to form deeper questions or extend the concept with some ambiguity. 0= Does not articulate the ability to form deeper questions or extend the concept. Figure 4 shows the comparison according to academic ability for the students to enhance learning by extending the concept being taught for the treatment lessons.

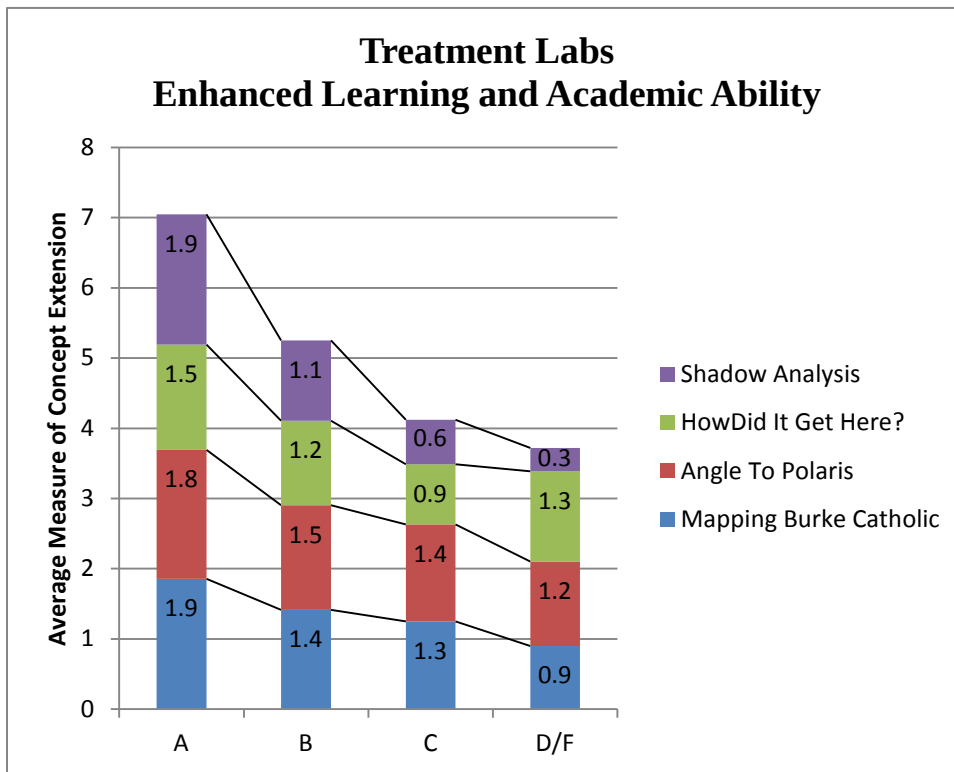


Figure 4. Enhanced Learning and Academic Ability for Treatment Labs, (N=96).

Note. A (N=7), B (N=47), C (N=32), D/F (N=10).

The trend displayed by Figure 4 shows that the ability of the students to extend the concept is pretty well associated with academic ability. I would hypothesize that students with a greater academic ability possess the critical thinking skills to connect concepts that are less obviously related once the concept has been grasped. This would explain the greater enhanced learning trend. The only lab that varies somewhat from the trend is “How did it get here?” During that treatment lab the D/F students show a greater ability to extend the concept when compared to the B and C students. I could pinpoint no specific reason why this particular lab showed a difference in results. Figure 5 shows the results for the non-treatment labs.

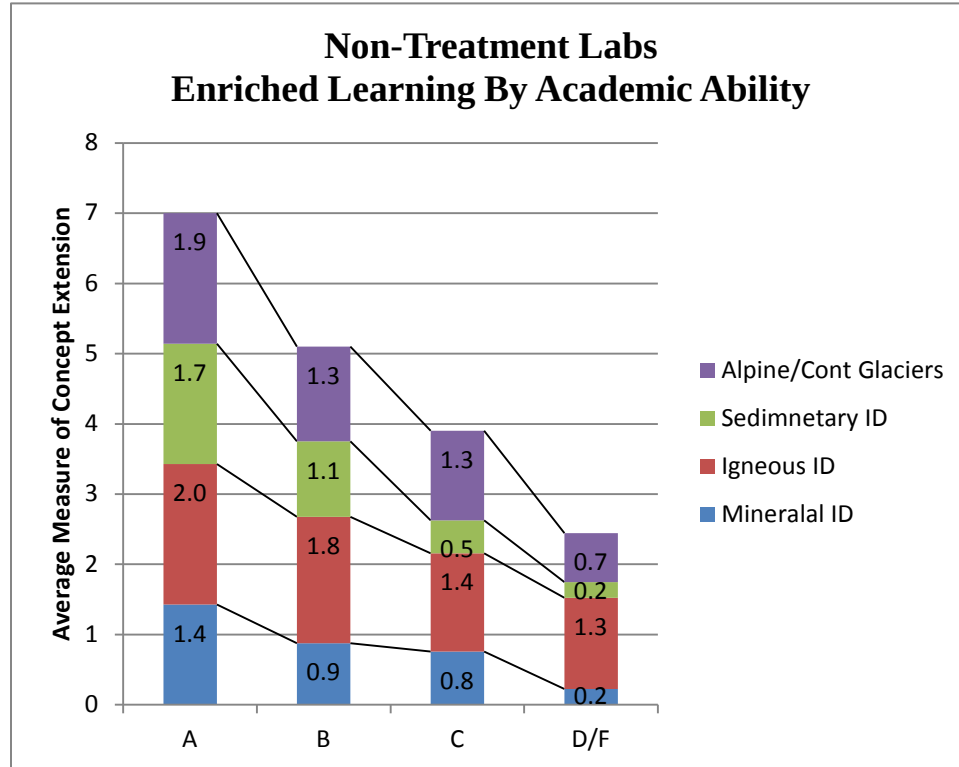


Figure 5. Enhanced Learning and Academic Ability for Non-Treatment Labs, (N=96).

Note. A (N=7), B (N=47), C (N=32), D/F (N=10).

When comparing the treatment and non-treatment labs there appears to be almost no difference between them when you look at the overall results. There also appears to be no difference from the expected trend for academic ability when just the non-treatment labs are looked at.

My own observations during the labs also showed a similar trend with no real noticeable difference between the treatment and non-treatment labs (Table 7). Table 7 shows that students did display an increased ability for enhanced learning based on

Table 7
Observed Percentage of Students Demonstrating Enhanced Learning (N=16)

Percentage of Students by Academic Ability Who Indicated a Deeper Knowledge of Concepts.		
	Treatment	Non-Treatment
A	80	80
B	47	43
C	40	22
D/F	10	10

academic ability, but the treatment and non-treatment results are very close (the differences in percentage for each academic ability group are at most one observation) which indicates very little difference between being outside or in the classroom.

In retrospect, the design of the labs and instruments may not have been focused enough on these higher order thinking skills. The Earth Science Lab Self Evaluation (Appendix F) contained only one question entirely focused on higher order thinking skills, and in my journal I had noted that the students “were challenged” by the How Did It Get Here Lab which was very focused on high order thinking. I also noted that we need to practice more at developing higher level thinking skills.

When academic gains were considered for the purpose of this research it would appear that being “in the field” has a positive impact on all students when compared to traditional classroom labs if the understanding of lesson objectives are considered. Also, it appears that A and D/F students appear to have even greater gains in comparison to the

rest of the students. This may be in part due to attitude and focus issues that keep these two groups on task more frequently.

It does appear that the treatment labs by themselves do not enhance learning by improving the students' ability to extend the concept or frame their own questions beyond the scope of the lab when compared to non-treatment labs. The reason for this could be that once a concept is understood then the ability to extend the concept is largely a function of academic ability or individual skills. Improving those skills, with more consistent practice in all settings, may in the future lead to a location (outside) based differentiation in scores of enhanced learning.

Attitude and Motivation

The second focus question for my capstone was, "To what degree do field experiences affect student attitude and motivation?" In order to measure the attitude of my students, the Earth Science Lab Self Evaluation (Appendix F) included an interest level rating as well as an open ended explanation of the reason that they chose the rating that they did for that particular lab. The interest level rating was on a scale of 1-4 with the following explanations: 4=I found the lab very interesting, 3= I found the lab interesting, 2=I found the lab boring, 1=I found the lab very boring. The overall results were very interesting. The results of the general population are summed up in Table 8. The results of Table 8 are from a paired t-test. The average mean for the treatment labs when compared to the non-treatments labs is not clearly higher or is it statistically significant.

Table 8
Analysis of the Interest Rating of Treatment and Non-Treatment Labs for All Students and Trials

Description	Treatment	Non-Treatment
Mean	3.259	3.247
Standard Deviation	0.674	0.674
N Value	344	344
p Value	.818	
t-Statistic	-0.231	
Degrees of Freedom	343	

This result came as a bit of a surprise to me since I noted 32 instances of enthusiastic behavior during the field labs and I only coded 10 times for enthusiasm during the in non-treatment in class labs. During the first treatment lab I actually observed students so enthusiastic that I noted in my journal, “Things went great, the students were actually running to get to the next station because they were so excited.” Also, during my interviews students were adamant that they really enjoyed the outdoor labs more. However, an indication that there might have been some variation with respect to the interest among the individual treatment labs and different student populations was brought to my attention in an interview with a female student who said she enjoyed them when it was nice, “but the cold kills me!” The boys did not really complain too much about the weather. Based upon that revelation I began to explore the different student populations.

The gender lines were obviously a good place to begin. Table 9 comes from the Earth Science Survey (Appendix E) and describes the average Likert Scale based response that students gave to the question, “I look forward to doing field (outdoor) labs.”

The survey was given in September and again in December. The results were coded into values as follows: Strongly Agree=2, Agree=1, Disagree=-1, Strongly Disagree=-2.

Table 9

Average Student Interest Over Time by Gender.

Note. Strongly Agree=2, Agree=1, Disagree=-1, Strongly Disagree=-2

I look forward to doing field (outdoor) labs.		
	September (N=85)	December (N=87)
Male	1.35	1.47
Female	1.47	1.44

The girls actually showed less interest in the field labs in December than in September by a very small margin. I would have hypothesized originally that the interest levels would have increased as time went by, but it was not the case and I believe that the weather had something to do with it. I knew from my literature review that I should take particular caution to make sure that the students were comfortable, but my schedule forced my hand and I needed to get the labs done on the days when I scheduled them (Christiansen, 2010). Two of the treatment labs were administered on very cold and blustery days. The first lab was on a Monday, and because of a mild weekend prior to an overnight cold front on Sunday, many of the girls did not bring warm enough clothes. The school uniform has the girls in a skirt/short combination and they found themselves very cold. The second lab was just later in the year than I wanted, and the students were cold. The feedback from the Earth Science Lab Self Evaluation (Appendix F) question about lab interest showed a similar trend (Figure 6).

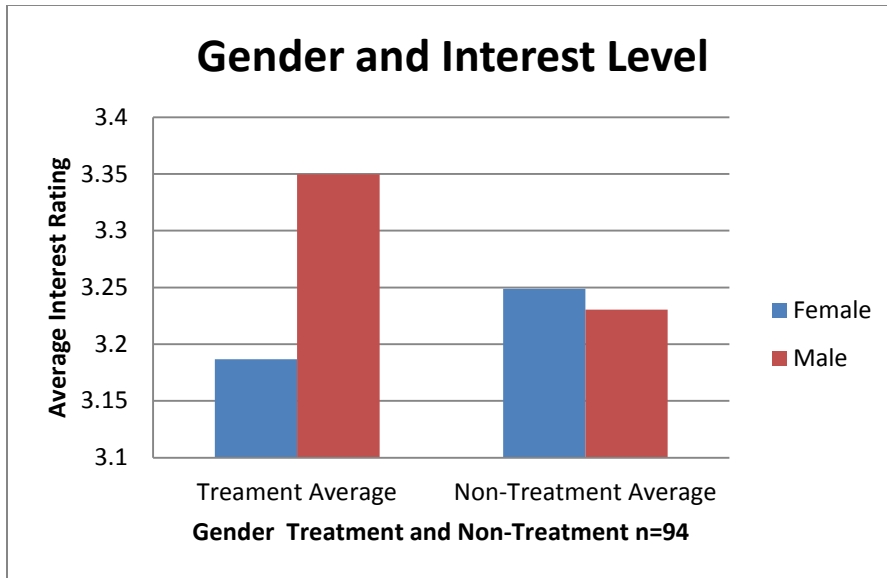


Figure 6. Average Interest Rating for treatment and non-treatment labs by gender, (N=96).

In fact the girls display a higher interest level for the non-treatment labs when looking at this data. This seems to further confirm the interview and survey results.

The other interesting trend that emerged when I looked at the data regarding attitude and motivation was related to time on task and behavior. When I looked at the Earth Science Lab Self Evaluation (Appendix F) I found that the students almost always reported perfect time on task and behavior scores for both the treatment and non-treatment labs. The treatment and non-treatment average for both time on task and behavior was 95% (N=96). When I looked at my observational data I also found that the non-treatment labs showed 32 instances of students being off task while the treatment labs showed only four. Review of my journal showed that 29 of the instances when the students were off task for the non-treatment labs were during the last 10 minutes of class when work with the materials was done and the questions/write-up portion of the lab was being completed. Interestingly, due to time constraints, most of the treatment labs have their write-ups completed at home. It was my theory that students feel the write-up is not

as important to the lab as the actual work with their hands. This was confirmed during probing questions throughout the interviews when 10 out of 15 students questioned all responded that they “felt the lab was over when I was done with the materials.”

Teacher Impact

Any time an educator can embark on a journey of inspired self assessment or be the recipient of friendly, constructive criticism they are sure to realize profound gains in their skills as a professional educator. Participation in this process has been affirming, and invigorating. My project has had a direct influence on my willingness to conduct these labs, the scope of my curriculum, and the focus I have on details in my classroom.

I came into this process always wanting to conduct field labs with my students because in my mind I knew there would be gains in both attitude and motivation for my students, but I was hesitant because of concerns over class management, time, and a lack of established lessons. In my journal I had remarked “I have really strived to create lessons that are interesting and well planned in order to alleviate my fears of students running crazy outside!” Certainly, the interviews, observations and pretest/test achievement data have affirmed my belief in the value of conducting these outdoor lessons. These results alone are enough to inspire me to continue to conduct field labs going forward. However, there has been additional affirmation from peer feedback and my own observations of the students’ behaviors and motivation to conclude that I was correct in initially assuming that the labs could serve to inspire the students in addition to educating them.

This process has also had an initial impact of immediately broadening my lab curriculum. I designed four entirely new labs (Appendix A, B, C, D) that I can use, and I

have been inspired to design even more going forward. Also, based on the Lei's influence, I have decided to combine local field trips in addition to my Yellowstone field trip to propose a "Naturalist: Independent/Guided Study" course at my school for students with whom these activities resonate (Lei, 2010).

The last area that has been impacted by this capstone has been my focus in the classroom. I have gained a sharper focus on three specific areas in my day to day classroom. First, I have realized that I need to emphasize and focus more on the importance of the write-up and conclusion portion of all the labs that we do in class. The data from the interviews shows that many of the students feel that the value of the labs is only in doing the labs. When I probed about why students seemed to be off task at the end of indoor labs periods, one student replied during an interview that "You can't really count those (instances) because the lab was over". They are missing a real opportunity in the write-up and questions to master concepts. Second, I have been awakened to the fact that I must organize all of my lessons and questioning skills to focus more on higher order thinking. I tend to do an adequate job focusing on higher order thinking in my questioning and probing in the context of the class, but this process has shown me a greater need to incorporate higher order thinking from the inception of all of my lessons. Finally, there is a need for me to view the achievement of my students more carefully by specific sub-groups. Analysis of achievement or motivation by gender or academic ability has been effective in this process to unearth strengths and weaknesses to improve instruction, and I feel that I can do more of that in everyday lessons as well as with labs. For example, the 17% difference in potential increase achieved by the D/F students when comparing treatment and non-treatment labs was 10% higher than the B students; I find

myself planning to see if there are similar trends with respect to graphing vs. true kinesthetic labs, or even seeing if flipping a classroom may have greater effectiveness with different academic abilities.

In conclusion, the use of field labs does seem to positively impact the ability of almost all students to understand lesson objectives when compared to traditional classroom based labs; however, outdoor labs may not impact the entire population of students when considering their effect on higher level thinking. It is important to remember the level of academic ability may mitigate or enhance the gains from field labs. Also, field labs are only as good as their planning and implementation. Labs that are well conceived and that focus on objectives that can benefit from being outside will tend to provide the best results. In addition, student attitudes and motivation will be maximized through careful planning that can minimize discomfort and distraction that can be associated with being outside.

INTERPRETATION AND CONCLUSION

The main reason that this particular project was undertaken was that outdoor labs make sense instinctively and based on my experiences; but it is something that is avoided many times because of fears that classroom management issues may cause subpar achievement and high levels of teacher stress. This project has been eye opening in many ways and has served as a confirmation of the value of outdoor labs.

The main research question undertaken was: To what degree do on campus field learning experiences influence achievement and enrich learning in earth science? The sub questions were,

1. To what degree do field experiences affect student attitude and motivation?
2. What impact has planning, researching and teaching lessons outdoors had on me as a teacher?

Outdoor lessons positively impact student achievement of the overall student population. The learning styles of the students (52% kinesthetic and 8% naturalist) would seem to make them inclined to benefit from active lessons in nature right off the bat. Pretest/test results (treatment improvement 1.71 compared to non-treatment improvement of 1.11) showed a significant advantage in achievement for field based labs and this was confirmed by observation (a journal entry after the Mapping Burke Catholic Lab “When they walked the steep slope, gradient and contour spacing really seemed to make sense”).

The field lessons also seemed to impact the student populations that had A and D/F ability levels even more profoundly when compared to the B and C students

(Difference in % increased achieved in treatment vs. non-treatment D/F=17.6, A=17.1, C=13.1, B=7.6). This difference could be due to a variety of different factors that may include attentiveness (time off task for D/F students was 8 instances ($N=10$) vs. B students was 33 instances ($N=79$)).

Field based labs did not in this instance seem to offer a significant advantage in comparison to classroom based labs (Figures 4 and 5). This lack of effectiveness of the treatment may be due to poor lab design that did not take advantage of opportunities to enhance higher order thinking in the field, or students may be limited by their academic ability and not the setting as it applies to enhanced learning.

Design, appropriateness and appeal of the lab may also influence the effectiveness of individual treatment or non-treatment labs when academic achievement is analyzed (the highest treatment lab showed an average gain of 2.49 out of 4 and the lowest showed a gain of 1.45; the highest non-treatment showed a gain of 1.52 and a lowest gain of 0.71). Careful attention must be paid to insure that labs are well conceived and implemented to maximize learning.

My second question dealt with student attitude and motivation. An eye opening fact is that students may be greatly affected by their comfort levels when outside (Dillon, 2006). The Polaris lab was conducted on a blustery Monday which saw many of the students, and the girls in particular not dressed for the weather. I joked in my journal that with one class I started off by saying “Okay, let’s whine right now to get it out of the way!” However, being distracted by the weather can likely lead to less than optimum student results. I also noted in my journal that I was, “Annoyed that students finished quickly so they could ask to stand in the sun during the lab.” A second moment of

realization is when one of my students came in late from Physical Education after being stung by a bee. She was allergic to bee stings. She had been administered a dose from an EpiPen and was still in a little respiratory distress when she came back to my class. I recall being a little annoyed at a few students for being distracted by bees when we were outdoors for one of the labs; I had not considered the safety value for those students since I was not allergic and had considered them off task. We all have different levels of discomfort and perceived levels of danger and if one is to successfully implement safe and effective field labs, caution and empathy must be at a premium.

VALUE

The immediate value of this capstone project has been for me professionally as a teacher, and for my current and future students. My last research sub question was specifically designed look at the impacts that this project has had on me as a teacher, and I can say it was profound. I finally got over my fears or excuses to get outside to conduct classes which were of benefit to most of my students. I have had many prior students who are currently juniors or seniors ask me why they did not get to go outside and I have only weak answers, at best, to their inquiries. This year's Earth Science students and those to come either have benefitted or will benefit from this project.

The value to my teaching skills and to my students comes in a variety of different ways. First, there are clearly academic achievement benefits to simple, field based labs when they are well imagined, planned and executed. Almost all of my students this year have been able to better comprehend at least some topics that they have encountered in the field (100% of students interviewed said that they did learn some things better in the field { $N=15$ }). In addition, this also seems to really help certain segments of the student population when weather and safety conditions are correct.

This process has also made me more aware of the differences between myself and my students, and it has made me more aware of the differences between the students themselves. I have most certainly gained empathy for my students when it comes to dealing with discomfort when facing the weather, but I have a deeper empathy based on this lesson learned for not being dismissive of concerns or complaints that I may not comprehend or see as trivial. In addition, the data has been a clear indicator that not all student populations will benefit the same from different teaching styles. This process has

allowed me, through my own self discovery in my classroom, to revisit and redouble my approach to differentiated instruction. I have found that this year's group is a mix of abilities and learning styles that I must strive to reach through a variety of methods. After all, Linguistic learners make up only 1% of my student population and kinesthetic learners account for 52%, so a lecture or sedentary graphing lab won't do.

This research certainly has implications beyond my classroom as well. I am fortunate enough to have a very good department at Burke Catholic who I will share my findings with and encourage further exploration of field based labs and data collection as a way to increase achievement in almost every course. This should be easily achieved because my research has confirmed the work of my support team member John Debold who was already conducting field based labs and served as an inspiration.

I am the only Earth Science Teacher at Burke Catholic, but currently I am assisting an eighth grade Earth Science teacher at one of our feeder schools. I am most certainly going to share my experience with her, as well as the four labs that I have developed. In addition, I plan to submit the labs I have developed to www.nyscienceteacher.com which is a site for NY science teachers that pools resources to assist in curriculum development.

During this journey I have broadened my professional skills, become aware of differences between myself and the many different groups of students I teach, and found inspiration on many levels. This project has equipped me with data collection tools to use to improve instruction in my classroom. It has also reminded me to be vigilant to the signs that my students are always sending me in a variety of ways, and it has been uplifting by affirming that my efforts and instincts about learning experiences outside are

correct. It is my goal to expand the field based class work in my Earth Science class and provide additional day trips to interested students to augment learning for those students with interest.

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APPENDICES

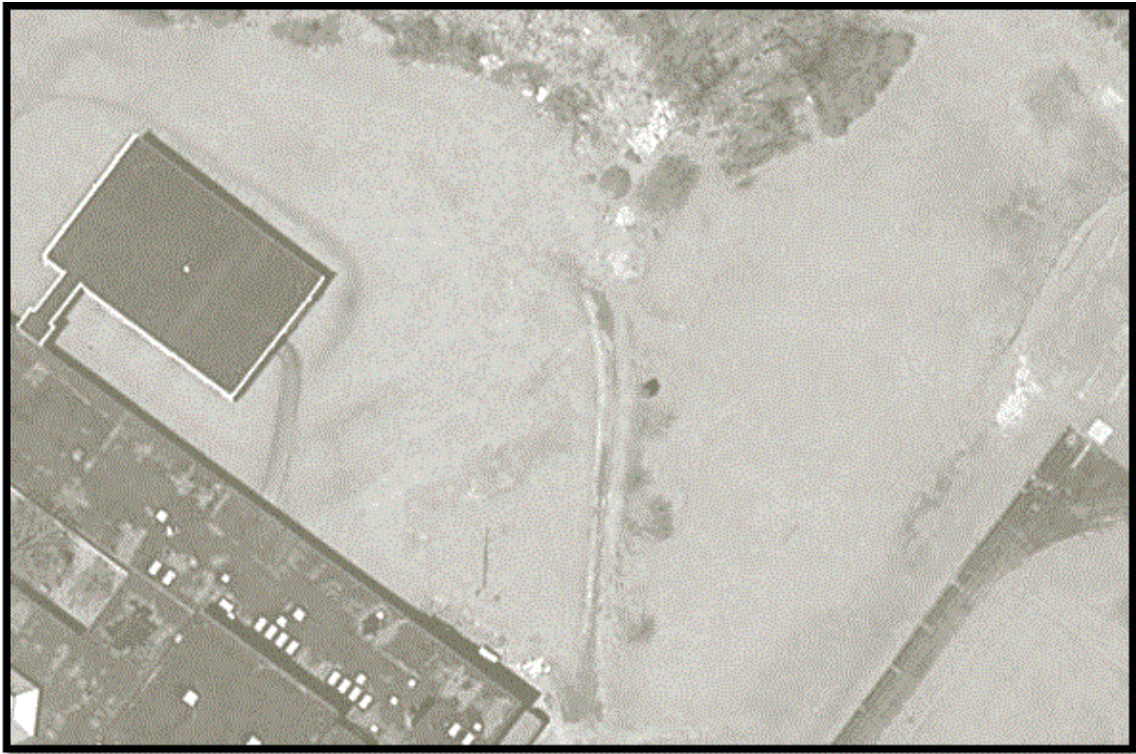
APPENDIX A

TREATMENT LAB: MAPPING BURKE CATHOLIC

Name:

Mapping Burke Catholic Lab

Date Sheet 1



Objectives: Students should concentrate on:

Contour lines, slope, gradient, map scale, map legend, profile construction.

Students will construct a topographic map using by walking a series of trails and recording elevations and counting paces. In addition students will create a map legend and place symbols on the map in correct locations. The students will then calculate slope and create a map legend. Using their map students will create a topographic profile.

Procedure:

Using the map above pace off the trail listed: BA, CA, DA, EA, FA.

1. While pacing the trail, stop at the marked blazes and record the elevation at each location and how many steps you are from the trailhead on Data Sheet 1.
 - a. You must keep a total count of steps from each trail (B,C,D,E,F) from the start to the tree which marks point A.
2. While stopped at each marked blaze, record the slope in that exact spot as F=Flat, M= Moderate, S=Steep on Data Shett 1.
3. Using your best guess based on paces you have taken and Figure 1, mark the blazes on Figure 1 above.
4. Make contour lines on Figure 1 using a contour interval of 10ft. Start with 460 (near the tree which is spot A).
5. On figure 1 insert a Map Scale (a graphic scale), the contour interval and a map legend. The legend should include: the Gravel Road, the Track & the Path...the mark your map with the correct symbols (that you invented).
6. Complete the Problems and Questions listed on the second page of this lab. Complete the Lab Self Assessment (the last page...don't forget your name.)

Problems:

1. Calculate the gradient for line C1-C4: (round to the tenth and include correct

Trail/Location Blaze #	Describe the hill as F=Flat, M= Moderate, S=Steep	Elevation (ft.)	Steps from trailhead (stp.)
CA 1		440	0
CA 2		450	
CA 3		460	
DA 1		430	0
DA 2		440	
DA 3		450	
DA 4		460	
EA 1		410	0
EA 2		420	
EA 3		430	
EA 4		440	
EA 5		450	
EA 6		460	
FA 1		400	0
FA 2		410	0
FA 3		420	
FA 4		430	
FA 5		440	
FA 6		450	
FA 7		460	

units):

2. Calculate the gradient for line F1-F10: (round to the tenth and include correct units):

Questions:

1. What was the flattest trail? What did the lines look like there in terms of spacing?
2. What was the steepest trail? What did the lines look like there in terms of spacing?

APPENDIX B

TREATMENT LAB: ANGLE TO POLARIS

Name:

Finding Your Latitude Using the North Star (aka.Polaris)

Objectives: Students should concentrate on understanding the connection between the angle of Polaris and latitude. In this instance the flagpole will be our imaginary North Star (Polaris).

Background: Polaris is almost directly above the North Pole. This means that when you stand on the North Pole and look directly up (at 90 degrees), you will see Polaris. This also means that when you stand at the equator and look directly north, you will see Polaris on the horizon (0 degrees). You cannot see Polaris from the Southern Hemisphere.

The angle that Polaris is above the horizon is equal to the degree latitude that you are standing on. Therefore at the equator, Polaris is 0 degrees above the horizon and at the North Pole, Polaris is 90 degrees above the horizon.

Materials: Protractor, paper bundle, 20 cm string, clear plastic straw, tape, scissors, metric ruler, ESRT, compass (geometry).

Sextant Construction Procedure:

1. Trim the straw to the exact length of the protractor along the flat end.
2. Tape the straw to the top of the protractor.
3. Tie the string to the paper clip. Make sure that the string hangs freely, and then tape it to the center mark. (Note: the string should go through the 0 degree mark if the straw is held parallel to the ground.)

Field Procedure:

We will use a little imagination to conduct this lab. Since it is going to be daylight as we perform this lab we cannot point our sextants at Polaris easily, so we will use the flagpole as our version of Polaris. When we point the sextant at Polaris it will show us how many degrees above the horizon Polaris is and that indicates our latitude.

1. Walk to the cone depicting a city in NY as directed by Mr. J.
2. When you arrive you should take three recordings (see the bullet below for procedure) of how far Polaris (the top of the flagpole) is above the horizon. Record them in Data Sheet1.
 1. Sight this object through the straw. Press the string against the protractor and when it stops swinging and read the scale on the protractor. This is the angle of the flagpole above the horizon.
3. On Data Sheet1 average the three recording and round to get rid of any decimal.

4. Use ESRT page 5 to figure out a location that you might be at (pick a spot on land that matches to your latitude) and record that longitude on Data Sheet1. Now put a dot on ESRT page 5 (last page of this handout) to mark your latitude and longitude.
5. Label Polaris/North Pole on the picture of Burke and write in the numbers of the locations and their latitudes. Use a compass to draw lines of latitude on your map of Burke (they will be circles around the North Pole) for each point we observed with the sextant.
6. Construct your own sextant at home (If you don't have a protractor, construct your own!
http://www.teachervision.fen.com/tv/printables/scottforesman/Math_6_TTT_17.pdf), complete the row in Data Sheet1 for the measurements you take. A great link to help you find Polaris if you need it.
 - <http://www.lpi.usra.edu/education/skytellers/polaris/about.shtml>

Date Sheet 1

Location	Angle to Polaris				Longitude (from ESRT page 5)
	Trial 1	Trial 2	Trial 3	Average Round to nearest	
	1				
1					
2				70N	
3					
4					
5					
6					
7					
Practice				50 N	80W
Your House using Polaris at night.					Use ESRT page 3

Questions:

1. What is your latitude if you get a reading of 45 degrees elevation by sighting the North Star with a sextant? Include N,S,W,E designation (only include what is appropriate).

What is the closest city (use ESRT page 3)?

What if your reading was 0 degrees?

2. If you were standing directly under the flagpole what place on earth would you be at if you are imagining our analogy?
3. What happens to the angle above the horizon where you see Polaris as you move from points 1-8? Please explain why.

APPENDIX C

TREATMENT LAB: HOW DI IT GET HERE?

Name:

How Did It Get Here?

Objectives: Students should concentrate on *making observations and thinking about how the earth's features has been formed. Asking questions of themselves and coming up with plausible explanations.*

Locations:

- Exposed Rock
- Front of Burke
- Rt. 17 Ramp

Procedure:

Mr. J will show you a piece of land or a geologic feature. You will have a limited amount of time to observe this piece of land. Make as many observations as you can in the time allowed; "How big is it? Of what is it made? Does it have different textures? How does it look?" All of the answers to these questions make good observations to record:

Location/Observation:

Explanation: (use back of sheet if needed)

DISCUSSION QUESTIONS

1. Does any piece of land just "happen" or are there always processes involved that shape the land? Explain.

2. Can more than one process have an impact on how a piece of land forms? If you answer "Yes" give an example, if you answer "No" explain why not.

3. Can a specific land form be created in more than one way? If you answer "Yes", give an example. If you answer "No", explain why not.

4. Describe a piece of land you have seen (where, what it's like, & attempt to tell how it formed).

(continue on back)

5. Describe how a human created landscape might be noticeable in nature.

(continue on back)

APPENDIX D

TREATMENT LAB: SHADOW ANALYSIS

Name:

Date:

Shadow Analysis Trial #1

Objectives: In this lab you will indirectly measure the changing position of the sun by keeping track of the length and direction of a shadow. Careful observations will allow you to accurately determine the position of the Sun and how it changes throughout the day and year.

Materials

Cardboard, nail, shadow recording sheet, tape, ruler(ESRT), pencil, magnetic compass, protractor, map pins

Materials

Cardboard, nail, shadow recording sheet, tape, ruler, pencil, magnetic compass, protractor, Circular protractor (360°), map pins

Procedure

1. Find the middle of the piece of cardboard and push the nail through it until the head of the nail is flush with the bottom of the cardboard. Tape the head of the nail to the cardboard so it does not slide out. The nail should be sticking through the cardboard at a 90° angle.
2. Take the shadow recording sheet and carefully push the point of the nail directly through the small circle found at the center. It may help to put a pinpoint through the center of the paper first to help line up the nail. Push the paper down to the cardboard and tape down the edges.
3. Take the apparatus outside to a level location that is in direct sunlight. Place the cardboard down on the ground.
4. Take the magnetic compass and position so the center point is on the line labeled N (north). Turn the cardboard until the red portion of the needle is exactly lined up with the arrow labeled N. Your cardboard is now pointing toward magnetic North.
5. Place a pin into the cardboard at the exact end of the shadow. Next to the pin record the exact time of day that the observation was made. Repeat each time when Mr. J calls for the recording of the next observation.
6. Measure the height of the nail in cm to the nearest tenth (for example 5.5cm). Record the height of the nail and date of observation on the shadow recording sheet and on data table one.

Analysis

1. Remove the paper from the cardboard. Construct lines from the center of the nail hole to the pinpoint that were made in the sheet. These lines represent the actual shadows.

2. Record the times of all observations on data table one.
3. Use a metric ruler (ESRT) to measure the length of each shadow. Record these measurements on data table one.
4. Using a straight edge extend the line of the shadow to measure the degrees each shadow. Record this information on data table one.
5. Calculate the change in degrees between each shadow and record on data table two.
6. Calculate the rate of motion of the shadow in degrees per minute for each pair of observations. The formula for rate is

$$\text{Rate} = \frac{\text{Change in degrees}}{\text{Change in time (minutes)}}$$

8. Calculate the rate of change in degrees per hour by using the following formula

$$\text{Rate (}^\circ\text{/hour)} = \text{Rate (}^\circ\text{/min)} * 60$$

9. Calculate the average rate of change in degrees/hour for all observations. Record your answer on the data sheet.

10. Use the directions found on the bottom of this page for Determining the Altitude of the Sun by constructing triangles to scale. Record the measured altitudes on data table one. This step can also be accomplished by using the following formula

$$\text{Altitude of Sun} = \tan^{-1} (\text{height of nail} / \text{length of shadow})$$

Directions for Determining the Altitude of the Sun by Construction of triangles to Scale

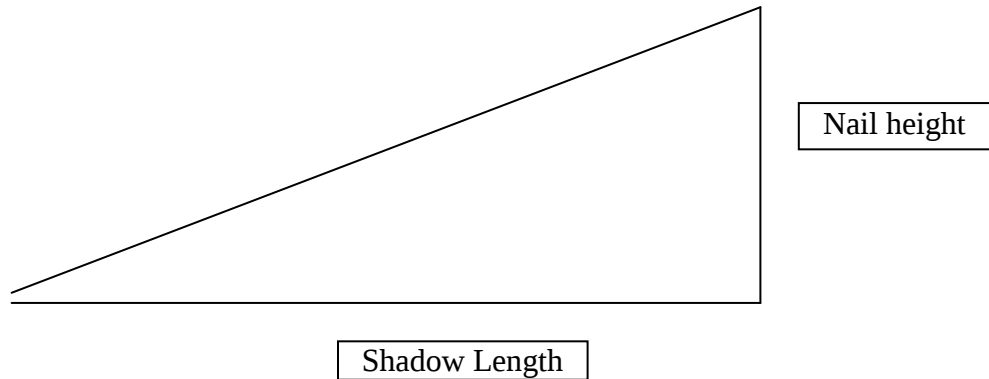
Materials - protractor and metric ruler

Procedure –

For each observation of the sun you will need to draw a triangle to scale to determine the angle of the sun. You will need the measurements for length of the shadow and height of the nail.

- 1) Use the ruler to draw a line the same length as the shadow.
- 2) Use the protractor to mark a point 90° from the endpoint of the shadow line.
- 3) Draw a line to represent the exact height of the nail from the end of the shadow line. Use the mark at 90° to draw the line 90° from the shadow.
- 4) Draw a line from the end of the shadow to the top of the nail.
- 5) Measure the angle between the shadow and the line you just constructed. This angle is the same as the altitude of the sun.

Example



Shadow Analysis Data Table One

Height of nail = _____ cm Date of Observation _____

Observation n	Time of Day	Length of Shadow (cm)	Degrees of the Shadow	Altitude of Sun (° above horizon)
1				
2				
3				
4				
5				
6				
7				
8				

Data Table Two

Observations	Difference in Time	Change in degrees	Rate (° / min)	Rate (° / hour)
1-2	4 minutes			
2-3	4 minutes			
3-4	4 minutes			
4-5	4 minutes			
5-6	4 minutes			
6-7	4 minutes			
7-8	4 minutes			

$$\text{Rate (°/hour)} = \text{Rate (°/min)} * 60$$

1. **Average Rate of Change (°/hour) = _____**

Questions

- 1) In what direction did the shadow move throughout the course of the investigation?
- 2) How is the direction of the shadow related to the direction of the sun?
- 3) How did the sun appear to move over the time observed?
- 4) What happened to the length of the shadow over the time observed?
- 5) How is the length of the shadow related to the angle of the Sun?
- 6) Around what time of day will an object cast the shortest shadow?
- 7) When will an object cast the longest shadow?
- 8) At what time do you think the Sun is highest in the sky?
- 9) As we approach winter what will happen to the length of the shadow?

APPENDIX E

EARTH SCIENCE SURVEY

Earth Science Survey

Circle the letter that represents your feelings about the statement.

Please add written detailed responses to the questions with asterisk at the bottom of the page.

SA= strongly agree A= agree D= disagree SD= strongly disagree

I am good at science. *SEE BOTTOM	SA A D SD
I think science is boring.** SEE BOTTOM	SA A D SD
I often ask my partner for answers without thinking about the concepts we are trying to learn.	SA A D SD
I often rush through the lab without thinking about the concepts we are trying to learn.	SA A D SD
I have gone camping or hiking and enjoy being outdoors.	SA A D SD
When outside I have good science observational skills.	SA A D SD
When outside I am very curious and think about things I have previously learned in science.	SA A D SD
I am constantly improving as a science student and this helps me better understand the world around me.	SA A D SD
I think I learn better inside the classroom than outside.*** SEE BOTTOM	SA A D SD
I look forward to doing field (outdoor) labs.****SEE BOTTOM	SA A D SD
I am comfortable in the outdoors and feel at ease.	SA A D SD
I do not understand the point of most labs.	SA A D SD
Students use their time well during labs.	SA A D SD
I feel I use my time well during labs.	SA A D SD
Students have been well behaved on labs done outdoors.	SA A D SD
I feel I have been well behaved on labs done outdoors.	SA A D SD
I am likely to do better if I enjoy the material.	SA A D SD
I thought the outdoor labs were fun.	SA A D SD
I thought the outdoor labs helped me to understand the concepts.	SA A D SD

* Please explain why in as much detail as possible.

** Please explain why in as much detail as possible.

*** Please explain why in as much detail as possible.

**** Please explain why in as much detail as possible.

APPENDIX F

EARTH SCIENCE LAB SELF EVALUATION

Name: _____

Period: _____

Lab Name: Mapping Burke Catholic

Date: _____

Earth Science Lab Self Evaluation..... This will not affect your grade!During this lab I was (Check **one**...Be honest this will not affect your grade):Almost always on task. ☐I was reminded to be on task, or should have been reminded to be on task. ☐I was reminded to be on task several times or should have been reminded to be on task several times. ☐I was not on task very much. ☐During this lab most other students were (Check **one**...Be honest this will not affect your grade):Almost always on task. ☐Were reminded to be on task, or should have been reminded to be on task. ☐Were reminded to be on task several times or should have been reminded to be on task several times. ☐Were not on task very much. ☐I found this lab to be (Check **one**...Be honest this will not affect your grade):Very Interesting ☐A little interesting ☐Boring ☐Very boring ☐During this lab I (Check **one**...Be honest this will not affect your grade):I have been focused on the concepts we are trying to learn and I asked questions of my teacher if I am stuck. ☐I asked my partner for answers without thinking about the concepts we are trying to learn. ☐If you checked that you asked your lab partner for answers without worrying about the concepts please explain why.

_____ Continue on back

What do the topographic lines indicate when they are really close together? How would that be helpful to a person planning a road? How about a hiker? Can you name another use?

_____ Continue on back

Why did I choose the Interest level rating that I did (the box I checked above)?

What was the most important thing you learned during this lab? What questions remain unanswered?

_____ Continue on back

APPENDIX G

STUDENT OBSERVATION FORM

Class Period: _____

Lab Name: _____

Date: _____

Student Observation Form

Student	Observed Code Tracking	Inter. Codes	Comments	Grade
Last Name, First				
Last Name				
Last Name				
Last Name				
Last Name				
Last Name				
Last Name				
Last Name				
Last Name				
Last Name				
Last Name				
Last Name				
Last Name				
Last Name				
Last Name				
Last Name				

Observation Codes:

T= Talking not related to task

A= Student not in correct location

O= Other, see comments

E= Enthusiastic

Q= Asks relevant question.

Interview Codes:

B= Indicated deeper knowledge of concepts.

C= Clearly articulates lesson objectives

M= Understands lesson objectives with few misconceptions.

N= Minimal or no understanding of lesson objectives.

Grade Codes/Explanation8 Outstanding - Always observed on task.6 Good - Was reminded to be on task, or should have been reminded to be on task once or twice.3 Lacking - Not on task very much.

APPENDIX H

SAMPLE PRETEST AND TEST

Sedimentary Rock LabPost

Name: _____

What is the easiest way to recognize a sedimentary rock?

Describe the sequence of events in the lithification of sandstone.

How can you check to see if a rock is limestone?

When we say sedimentary, what does that mean?

When first deposited, what would the cross section pattern of sedimentary rocks look like?

APPENDIX I

INTERVIEW QUESTIONS

Interview Questions

1. Describe your feelings about learning science.
2. Are there certain aspects that you like or dislike about learning science? Can you give me an example?
3. How do you feel about being outdoors in general (not just for science class)? Do you spend a lot of time outdoors?
4. What kinds of things do you like to do when you are outside?
5. How do you feel when your teacher tells you that the class is going outside for science?
6. If you had the choice, would you rather have science class inside or outside?
 - o Probe: Why would you rather have it inside/outside?
7. What are your 3 favorite things about learning science outside?
8. Compare inside and outside labs.
 - o Probe: Why do you say that?
9. Are you afraid of or worried about anything when you spend time in nature?
10. What is the best outdoor science experience you have ever had?
 - o Probe: Why was that the best?
11. What is the worst outdoor science experience you have ever had?
 - o Probe: Why was that the worst?
12. Are you comfortable learning in outdoor settings?
 - o Probe: Why are you comfortable/uncomfortable learning outside?
13. What was your favorite indoor lab?
 - o Probe: Why?
14. What was your favorite indoor lab?
 - o Probe: Why?
15. Is there anything else you would like to share with me?