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# INQUIRY-BASED ACTIVITIES FOR ON-LEVEL STUDENTS IN A HIGH SCHOOL SCIENCE CLASSROOM

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**ABSTRACT**

In my study, I investigated what are the observed and reported experiences of implementing inquiry-based activities in the high school science classroom for On-Level students. The 20 students that were part of my study were enrolled in the course, On- Level Earth and Space Science.

I assessed four units of Earth and Space Science by using 17 graded inquiry-based activities, including: the Lab Safety Group Activity, Solar Heating Lab, Lab Report on Designing a Barometer, and the Group Atmosphere Project. Students accomplished these units through group cooperative problem solving activities, laboratory activities, and a group project. Each of these activities was classified as being one of three types of inquiry: structured inquiry, guided inquiry, or open inquiry. I formatively assessed group participation for each unit with the use of a cooperative group assessment checklist. In addition, the students were given a survey and interview to assess their attitudes on learning science using inquiry-based activities versus more teacher-centered instruction.

Overall, my findings were supportive of the educational benefits of using inquiry-based activities in the classroom for On-Level high school science students. Academically, the class average results included: problem-solving activities—81%, laboratory activities—81%, and group project—82%. According to a survey given on student attitudes toward science, all students surveyed preferred to be active learners. The interview that was given also

reflected overwhelmingly, students learned science best by being active learners, which is an integral part of inquiry-based activities.

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## RESEARCHER STANCE

My interest in teaching all students is a personal one. The beginning for me was when I was in second grade. My family moved from an urban to a suburban area. The suburban school was supposed to be a much better school. What I began to experience however, was quite the opposite.

At this new school, I was placed in the lower ability reading group, not the lowest of the four groups, but second to the lowest. There were no ability groups for the other subjects in second grade, but I felt that everything that I was doing, even though I was by this time very unmotivated, was counting against me. This lack of motivation was probably a result of me feeling academically inferior. We completed a lot of worksheets, and I would write any answer, just to finish the sheets sooner. I was not scoring well because I was not trying my best. I did not realize that by putting any answer on these sheets, my teacher would grade and interpret those results incorrectly. I felt like an outcast; I did not fit in. My second grade teacher was not supportive and encouraging to me, as my first grade teacher had been.

By third grade, I had two teachers, one for math and the other subjects, and one for language arts. We still completed a lot of worksheets, but not as many as in second grade. I started to become aware that I was being judged on my performance. For example, if I wrote down any answer on worksheets in order to get done quicker, my teachers would grade this and think that I was stupid. I wanted to show my teachers that I was not stupid. I remember consciously trying my best. In fact, both of my teachers told me that I did not belong in these "lower classes." I wanted to move up to a more challenging level.

For the next three years, fourth through sixth grade, I was still in lower classes. I felt lied to; teachers I had hoped would correct this problem did not follow through with what they said that they would do. I did not mention anything to my parents; my father was a science teacher at a neighboring district, and I was ashamed. I scored well, receiving very good report cards, so they did not suspect any misplacement.

Similarly in sixth grade, which was considered part of elementary school in the 1970s, both of my teachers were saying the same thing I had heard before. I was getting angry, especially now, because I was really starting to enjoy school, but thought I was going to be lied to again. However, things took a turn for the better.

I credit my sixth grade teachers, especially my English teacher, for being more proactive than all of the others. Not only had he verbally told me that I should be in higher classes, but he spoke with my parents, and wrote a formal letter of recommendation for my placement change. I remember my father meeting with the principal of the middle school to assess my testing records and grades. With much delight, I will always remember my father explaining to me that day that everything was finally fixed. He apologized to me for not being aware, said all of my standardized testing supported that I had the ability necessary for Honors classes, and that my English teacher had really been quite insistent that these changes be made.

In seventh grade, I was in all Honors classes. I continued taking Honors and Advanced Placement classes throughout my schooling, and I graduated high school with highest honors. I went on to obtain a Bachelor's and Master's Degree, graduating Summa Cum Laude each time.

I have experienced being in an educational system that was often unfair: being placed in lower level classes, experiencing the many worksheets and the boredom of monotony, focusing on simple tasks, and being unchallenged. I have also experienced the joy of being an active learner, which the Honors and Advanced Placement classes provided me. Here, we did interesting projects; often working in groups with other students to achieve a goal, experienced real science labs, and thought intelligently because of teacher expectations. In these higher classes, students could do more. Through active learning, I was personally interested in learning, and learning was enjoyable. In fact, my desire to encourage and assist others with their learning led me to become an educator.

As an educator who desires the best for all of my students, I want all of my students to think intelligently and develop higher order thinking skills, not merely memorize facts. Currently, the Honors Science classes and College Preparatory Science classes that I teach have a scheduled laboratory period as part of their curriculum, which encourages laboratory and discovery and other types of inquiry-type of activities. The students in the On-Level Science ability groups do not have this same experience. Much research supports inquiry-based activities as a means to foster these higher order skills (Zohar & Dori, 2003).

In a previous graduate course I conducted a pilot study, which was initiated because of my desire to educate all students. I had already witnessed the benefits of including hands-on activities in the curriculum for the Pre-AP, Honors, and College-Preparatory classes. In addition, I was experiencing On-Level Science students of mine telling me how much they learned from the "hands-on" activities that I was including in their class. This reinforced my interest in pursuing this line of research.

In my pilot study, I observed the positive effects of hands-on activities, where my results provided evidence that 5 out of 6 students studied improved their marking period grade average. In fact, 4 out of 6 improved by a whole letter grade. Despite the positive academic benefits observed, I had not examined how these activities would improve higher order thinking skills, and wanted to expand my question to include observing the effects of implementing other inquiry-type activities. Consequently, I have since expanded my question to include, in addition to hands-on activities, other inquiry-type activities, as they relate to On-Level students and higher order thinking skills.

Therefore, my underlying desire to educate all students optimally, with my pilot study as a stepping-stone, has led me ultimately to my research question. My research question is: What will be the observed and reported experiences when inquiry-based activities are integrated into the high school Science curriculum for an On-Level ability class? Therefore, despite not having a designated laboratory period, I plan to include curriculum based, inquiry-type activities within the assigned class period.

# LITERATURE REVIEW

## Introduction

Inquiry-based education in the science classroom involves the topics, higher order thinking skills, and active involvement learning. The use of active involvement learning, of which inquiry-based education is categorized, should increase all students' higher order thinking skills in the science classroom, including On-Level students (Zohar & Dori, 2003).

## Higher Order Thinking Skills

Essential to every student's educational learning is being able to utilize higher order thinking skills effectively. Mysliwiec, Dunbar, and Shibley (2005) addressed the concept of higher-order thinking skills by offering suggestions that could be implemented within the classroom to promote such a level of thinking. The focus was to have students take greater charge of their own learning by proper preparation with regard to assignments, thus, having the classrooms become more student-centered versus teacher-centered.

In addition to having greater student ownership for learning, Bloom's six levels of cognitive domain are descriptive regarding the desired progression towards reaching the more complex levels (Mysliwiec, Dunbar, & Shibley, 2005). The lowest level is the Knowledge, or factual level. Comprehension is second, followed by Application, Analysis, Synthesis, and Evaluation level, respectively, where Evaluation is the most cognitively complex level. According to Bloom, Engelhart, Furst, Hill, and Krathwohl (1956), "Evaluation is placed at this point in the taxonomy because it is regarded as being at a relatively late stage in the complex process which involves some combination of all the other behaviors of Knowledge, Comprehension, Application, Analysis, and Synthesis" (p. 185). When there is higher order thinking present, this is a valuable precursor to inquiries (Freedman, 1998).

***High School Science***

Colburn (2004) expressed that for a greater, more in-depth understanding of science and various scientific concepts, inquiry-based teaching provides students the necessary opportunities to "actively grapple with the content" (p. 64), but cautioned the teacher to assist in preparing the students to be developmentally ready for the inquiries to be utilized.

In a study by Bottoms (2002), the importance for increasing higher order thinking skills as expressed in Bloom's Taxonomy of Cognition suggested that for the improvement of science achievement of low-performing students, more interpreting, inferring, constructing, and evaluating of scientific data and procedures needs to be implemented.

Similarly, the National Science Education Standards and Benchmarks For Science Literacy emphasizes inquiry-oriented activities for incorporation into all high school science curriculums (Trowbridge & Bybee, 1996).

## Ability Groups

A detailed study presented by Zohar and Dori (2003), a culmination of four separate studies involving students from grades 7 through 12, aided in answering the following question, "Do low achieving students gain from teaching and learning processes that are designed to foster higher order thinking skills?" (p. 145). Zohar and Dori (2003) concluded that instruction of higher-order thinking skills is appropriate for students with high and low academic achievement alike.

In addition, the reform of science education in America emphasizes the need for all ability levels to perform and communicate scientific inquiry with others (Beeth & Huziak, 2001).

According to the National Science Education Standards, (Trowbridge & Bybee, 1996), "the level of understanding science that all students, regardless of background, future aspirations, or interest in science, should develop" (p. 58) is specified. The Science Standards "embody the belief that all students can learn science" (Trowbridge & Bybee, 1996, p. 58). In fact, scientific models of inquiry and the application of such scientific knowledge to ones' life are emphasized within the context of scientific literacy, a crucial part of the Science Standards. Higher order thinking skills are necessary to implement these standards adequately for all students.

***Motivation***

Student motivation to learn depends on several factors. One critical factor is one's learning style. Students have a preferred style of learning, although many can learn to adapt using another. The preferred learning style becomes essential when looking at incorporating the various active involvement learning methods as previously described. Various studies (Lee & Fraser, 2001; Roth & Bowen, 1995; Wilson, 1996) express consideration for student preference and mention possible learning style factors as playing a role in the effectiveness of active involvement learning.

Another factor influencing student motivation is the incorporation of students becoming active learners (Carroll & Leander, 2001), where higher order thinking techniques are incorporated into the learning process. This is critical, as educational experiences, according to Dewey (1997), will be found either agreeable or disagreeable to the student. Dewey states, "Everything depends upon the quality of the experience had" (p. 27). This means that experiences have an influence on later experiences. Dewey (1997) also states, "Experience does not go on simply inside the person. It does go on therefore, it influences the formation of attitudes of desire and purpose" (Dewey, 1997, p. 39).

A study presented by Fisher, Gerdes, Logue, Smith, and Zimmerman (1998) found an improvement in student's science grades, and an increase in their positive attitude towards science when hands-on, inquiry-based activities were implemented within the science class.

***Teaching Techniques***

By being cognizant of different learning styles and preferences, teachers can implement a variety to attempt to reach the majority of students. In addition, according to a study presented by Swaak and van Joolingen (2004), an integrated program of both expository instruction (teacher-centered instruction) and discovery/simulation (student-centered) instruction was beneficial.

Similarly, the Learning Cycle, the result of work done by Karplus and the Science Curriculum Improvement Study (SCIS), consisting of three phases (Trowbridge & Bybee, 1996) incorporates active student learning with areas of teacher-guided instruction. The phases include: Exploration, Invention, and Discovery. The Exploration phase of the Learning Cycle emphasizes active student learning. The Invention phase emphasizes other instructional teaching methods, including more teacher-guided methods. The third and final phase of the Learning Cycle is known as the Discovery phase. Here, students apply learned knowledge. All three phases of the Learning Cycle focus on students' scientific learning, which emphasizes students being active participants in their learning where higher order thinking skills are developed.

Implementing the Learning Cycle (as presented by Lawson in Trowbridge & Bybee, 1996) would include some teacher-centered instruction in order to guide their students' learning, especially connecting them from their previous level of knowledge. Then, students could be actively engaged as they explored and applied the concepts learned, utilizing higher order thinking skills.

White and Frederiksen (1998) emphasized the need for scaffolding the curricula to foster student's inquiry development. They expressed the importance of scaffolding to promote learning for all students, especially the lower ability achievers and younger students. They believed that this was a "crucial part of the conscious expertise about learning that they lack" (White, & Frederiksen, 1998, p. 6).

To insure higher order thinking, teacher lessons should not focus on mere description of events, which is low on Bloom's Taxonomy of Cognition. Instead, the students should be challenged to analyze the data, encouraging alternative solutions and explanations to questions. Gupta (2005) supports progressive questioning as a means to develop students' critical-thinking, logic, and problem-solving skills, all of which involve higher order thinking. Educators should therefore include questions in their inquiry activities, which will foster student's cognitive development.

"Good inquiry-oriented teachers listen well and ask appropriate questions, assisting individuals in organizing their thoughts and gaining insights. Inquiry-oriented teachers seldom tell but often question" (Trowbridge & Bybee, 1996, p. 156).

Polman (2004) concluded in his study that it is important for the teacher to scaffold students through questioning. Teaching techniques should include purposefully designed activities, which scaffold and foster students' higher order thinking skills.

## Active Involvement Learning

There are various forms of active involvement learning. These include: inquiry-based learning, lab-based learning, hands-on learning, project-based learning, constructivist learning, discovery learning, and student-centered learning. Basically, all the forms implement active versus passive student involvement with regard to the learning process.

The study done by Wilson (1996) showed that many students have a definite preference for active learning, based on the results from the Learning Styles Inventory. The highest percentage, 43.4% (n=72) were categorized as active learners in this study. Their preferences for learning involved: auditory language, kinesthetic learning, and oral expression. In addition, the category from this study entitled, "the social butterflies," which comprised 35.0% (n=58), preferred group learning. Therefore, if these two typically active learning groups were combined, where the student is actively engaged as a participant, this would represent 78.4%, or the majority of the student population.

However, the third group in the study, comprising 21.1% (n=35), preferred learning by visual language, individually, or involving written expression. Interestingly, this group was comprised mostly of higher achieving honors classes versus the lower achievers in regular classes (Wilson, 1995).

In a study by Burbach, Matkin, and Fritz (2004), where active learning techniques were utilized in the classroom, improvement of critical thinking, or higher-order thinking resulted.

***Inquiry-Based Learning***

One specific form of active learning is inquiry-based learning. Haranda and Yoshima (2004), inquiry-focused learning is described as a process that provokes deeper thinking, investigation, and a greater student motivation to learn. They expressed the importance of engaging students in higher-order problem solving and hands-on activities, where learning involves social interaction. This was optimal learning where students would be more enthusiastic and learn more than merely memorizing.

With this approach to learning, there are three different kinds: structured inquiry, guided inquiry, and open inquiry. The major difference between all three types of inquiry is who makes the majority of decisions, the student or the teacher. Structured inquiry is similar to the verification approach, lab cookbook type of learning, but the students have some input. For example, with structured inquiry, the students decide which observations are most valuable, and they must interpret their data (Colburn, 2004). With guided inquiry, students select the data to record and interpret, and then design the actual procedure to answer the questions.

Lastly, open inquiry provides students almost complete ownership of their learning, in that students make the majority of decisions. Here, the teacher will instruct the students as to the general topic area to be investigated, then, the students basically complete the scientific method on their own.

According to Harwood (2004), "the activity model for the process of scientific inquiry involves ten activities to develop and carry out inquiry: ask questions, define the problem, form the question, investigate the known, articulate an expectation, carry out the study, examine the results, reflect on the findings, communicate with others, and make observations" (p. 30-31). He emphasizes that scientists move around these ten areas, repeating some of the activities, as they deem necessary. He encourages this inquiry-based model for use within the science class.

Regardless of which type of inquiry-based learning, Colburn (2004) mentions several challenges. The challenge of greatest importance was that it be important for the teacher and students to feel comfortable with the activities. Then it would be possible to shift from a more guided, or structured inquiry to a less guided, open inquiry methodology. In addition, the importance of formative assessment to aid in the transition was discussed. Overall, the use of inquiry-based teaching is to assist students to become better problem solvers, and to think more independently, therefore improving student's higher order thinking skills.

***Lab-Based Learning***

Another example of active learning is using laboratory investigations, which actively engage students with regard to problem solving. Here, students work in groups to hypothesize about a problem, design an experiment and procedure, and follow though with data collection. Then, they analyze and make conclusions. In the study by Roth and Bowen (1995), it was expressed that experiments and investigations for students not become merely exercises in data collection. Student dialogue on the results and interpretation of data obtained is critical. Analyzing and making conclusions involves higher order thinking skills.

According to Polacek and Keeling (2005), questioning, both pre-lab and post-lab, assists the student to both focus and reflect on the laboratory experiment. Experiments may include smaller, less time consuming ones or independent, more comprehensive experiments. Both can be beneficial to the student, (Polacek & Keeling, 2005). Higher order questioning that reflects the scientific process is the crucial element in both.

***Hands-On Learning***

This form of active learning also engages students actively in the learning process. According to a study by Shapiro (1999), students were immersed into true-to-life science using a Moon Base America simulation, which provided for the hands-on activities and required higher-order thinking and participant collaboration in order to problem solve.

Hands-on learning involves the use of manipulatives or models. As a form of kinesthetic type of learning, it is an integral part of science where students learn by doing. In fact, hands-on activities were given the highest ratings in a study by Bollinger (2004). The problem solving capacity of hands-on activities supports higher order thinking skill development.

***Project-Based Learning***

Another type of active learning is project-based learning. Science projects can come in various forms. Often in science there are three forms of inquiry, ranging from the discovery approach, which often consists of open-ended exploratory activities, to the verification approach, where the final result or expected outcome is communicated to the students (Colburn, 2004). Here, they collect data and verify the results. The other form of inquiry, the inquiry-based approach, can represent a range of inquiry (Colburn, 2004). According to Harada and Yoshima (2004), projects that involved the inquiry-based learning provided for a greater level of thinking and student motivation. The inquiry-based models for projects and learning engage students in higher questioning, further investigation, and generation of new questions. This form of investigation is essential for students to learn science.

According to a study by Grant and Branch (2005), the project-based investigation of middle school students presented a means for different ability students, as determined by a Multiple Intelligence Inventory, to be represented through a project. This activity was learner-centered, which used scaffolding and computer resources and tools to assist the learners in a cooperative setting.

An important aspect of project-based learning is cooperation; cooperative learning is a part of this project endeavor. Cooperative learning, which is an educational strategy, has students working actively in small groups to understand the material.

Therefore, since project-based learning engages students with the generation of questions and making connections with regard to topic, higher order thinking is involved. Students, who work in cooperative groups, apply higher order thinking skills to process information (Freedman, 1998). They do so by creating a team assessment in the form of a project, active performances and presentations. These are all forms of active learning.

In addition, as criteria for classroom student presentation, various forms of media can be utilized. According to Beeth and Huziak (2001), students utilized a journal format as a means to share their scientific inquiry of their projects with their classmates.

***Constructivist Learning***

Constructivism is an educational theory whereby the learner constructs his/her own knowledge through an active learning process, rather than passively listening and memorizing from a teacher-centered type of instruction. By nature, constructivism is more student-centered, therefore requiring students to problem solve, characteristic of higher order thinking skills. The research study by Bollinger (2004) focused on student perception of the constructivist approach to learning. The constructivist approach involves students who create solutions to questions or problems and then interpret and reflect. However, as expressed in Bollinger's study, "student-centered activities such as: discussions or group work take more time than lectures" (Bollinger, 2004, p. 119).

Survey responses in Bollinger's study (2004) were supportive of a constructivist approach for many individuals, but not all students. As a result, the issue of learning styles and individual differences was mentioned. Similarly, in a study by Lee and Fraser (2001), the least favorable scores on the Constructivist Learning Environment Survey (CLES) was apparent with the humanities students versus the science oriented or science independent groups of students. Again, the issue of learning styles could be a factor.

By nature, constructivism is more student-centered, therefore requiring students to problem solve, characteristic of higher order thinking.

***Discovery Learning***

Discovery learning, which is described by Colburn (2004) as consisting of open-ended exploratory lab activities guided only by a handful of questions and some materials from the teachers, has some support and some critics. However, the inquiry-based approach has been described by Colburn as, "the middle ground between the cookbook approach, known as verification science, and discovery learning" (p. 65).

According to Trowbridge and Bybee (1996), "Discovery is the mental process of assimilating concepts and principles. Discovery processes include: observing, classifying, measuring, predicting, describing and inferring" (p. 176). The focus is on the student, as an individual, discovering a scientific concept. According to a study by Lee and Fraser (2001), science educators are concerned about their students' understanding concepts. Because discovery is a crucial part of discovery learning, this would involve higher-order thinking.

***Student-Centered Learning***

Here, as with the other types of learning previously reviewed, the student is an active participant in the learning process. The teacher's role is one of being a facilitator in the learning process. In other words, the students have greater ownership over their own learning. If the teacher is the facilitator, not the center of instruction, more onus is on the students to think, thus fostering a higher level of thinking.

Jones-Wilson (2005) emphasizes the importance of pre-class notes or outlines as a means to assure a prepared mind before class. Her study concluded positive results in both academic performance and course evaluations by her stronger and weaker academic students. She attributed this to greater student ownership resulting from better student preparation. Facilitating students to become actively engaged in their learning is the focal point of student-centered learning. "In these inquiry situations, students learn, not only concepts and principles, but self-direction, responsibility, and social communication" (Trowbridge & Bybee, 1996, p. 177).

## Summary

Higher order thinking skills involve students utilizing the higher levels on Bloom's taxonomy, where students are able to satisfactorily demonstrate the application, analysis, synthesis, and evaluation of material versus mere retention of knowledge and comprehension of material. Through active involvement learning, students should have the means provided by the teacher to stimulate, and demonstrate the use of higher order thinking skills. These forms of active learning: inquiry-based, hands-on, project-based, discovery, and student-centered learning are collectively more student-centered rather than teacher-centered, and therefore place more responsibility on the students to be active in the learning process. By being active in the learning process there is a greater emphasis on student questioning and problem solving, which are critical to further develop higher-order thinking skills.

# METHODOLOGY

## Introduction

In my study I investigated what are the observed and reported experiences of implementing inquiry-based activities in the high school science classroom for On-Level students. Within the science classroom higher-order thinking skills are a critical aspect of learning science. Science by definition involves problem solving, and utilizing the scientific method where students need to be able to design, test and evaluate their work. Inquiry-based activities have the potential to develop students' higher-order thinking skills (Mysliwiec et al., 2005).

The types of inquiry-based activities that my study included were: problem-solving activities, laboratory activities, including a laboratory report, and a group project. Each of these activities represented structured inquiry, guided inquiry or open inquiry. The problem-solving activities that I chose for my students typified structured inquiry. The laboratory activities were mostly guided inquiry, and eventually the students progressed to a lab report, which was mostly open inquiry. The group project was also mostly open inquiry.

For the purposes of my study, structured inquiry was defined as being a procedural process. For guided inquiry, the students had more leeway with their investigations; there were more aspects that they filled in on their own with regard to the scientific method of problem-solving. For open inquiry, the students were given a topic with more freedom as how to complete the investigation.

## Setting

My study took place in an urban high school located in eastern Pennsylvania that includes diverse groups with regard to ethnicity, academics, and socio-economic status. The original building is approximately 47 years old, and has had three added wings over the past eight years due to the growing student population within the district. There are approximately 3,000 students who attend this school, and the grades that it encompasses are 9th through 12th, with 9th grade being the largest class of about 850 students.

My classroom has a total of six lab stations, which are numbered one through six, comprising a U-shaped perimeter of the room. Each station has a sink and a gas hook-up, which is centrally located on each of the large, dark-colored tables. Each lab table has 4 lab stools where the students sit to complete their inquiry-based work. The teacher desk and teacher demonstration table are located at the front of the room. Student desks are located in the middle of the classroom.

## Participants

The students that were part of my study were enrolled in the course, On-Level Earth and Space Science. The Earth and Space Science course is offered at these levels: Pre-AP, Honors, College-Preparatory, and On-Level. On-Level classes are typically comprised of students with average ability who are non-college bound. They meet six times in a six-day cycle versus eight times for the

Pre-AP and Honors classes, and seven times for the college-Preparatory classes. The class that I studied was comprised of 20 students: 19 students in the ninth grade, and one tenth grader. The number of males and females were ten for each. Two of the 20 students were retained from the previous grade for academic failure, and one of the 20 students has an individualized education program (IEP).

## Procedures

I began my study with an explanation to the entire class of the purpose and methods of my project, including the importance of informed consent (see Appendix A). This occurred within the first week of my study. Throughout my study I assessed each of the four units by using a total of 17 total graded inquiry-based activities. The activities were designed to scaffold the students through structured inquiry, guided inquiry, and eventually open inquiry. I planned to scaffold them with regard to learning the skills necessary to problem solve, learn and practice all aspects of the scientific method, and then progress to actually designing a lab report and a group project.

I assessed group participation for each unit with the use of a cooperative group assessment checklist (see Appendix B). In addition, the students were given a survey (see Appendix C) and interview (see Appendix D) to assess their feelings on learning science using inquiry-based activities versus more teacher-centered instruction. The survey was given mid-study, and the interview toward the end of my study. In this study, the students completed four units of Earth and Space Science.

***Unit 1--Introductory Unit***

The first unit covered introductory material and topics such as: science and what is involved, including specifically what comprises the study of earth and space science, using units of metric measurement, applying the scientific method, using and understanding scientific tools, and implementing laboratory safety (see Appendixes E through H).

The students worked in cooperative groups for all inquiry activities. All cooperative grouping was teacher selected, with cooperative warm-up activities completed prior to any classroom inquiry activities being initiated. Cooperative group effectiveness was formatively assessed for the effectiveness of the group. This provided the necessary feedback to support group member changes as determined by the teacher. The following are the inquiry activities implemented in this unit:

1. Activity- Introduction to Earth and Space Science
    - Structured Inquiry
2. Activity- Scientific Method
    - Guided Inquiry
3. Activity- Lab Safety
    - Structured Inquiry

4. Lab- Measurement
    - Guided Inquiry

***Unit 2--The Atmosphere***

In the second unit, the topic was the atmosphere. Students studied the different atmospheric layers, causes for wind, effects of solar heating, the various types of winds, and the hydrologic cycle. Graphing was included as a means to represent data obtained (see Appendixes I through K and Resources). The following is the list of inquiry activities included in this unit:

1. Activity- Structure of the Atmosphere
    - Structured Inquiry
2. Activity- Layers of the Atmosphere
    - Guided Inquiry
3. Lab- Measurement and Graphing
    - Guided Inquiry
4. Group Project- The Atmosphere
    - Open Inquiry
5. Lab- Solar Heating
    - Guided Inquiry

***Unit 3--Meteorology***

The first two units served as a foundation for the third unit, meteorology. In the meteorology unit, students investigated weather by making observations utilizing several meteorological tools and the school's electronic weather station. They compared data to several on-line weather sites. They interpreted and predicted weather forces and occurrences, and designed and assessed weather data collected from their own barometers (see Appendixes L through N and Resources). There were several inquiry-based activities for this unit:

1. Lab- Relative Humidity
    - Guided Inquiry
2. Lab-Weather Observations
    - Guided Inquiry
3. Activity- Interpreting Weather Maps
    - Guided Inquiry
4. Laboratory Report -Designing a Barometer
    - Open Inquiry

***Unit 4--Climatology***

Climatology is an extension from the previous units. Climate zones and their characteristics, as well as other related scientific concepts about the differences in the heating and cooling of different states of matter, the effect of altitude, wind direction, varying of solar radiation angles, and the effect of the amount of heat energy on our planet were included (see Appendix O and Resources). The following is a list of those activities incorporated in this unit:

1. Activity- Factors That Influence Climate

- Structured Inquiry

2. Activity- Climate Zones
   - Structured Inquiry
3. Lab- Cooling and Heating Rates of Land Compared to Water Surfaces
   - Guided Inquiry
4. Lab- Why is it Hotter at the Equator than at the Poles?
   - Guided Inquiry

**Data Sources**

I used a survey, field log, interview, inquiry-based graded activities, rubric for cooperative group assessments, and a rubric for the atmosphere project-based inquiry activity.

The survey had ten questions with a number rating scale from 1 to 5 where students circled the response about how they feel they learn science best. The responses on the rating scale ranged from: 1-little, or do not agree, 2-somewhat agree, 3-agree, 4-mostly agree, and 5- agree strongly (see Appendix C).

In my log, I recorded participant observations, utilizing the two-column format. The two-column format allowed me to carefully document observations on the one side, and then reflections on the other side.

Inquiry-based activities were graded for each unit. The atmosphere project, which involved a formal project presentation, was graded using a project-based rubric (see Appendix P).

Cooperative group activities were assessed formatively to measure the effectiveness of the cooperation of the group (see Appendix B).

Lastly, I interviewed each student towards the end of my study, regarding how they felt that they learned science best (see Appendix D). This interview gave me feedback as to their perception of the use of inquiry-based activities and their learning of science.

## Teacher Observations

Within the inquiry classroom, the role of the teacher as facilitator is crucial as these students often lack the self-confidence and experience to think with higher-order thinking skills. Advancing the students' level of inquiry from structured inquiry to guided inquiry, and eventually open inquiry was necessary in order to scaffold the students to successfully make the transition from problem-solving activities to completing laboratory assignments, to a laboratory report and a group project.

When students were working in their respective groups, the teacher circulated within the classroom. The circulation that I conducted was sometimes passive, where I made myself logistically available for student directed questions and concerns. I also was actively circulating to the groups as well. This meant that I would stop at each group and I would ask questions to the students in an attempt to assess their level of understanding. Often I would ask them to explain or demonstrate science techniques. This questioning afforded me the opportunity to re-teach as needed, and also emphasized to the students my sincere interest in their progress.

## Summary

In this study, On-Level ability students in a high school Earth and Space Science classroom completed four units of Earth and Space Science. I utilized three forms of inquiry-based learning, which included: structured inquiry, guided inquiry, and open inquiry. I documented the observed and reported experiences of each activity. The role of the educator was one of a facilitator, and was vital to scaffolding the students through the three types of inquiry that my study involved.

## RESEARCHER TRUSTWORTHINESS

To assure researcher trustworthiness in my action research study there were several points that I had to consider. The following are the areas that I considered to assure researcher trustworthiness.

I obtained the appropriate permission to perform this action research study from my building Principal (see Appendix Q). I also received the appropriate approval of Moravian College's Human Subjects Internal Review Board (see Appendix R). Then, I explained the study to my students, reminding them that they could withdraw from the study at anytime without any penalty. An informed consent was obtained on all student participants prior to me beginning my investigation. The informed consent was signed by their respective parent or guardian allowing me to utilize the data obtained for my study (MacLean & Mohr, 1999). These consents, and the inclusion of making the children partners in my study, fostered a relationship of trust throughout my study (MacLean & Mohr, 1999).

For my research study I collected data from the end of August through mid-December. I used a log, as explained in MacLean and Mohr (1999), to record my data. When I recorded in my log, I ensured anonymity of all students; I did this by using pseudonyms and excluding student names from the study. In addition, I kept all research materials locked up in a secure location when not being used, to assure confidentiality. All data were destroyed at the conclusion of my study.

I triangulated the data, as expressed in Holly, Arhar, and Kasten (2005). This meant that I used at least three different kinds of data to support my conclusion. This included observations in my two-column field log, a formal and informal student interview, a survey, and student work.

I was self-reflective as to the data that I obtained (Holly, Arhar, & Kasten, 2005). In addition, I shared these data with my teacher inquiry group and we assessed my interpretation of these data (MacLean & Mohr, 1999). We also discussed possible biases related to my study. My biases include: my strong belief that inquiry-based activities will motivate all students to learn, including On-Level students, and that inquiry-based activities will facilitate learning and develop higher order thinking skills.

I also made my students active participants in this study. I explained the study to the students, reminding them that they could withdraw from the study at anytime without any penalty.

These were the guidelines that I followed to ensure trustworthiness in my study.

## MY STORY

My story begins on August 23rd, 2006. This was the first day of school for the new school year, and I met the students that I would be responsible for educating this year. The first day of school has always been exciting for me. I view the beginning of the new school year as a new beginning, even after 18 years of teaching. I was finally able to see for the first time the faces that went with the names that I had received on a roster during the previous days of in-service. New beginnings, I have often felt were important, building from the old, but always building, improving, and making things better. I have always had a desire to educate all students.

### Introductions

Three school days after the first day of school, I explained to my students the purpose of my study. I distributed the parental consent form to my students, and reminded them that I needed parental permission to include their data results. I assured the students that I would not be using their name, but a pseudonym. I encouraged questions, and there were none. They appeared to be listening; they were making good eye contact, but they were quiet.

### Cooperative Lab Group Warm-Up

After the introduction to my study, I continued my lesson. I was going to have the students meet their cooperative lab group. I had the students count off by sixes until every lab group station had 3-4 students. After the groups were formed, I had the students complete a warm-up activity where they interviewed and then introduced a lab group member to the class. I provided the groups with three good interview questions that they could use, and encouraged them to think of others. The students really seemed to enjoy and appreciate the activity, as it gave the students a chance to get to know each other before we started any science-inquiry activities, and most not only used the three lead questions that I provided, but also came up with others. The groups and their members included:

- **Lab Group 1-** Kurt, Kim, Matt, and Alex
- **Lab Group 2-** Jackie, Amy and Lisa
- **Lab Group 3-** Harry, Jenna, Will, and Ralph
- **Lab Group 4-** Rick, Stacey and Jill
- **Lab Group 5-** Katie, Sara, and Tim
- **Lab Group 6-** Alice, Sam, and Keith

## First Inquiry-Based Activity--Gaining Their Trust

The groups had been established, and had a chance to get to know one another; it was now time for the first inquiry-based activity, which was entitled, Introduction to Earth and Space Science Activity. This inquiry activity was a structured inquiry activity. We previewed the directions together; students were to pretend that they were Earth Scientists and they had the job of teaching others about Earth and Space Science. They were to brainstorm and record a description of the major areas that Earth and Space Science encompasses. Each member had to design a mini-poster to depict their individual ideas, which would then be taped together within the group to make one large group poster. They also had to share their ideas with the class. I circulated and stopped at each lab station, setting my routine for observing. A few questions arose regarding them having to speak to the class.

**Rick:** I don't know if I can do that. I don't like to talk in front of other people.

**Alice:** (with some apprehension noted in her voice) We have to talk?

I reassured them that the talking was informal; that they would be able to do what was required provided they completed the work. I observed students nodding their heads, demonstrating signs of approval, and a greater level of comfort. Each group was able to report their findings, as I provided each group with a lead question from their inquiry-based activity, and they all completed the activity satisfactorily. For several, their success with this activity seemed to rely on the reassurances I provided them. This reassurance in turn helped build their trust in the classroom.

## Scientific Method Group Activity

I assigned the group inquiry activity on the Scientific Method. This activity was a guided inquiry activity, but still required a considerable amount of teacher prompting, as it was their second inquiry activity. I wanted them to be exposed to a progression of inquiry thinking, but remain motivated and not become overwhelmed.

Similar to the Introductory Earth and Space Science Activity, the students had been prompted to pretend that they were scientists. Thinking like scientists as a cooperative group, they had to logically problem-solve, utilizing the scientific method to solve a related earth science problem related to erosional forces. They were being asked to formulate the hypothetical pieces of the scientific method for a specifically assigned problem.

I circulated among the groups and helped each group to decide on how to form a question or problem, based on the situation given. The groups collectively did well; they seemed to benefit from the guidance I was able to provide the group upon circulating.

**Jenna:** I don't know what you want for the problem. (The other group members were also collectively nodding their heads or replying in agreement with Jenna their lack of understanding as well).

**Teacher:** (Directing the question to Jenna, but also looking at the other group members as I responded) Well, let's look at the description of the situation given. (I read it through slowly to them, and I was about to ask, how can we phrase that as a question, or something we want to solve, when another group member contributed almost immediately).

**Will:** Do you mean saying something like, how can erosion be lessened?

**Teacher:** What do the rest of you think? Does Will pose a question that relates to the situation?

**Ralph:** Yeah, that sounds like what you mean.

**Jenna:** Yeah, but we should say something about it being a hillside, right?

**Teacher:** Try it.  Like?

**Will:** How about, how can erosion on a hillside be lessened?

**Teacher:** Boy, you guys are really thinking like a scientist.  Now, what's the next step?

**Ralph:** It's the hypothesis.

**Teacher:** Right, now remember, a hypothesis is your answer to the problem.  Try it, keep going!

At this point they had been guided and felt some confidence with the progress that they had made.  I moved to another group with the same purposeful desire to facilitate the group's understanding.  However, before moving onto another group, I knew that this group was motivated to take the next step on their own.  Similar experiences with the other groups were prevalent.

**Sara:** Does this look like a good problem? (She asked me when I got to her lab station, as she was pointing to her sheet.)

**Teacher:** (Looking at Sara, but also the rest of the group members, as it was obvious they all had the same question, I responded).   Does your problem focus on the situation given, and put it into a question?

**Sara:** Yeah it does.  (The others also nodded their heads in agreement).

**Teacher:** You guys are doing great, did you think of a hypothesis?

**Tim:** Yes, look what we came up with. (He was excited, you could tell by his voice inflection).

**Teacher:** Looks great! You guys are thinking; nice job, keep going.

**Active Participants**

Wow! It is only a few days after distributing the consent forms, and many of the students have already turned them in.  They remembered, and they seemed excited; they were going to be an active part of my study, and the class as well.

After reviewing the class agenda as I normally do at the beginning of each class period by reviewing the class goals, homework assignments, and any other announcements, I instructed the students to return their lab groups and continue with their Scientific Method Group Activity.  The students seemed to be really interested in the activity, taking it seriously.  I circulated to all groups, to initiate where needed, or be available for their specific questions.

**Group 6** was talking about trees helping the soil.

**Group 1** was discussing mudslides.  They were on topic.

**Groups 1, 2, 4, and 5** needed re-phrasing of definitions.  For example, for the definition of hypothesis, many of the students at some time in their schooling have memorized the definition as being an educated guess.  However, if asked to explain what that means, they were not certain; they just give a blank stare.  I told many of the groups, a hypothesis is a suggested answer to a problem. When re-phrased like that, they were able to understand that prompt, and could then figure out the question, or problem that they needed to ask, and then responded with their suggested answer, their hypothesis. In fact, I witnessed that the re-phrasing seemed to help them to help themselves. They were being connected to their comfort level of understanding; educational philosophers would consider this scaffolding.

**Kurt:** Oh, I get it!

**Jill:** Thanks for helping me.

**Jackie**: That' s easy.

**Katie:** That makes sense.

## Lab Safety Group Activity

I assigned a group activity on lab safety. This required the students to construct a mini-poster and verbally share with the class the ideas of each member of the group. This activity was set up similarly to the Introduction to Earth and Space Science activity, and was a structured inquiry activity. Basic skills were therefore reinforced in anticipation for more advanced forms of inquiry that would come later. Prior to beginning this activity, there was a brief discussion on the importance of laboratory safety. The students seemed attentive to the introduction as they would soon be scientists and complete laboratory experiments. To assist the students in this endeavor, the students were provided with several safety review handouts, a sheet describing my expectations for the activity, and a brief review of the activity with regard to the materials, including helpful textbook reference pages and other supplies that would be needed, such as: colored pencils, paper and tape.  The students seemed to enjoy this activity.

## Student Work Sample

**EARTH AND SPACE SCIENCE**

**Lab Safety Activity**

**Directions-** Within your group, each member should sketch on the paper provided a picture depicting a laboratory safety rule. Beneath the picture, the rule should be written. Collectively, all individual sketches will be joined to make one group poster. Each member of the group will explain his/her different rule in a brief sharing with the entire class. Everyone will submit this sheet at the end of the group "mini" presentation.

- Be creative
- Use colored pencils/markers
- Use tape/glue to adhere all "mini" posters into one big one
- Use text
- Use computer
- Speak loudly when explaining your lab safety rule

**Group Members-** Record names of people in your group and safety rule each person will address.

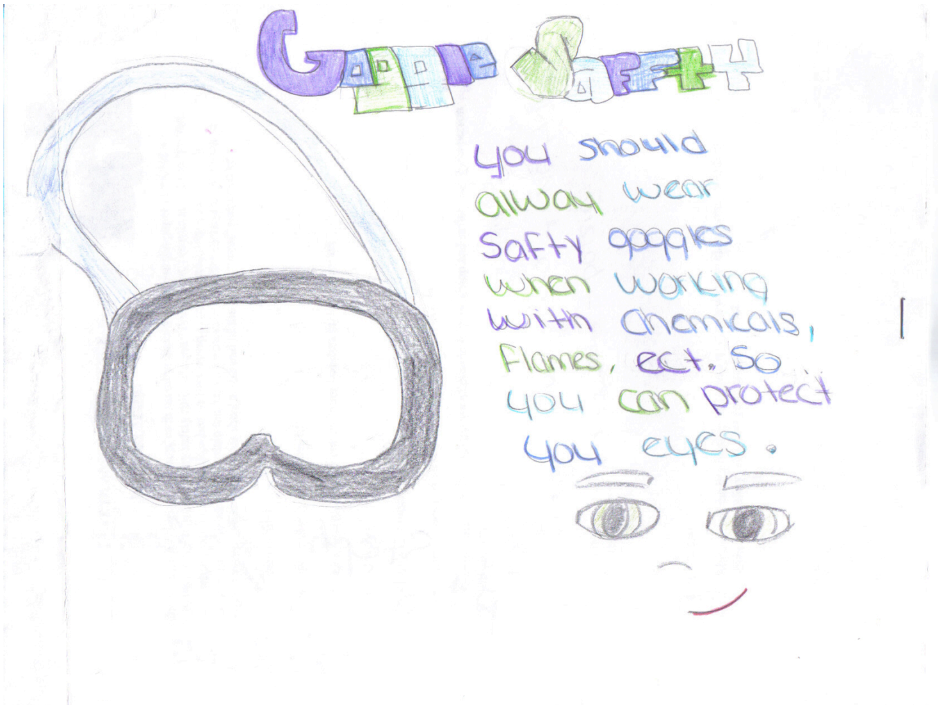
1. [redacted] - Dress Code
2. [redacted] using sharp instr
3. [redacted] - heating & fire safety
4.

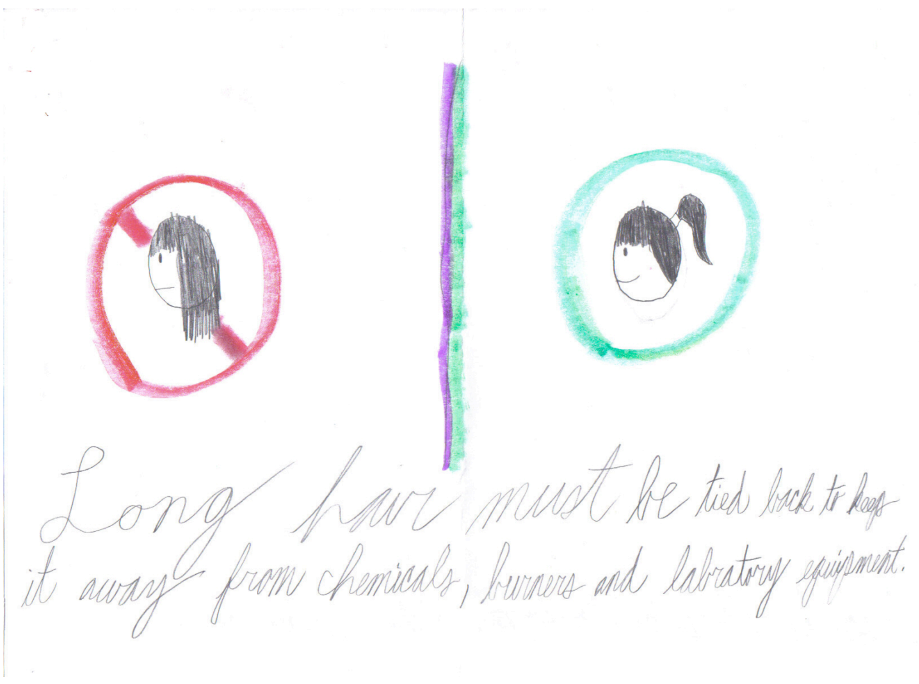
**Conclusion-**

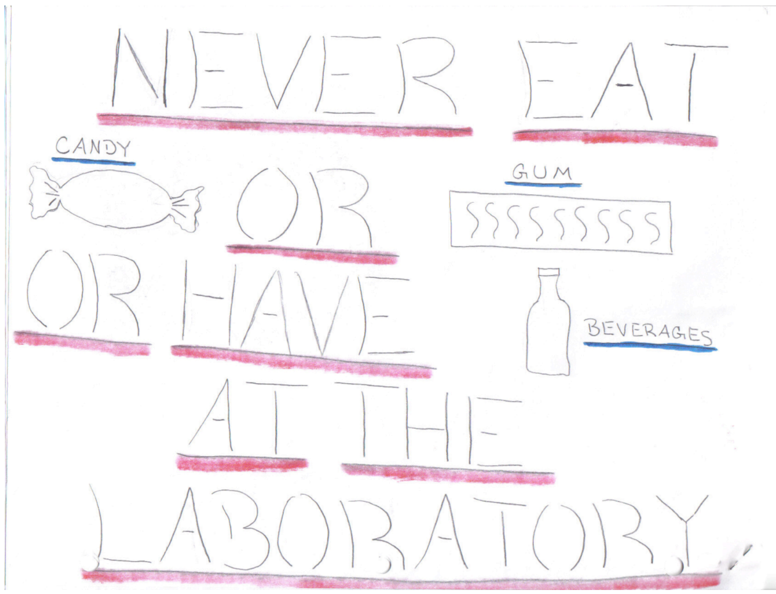
1. Summarize the importance of Laboratory Safety in the classroom. Mention several lab safety rules that your group covered.

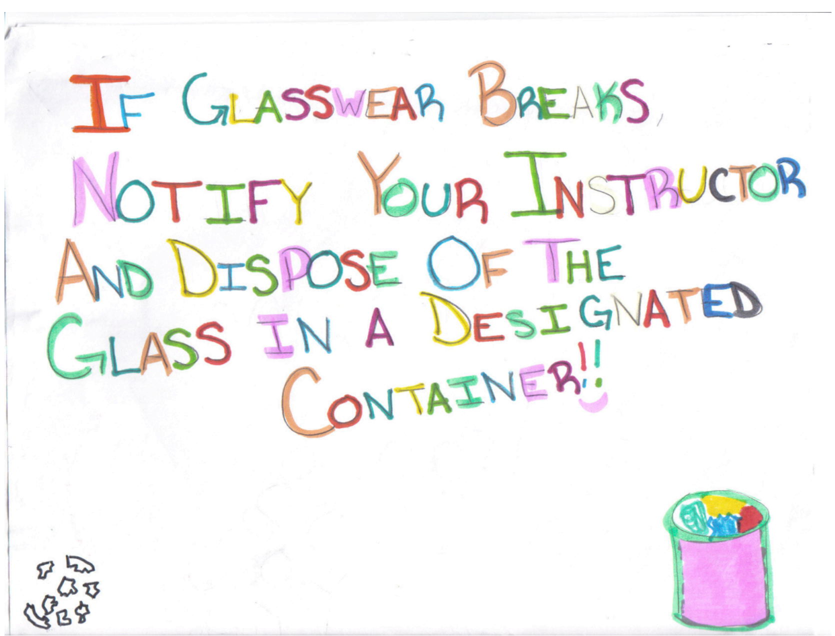
Why it's important to be safe and follow safety rules, because if you don't you could get seriously hurt, or you could explod something very dangerous.

*Figure 1.* Lab Safety Group Activity


Goggle Saffty
you should
allway wear
Safty goggles
when working
with chemicals,
Flames, ect. So
you can protect
you eyes.


Long hair must be tied back to keep
it away from chemicals, burners and laboratory equipment.


NEVER EAT
CANDY
OR
GUM
OR HAVE
BEVERAGES
AT THE
LABORATORY


IF GLASSWEAR BREAKS,
NOTIFY YOUR INSTRUCTOR
AND DISPOSE OF THE
GLASS IN A DESIGNATED
CONTAINER!!

I believe this activity provided a means for students to express themselves creatively. Providing the students with the scaffolding of information and specific tools necessary to complete the activity seemed to foster their understanding. There was less apprehension and fewer basic questions, as compared to the first inquiry activity. The transfer of knowledge and a greater self-confidence was apparent.

**Lab Measurement**

I assigned a group laboratory activity, which required the students to make several metric measurements and conversions of length and mass. In addition, the students were to analyze and draw conclusions on the meaning of the data obtained. This activity was a guided inquiry activity. Prior to beginning this lab activity, I reviewed with the students the basic definitions, importance, and understanding of making mathematical conversions for the units. The students were paying attention; there were no distractions, eye contact was good, and several students answered questions. After reviewing the location and how to use the tools necessary for this lab, I instructed the students to report to their lab groups and begin working.

I circulated to each lab station/group, having students demonstrate for me how to use the balance and ruler. This personal attention seemed to comfort them, reassuring them that I am approachable, and want them to do well. Their questions were very basic.

**Alex:** How do you read this? (He was pointing at the balance).

**Teacher:** Well Alex, what do we want to do?

**Alex:** We need to put the item in balance, so then doesn't the needle need to be pointing to zero, in the middle?

**Teacher:** Yes, you are right. So show me how to turn the knob, and then read it.

**Alex:** How's that? (He turned the knob, and the needle was pointing to zero).

**Teacher:** Very good Alex, now how do you think you read it? Show me.

**Alex:** Well, is it two and a half?

**Teacher:** Well, what do you guys think? (I looked at the other members of Alex's group).

**Kurt:** I don't know.

**Kim:** I'm not sure either.

**Matt:** Yeah, how would that be read?

**Teacher:** How about reading it the other way, in other words, if it lines up at beyond four, and it is six lines beyond four, how do you think we would read that?

**Kim:** How about 4.6?

**Teacher:** Good job! What units are you going to use?

**Kurt:** I know, it would be grams! (He said this with such excitement in his voice).

**Teacher:** Excellent! Now, what if I turn the knob like…how would you read it now? (I turned the knob so it was on 8.2 grams).

**Matt:** Oh I get it, would that be 8.2 grams?

**Teacher:** Excellent! Now you got it!

This group had been satisfactorily able to work through their questions with my facilitation. I was then able to progress to other groups who had similar questions.

**Teacher:** Amy, hi, how are you making out with that ruler?

**Amy:** I'm okay.

**Teacher:** Good. How are you reading that?

**Amy:** Well, (a long pause). I'm really not sure.

**Teacher:** Okay. Well, tell me, we are thinking like a scientist so, what kind of units do they use, English or metric?

**Amy:** Metric?

**Teacher:** You are right! Scientists use metric units. Now, show me how you would read this. (I had her measure the length of her pencil).

**Amy:** Is it fourteen?

**Teacher:** Well, you are close. But, if you look closely it extends beyond the fourteen. Count how many lines beyond the fourteen that it goes.

**Amy:** It looks like three.

**Teacher:** Lisa, what do you think? (Lisa, a lab group member was looking intensely).

**Lisa:** It looks like three lines to me too. So, how would you read that?

**Teacher:** Well, what do you think?

**Jackie:** Would it be fourteen point three?

**Teacher:** Amy, Lisa, what do you think?

**Amy:** I think that sounds right.

**Lisa:** Yeah, it should be fourteen point three, and it is in centimeters, right?

**Teacher:** Good job girls, you did it!

This purposeful assessment, involving probing questions, and the demonstration of their skills, was critical for them to be prepared for more involved inquiry lab work that I had planned for them to accomplish later.

The students initially seemed frustrated and were functioning with lower level thinking, just desiring to learn how to use the balance, not concerned yet with what the results meant. They collectively seemed to gain confidence with mastering the basics first. I focused on having the students make calculations correctly, using the appropriate tools. They would need more time to work. The higher-order thinking, the analysis and conclusions of the data, would have to come after mastering the basics.

## Students Gaining Confidence

The Measurement Lab was concluded the next day. This day went smoother than the first day when the students first began. Most students were more confident with the balances and rulers this time, but some asked to be shown again. The students who needed reinforcement from the day before were all able to demonstrate understanding satisfactorily after I reviewed and demonstrated again. Today, after completing the beginning sections of the lab, they were able to advance to address the analysis and conclusion questions. The students had gained confidence through first grappling with the lab, and knowing that I would be available to help them master the basics before moving on to the more complicated tasks of the lab activity.

## Structure of the Atmosphere Group Activity

I assigned a group activity on the structure of the atmosphere. This structured inquiry activity required the students to act like scientists by collecting background research on the structure of our atmosphere. The background research was then to be incorporated into a labeled sketch, including common items located at each layer and a written explanation of each layer. Similar to the other activities completed previously, the students were responsible to share their findings with each other and then as a group to the entire class.

Prior to beginning, I discussed with my students the basic concept of layers each with a specific function existing to collectively comprise what is known as our atmosphere. Students were attentive. I asked the students to report to their groups, and I circulated. Questions arose:

**Rick:** Do I write down heights? (I reviewed the directions with him and his group, Group 4, and they followed through correctly).

**Jenna:** Do we need to use color? (Jenna asked the question, but the others in her group, Group 3 were attentive to my response).

**Jenna:** Okay, we thought so, but we just wanted to check.

The students seemed comforted knowing that I would be there if they had questions. They were being assured by my actions that I would circulate while they worked, thus providing them the reassurance to help build their confidence in me, and hopefully themselves.

**Layers of the Atmosphere Group Activity**

I assigned a group inquiry activity on the layers of the atmosphere. This activity was a guided inquiry activity, which required the students to graph specific data as related to the layers of the atmosphere. In addition, they had to analyze and draw conclusions on the data that was included in their graph. Each student was to submit a completed graph and answers to the questions. However, like the other activities, they were to discuss with each other any progress made or questions as they arose. This guided inquiry activity was designed to purposefully have them focus on certain aspects of the scientific method; analysis of graphed data, and drawing conclusions on that data.

Prior to beginning this inquiry activity, I emphasized that the purpose of this graphing activity was to assist them in making connections between temperature and altitude changes. I reviewed the importance of using pencil with graphs, and reviewed the basics with the class regarding the x- and y-axis and plotting points. I reminded the class that I would be around to each lab group to help them if they had specific questions. As I circulated these questions were asked.

**Jackie, from group 2**, asked a question regarding how to plot the points. I showed her one, and then had her show me how to do the next two. She was successful.

**Harry, from group 3,** was not engaged on topic. I went to his lab group and asked him to show me how he would locate the points. He was not certain. I circled what each axis was labeled, altitude (y-axis), and temperature (x-axis). He had some confusion with regard to the altitude at 0 level. I showed him how to correctly figure this elevation, but then had him demonstrate how to graph the second set. He demonstrated these correctly.

**Groups 4 and 5** needed to be shown one example and then they were fine doing the rest themselves correctly.

Students, with some scaffolding, were able to correctly graph and label the layers of the atmosphere in this activity. However, they seemed to hesitate with regard to the analysis questions. Perhaps they needed more scaffolding concerning this area.

**Measurement and Graphing Lab**

Knowing that the students required more scaffolding in analyzing the data from a graph, I assigned an activity specifically on measurement and graphing. In addition to obtaining more graphing practice, they would also have to analyze and make conclusions on the data obtained. In addition, this guided inquiry lab activity would help reinforce their measurement skills of using a ruler and balance correctly and then make accurate conversions within the metric system. These were all skills that they needed to master before advancing on to other lab activities requiring a greater synthesis of information.

Prior to beginning this activity, I reminded the students of the importance of thinking like a scientist regarding the maintenance of good data collection, graphing carefully, and then analyzing and drawing conclusions on this data. I reminded the students that they would be doing many more of these types of scientific activities. I reminded my students that I would be around to each group, or to come to me if I did not see their hand. I circulated.

**Rick:** I need some help with how to read this. He was pointing to the balance.

**Teacher:** Read it and tell me. (He read it correctly, and I praised him. He smiled).

**Rick:** Thanks.

This motivational praise seemed to give him more self-confidence.

**Harry:** I need help too. (He was pointing towards the balance).

**Teacher:** Show me.

He tried and read the dial incorrectly, so I explained it and he was then able to correctly demonstrate how to use the balance. Having the students demonstrate, not just explain, really makes them accountable.

**Lisa:** Are we reading the ruler correctly? (I reviewed it with her).

**Lisa:** Thanks, I just wasn't sure.

**Tim and Katie**: We're not sure if we read the balance correctly; could you check what we wrote? (They were correct; they just lacked the self-confidence, and needed reinforcement).

**Teacher:** Great job! You did it!

The students seemed to enjoy being asked to think like a scientist. I believe it fosters a greater self-worth; they feel that they are important because they are asked and expected to do real science. The students needed more reinforcement than I anticipated for this activity, but were able to advance to the higher order questions of analysis and conclusions for their data; the added reinforcement was essential to their progress.

## The Group Atmosphere Project

I assigned a group project on topics related to the atmosphere. This required the students as a group to research an assigned topic and then organize an oral presentation utilizing various visuals. Each group would be required to teach the class in about five to ten minutes the topic they were responsible for. The topic possibilities included: Daily Winds, Seasonal Winds, Global winds, High Altitude Winds, Synopsis of the Layers of the Atmosphere, and the Hydrologic Cycle. Since this activity was more open-ended, I classified it as an open inquiry activity.

Prior to beginning this project, I explained to the students that I would begin each class period for the next few weeks discussing each of the assigned topics. I informed them that I would be providing them with some introductory notes, but that it was their job to research more, and present what they learned in an understandable manner to their classmates. I reminded the students that after each presentation, the class should ask questions about the material to assure their understanding.

The next two weeks proved interesting. After teaching the basics on each topic everyday, I would remind the class daily what they should get accomplished. These prompts, in addition to a few minor behavioral prompts, seemed to keep the class focused and on task. Thus, the students were largely productive regarding the construction of their Group Project. I observed that as I would discuss each topic daily, prior to the students having group time to work on their project, the students were attentive; they had a vested interest in learning about their topic, and the other topics that other students would be teaching the entire class soon. Their interest was sparked. Finally, at the conclusion of the two-week time frame, the students presented their findings. The class required two days to enable all groups to present. All projects were assessed using the Rubric for Group Presentations (see Appendix P). Overall, the students performed well, and it was a positive educational experience.

**Solar Heating Lab**

Thus far, my students have completed several group activities, structured labs, and a large group project, but this lab activity was going to be a leap. Hopefully, I had scaffolded them enough to succeed, because this inquiry activity was going to build on all of the previous activities; it was a more involved lab, but still required the students to complete certain unfinished parts, thus a guided inquiry activity. Even though the lab had an established structure, the students had to address all aspects of the scientific method. I would still be circulating to guide them as needed. Prior to beginning, I handed out all of the pages of the lab, and instructed the students to read the pre-lab by themselves and answer the questions associated with that part. I reviewed with the students the problem that they would be investigating, and prompted them with, "What comes after the problem in the scientific method? I was pleased there were many hands were up.

**Keith:** The hypothesis.

**Teacher:** Good, and what is the hypothesis?

**Alice:** It's an educated guess.

**Teacher:** Good, that's correct, so after reading the information in the pre-lab, and from what we have learned so far, you are a bit more educated. Now, you can formulate a hypothesis, a suggested answer to the problem, which is educated. You are now scientists, you must think like they do.

This reminder for them to think like a scientist, as seen with previous activities, seemed to help them focus, and perhaps motivated them because they felt like a real scientist. I directed the students to report to their lab groups.

I asked the students to read over the lab procedure and materials list when they were done with the pre-lab. I circulated, when it looked as if all were done with page 1, and were beginning to look at page 2, I instructed them to find their observation data chart. I reviewed the importance of accurate measurement, and following the experimental procedure carefully. The students maintained good eye contact; they were listening, and interested. They were following along, so I pushed onward and asked, "Does this lab tell us what the constants are?" A few hands went up.

**Kurt:** How about the light wattage?

**Teacher:** Yes, good job.

**Teacher:** How about another?

**Jill:** How about where our lab station is located?

**Katie:** Oh yeah, that's true.

**Teacher:** Good, keep going.

There was a long pause, so I said, "How about the distance from the light source to the containers?" I heard several students, almost collectively say, "True", " That's a good one", or some similar comment. They had made the correct connections thus far; they were underway. I directed them to continue onward together. Remarkably, they engaged the task with only minor difficulties. Most of these were with regard to assuring the constants in the experiment were accurately maintained and documented. I had scaffolded them to undertake such an endeavor, and do it successfully.

**Student Work**

Name [redacted] Date 10-13-06 Class Period 5

LAB 10 LABORATORY INVESTIGATION

## Solar Heating

### ◆ Pre-Lab Discussion

It has been estimated that 1,000 times more energy reaches Earth's surface from the sun each year than could be produced by burning all the fossil fuels mined and extracted during that year. Imagine if people could use even a small fraction of that solar energy; many of our resource and pollution problems would be solved!

The idea of using the sun's energy is not new. Many ancient peoples used solar energy for heating their homes, including the Egyptians, the Greeks, the Romans, and Native Americans. These peoples built their homes facing the south or southwest, where the sun is located in the sky most often in the Northern Hemisphere. This passive solar-heating system, in which sunlight heats an area, is used today to provide renewable, nonpolluting energy. But the sun is not always shining, so the sun's heat must be collected and stored for later use during the night and on cloudy days. This task is usually part of an active solar-heating system, in which solar energy is collected and distributed throughout a building using fans and pumps.

Solar collectors are used to absorb and collect solar energy. A solar collector is basically a box mounted on a roof. The box is covered with a material that absorbs the sun's energy. This energy transfers to air or water in the box and moves into the building where it can be used. In this investigation, you will discover how the color of an object affects the amount of solar energy it absorbs.

**1.** What forms of energy are constantly given off from the sun?

Solar energy.

**2.** What is the difference between a passive solar-heating system and an active solar-heating system?

Passive solar heating means sunlight is heating an area to provide renewable, nonpolluting energy. Active Solar is Collecting energy and distributing it throughout a building.

### ◆ Problem

How does the color of an object affect the amount of solar energy it absorbs?

The color affects alot. Darker colors will absorb more energy then lighter colors.





*Figure 2.* Sample Solar Heating Lab

Name ______________________ Date __________ Class ______________

**SOLAR HEATING** *(continued)*

## ◆ Materials *(per group)*

~~black and white construction paper~~
~~tape~~
~~scissors~~
2 metal or plastic containers with plastic lids
2 thermometers
tongs or gloves
clock or watch
colored pens or pencils

## ◆ Safety *Review the safety guidelines in the front of your lab book.*

Be careful when using scissors.

## ◆ Procedure

1. Tape two layers of black paper completely around one container. Also tape two layers of black paper over one of the lids. Keep the edge of the lid paper-free so that it will fit on the can. Tape two layers of white paper completely around the other container. Cover its lid with two layers of white paper.
2. Using scissors, carefully punch a small hole through the center of each lid. Each hole should be just large enough to hold a thermometer.
3. Cover each container with its plastic lid of the same color. Place the containers on a sunny windowsill.
4. Carefully insert a thermometer through the hole in each lid as shown in Figure 1. Make sure the bulb of the thermometer is near but not touching the bottom of the container.
5. Record the temperature of the air in each container every 3 minutes for 30 minutes. Record your data in the Data Table. Then answer the questions in Observations.
6. Use the graph paper on page 45 to make a graph of your data. Plot temperature on the vertical axis and time on the horizontal axis.

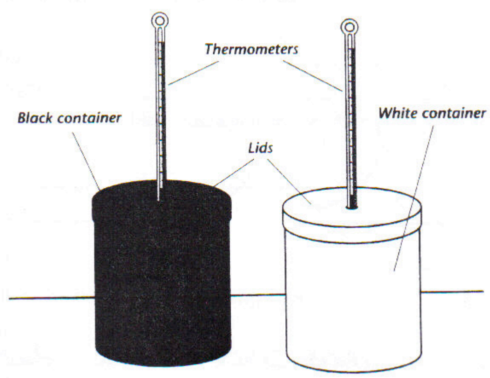



**Figure 1**

Name ______________________ Date __________ Class ______________

## SOLAR HEATING *(continued)*

### ◆ Observations

**Data Table**

| Time (min) | Temperature in Black Container (°C) | Temperature in White Container (°C) |
|---|---|---|
| 0 (off) | 28°C | 24°C |
| 3 | 31° C | 24°C |
| 6 | 35 °C | 25 °C |
| 9 | 36 °C | 26 °C |
| 12 | 38 °C | 26 °C |
| ~~15~~ | ~~°C~~ | ~~°C~~ |
| ~~18~~ | ~~°C~~ | ~~°C~~ |
| ~~21~~ | ~~°C~~ | ~~°C~~ |
| ~~24~~ | ~~°C~~ | ~~°C~~ |
| ~~27~~ | ~~°C~~ | ~~°C~~ |
| ~~30~~ | ~~°C~~ | ~~°C~~ |

~~constance~~

Constants:

#1 of lab Station

Watt of light bulb: #200

distance from light: 20cm

1. During which time interval did the temperature in the black container begin to rise? During which time interval did the temperature in the white container begin to rise?

   Black: 3 min

   White: 6 min

2. What was the final temperature of the air in the black container? In the white container?

   38° C

### ◆ Analyze and Conclude

1. Did the color of the containers affect the amount of solar energy they absorbed? Explain your answer.

   Yes, the black container was hotter then the white.

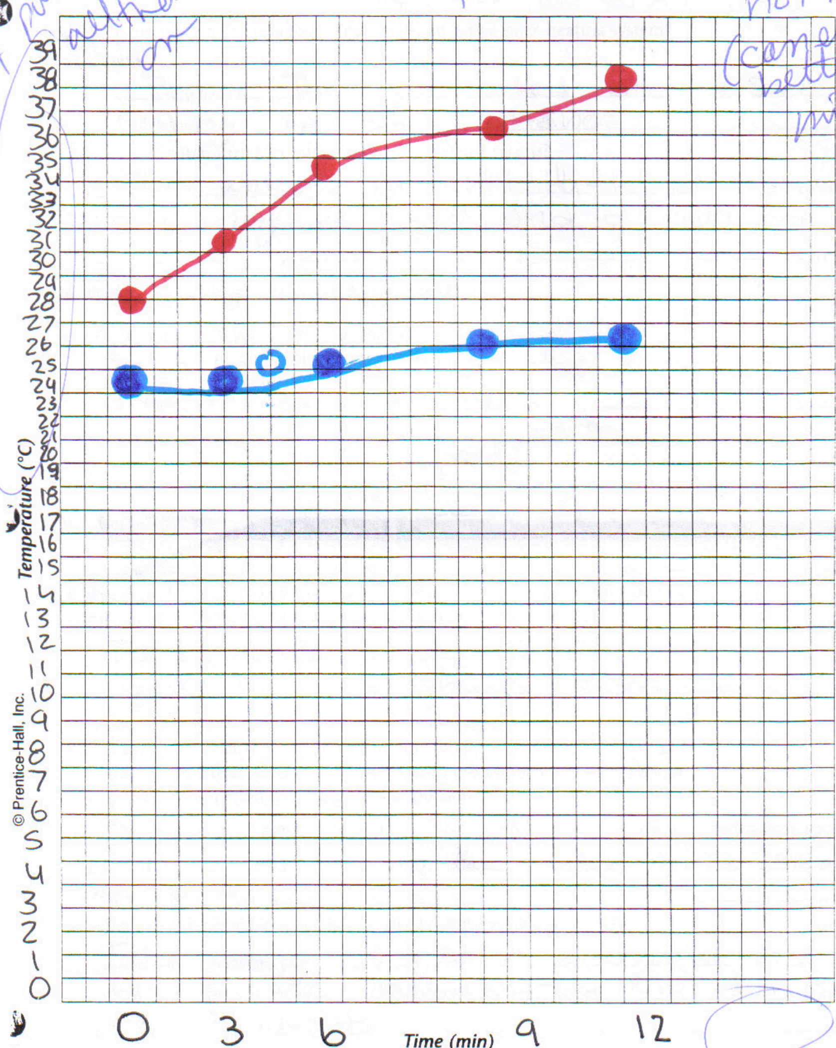
Name -2 Date Class

**SOLAR HEATING** *(continued)*

title? -2

* use colored pencils not markers (can erase better w/ mistakes)

Do not put all these on






: Black temp.

: ~~Red~~ Temp.
White

Name ____________________ Date ________ Class __________

## SOLAR HEATING *(continued)*

**2.** Did your experiment represent a passive or an active solar-heating system? Explain.

Passive. The light acted as the sun heating the black container.

**3.** What additional variables might have affected your results?

The wattage of light bulb, the lab stations, positioning of light and distance from light.

### ◆ Critical Thinking and Applications

**1.** Why was it important that both containers be the same size?

So they both have the same amount of air heating.

**2.** How would this system need to be modified if it were to be used to heat a home?

You would need to have a much bigger lightbulb.

**3.** Based on the results of this experiment, what color clothing would best help you stay warm in the winter? Cool in the summer? Explain.

Dark colors in the winter.
Light colors in the summer.

**4.** In what other situations would you be able to apply the knowledge you gained in this investigation? Consider surfaces used both indoors and outdoors, in which heat absorption or reflection is important.

You could use this for things like knowing how to dress in the seasons; winter, summer, spring, fall.

**5.** What are some advantages of solar energy compared with fossil fuels?

Solar energy is a safer alternative and better for the inviroment. The fossil fuels won't last forever too.

## Mid-Study Cooperative Group Progress

All of the inquiry activities completed for units 1 and 2 involved students working cooperatively within assigned laboratory groups. As the students would work in their groups I would assess them formatively regarding four specific areas. These areas of assessment included: Work Habits, Persistence, Study Habits, and Social Skills. The three levels used on the rubric to represent student progress include: Frequently, Sometimes, and Not Yet. For each activity I assessed the progress of two groups. Therefore, at this point all of the groups have been observed a minimum of three times. The following table represents each group's overall progress for the duration of Units 1 and 2. The labels: Frequently, Sometimes, and Not Yet are rubric labels used to represent student performance at the time of the formative assessment.

Table 1

*Cooperative Group Assessment for Units 1 and 2*

| | | | |
|---|---|---|---|
| | | **Group 1** | |
| **Kurt** | Not Yet | Sometimes | Sometimes |
| **Kim** | Frequently | Frequently | Frequently |
| **Matt** | Sometimes | Sometimes | Frequently |
| **Alex** | Sometimes | Sometimes | Sometimes |
| | | **Group 2** | |
| **Jackie** | Not Yet | Sometimes | Sometimes |
| **Amy** | Sometimes | Sometimes | Sometimes |
| **Lisa** | Sometimes | Sometimes | Frequently |
| | | **Group 3** | |
| **Harry** | Not Yet | Not Yet | Sometimes |
| **Jenna** | Sometimes | Sometimes | Sometimes |
| **Will** | Not Yet | Sometimes | Sometimes |
| **Ralph** | Sometimes | Frequently | Frequently |
| | | **Group 4** | |
| **Rick** | Not Yet | Not Yet | Not Yet |
| **Stacey** | Frequently | Sometimes | Frequently |
| **Jill** | Sometimes | Sometimes | Sometimes |
| | | **Group 5** | |
| **Katie** | Frequently | Sometiems | Frequently |
| **Sara** | Sometimes | Sometiems | Frequently |
| **Tim** | Sometimes | Sometimes | Sometimes |
| | | **Group 6** | |
| **Alice** | Sometimes | Sometimes | Sometimes |
| **Sam** | Not Yet | Sometimes | Sometimes |
| **Keith** | Sometimes | Sometimes | Sometimes |

Certain group changes were implemented as related to the formative assessments performed and behavioral concerns regarding certain students, therefore attempting to improve overall group performance. Through careful monitoring, both Rick and Harry were told to work by themselves until behavioral changes were improved. Within one activity they both had improved. In fact, both requested to return to a group setting. They were returned and the group performance was not compromised. The following is a list of the new Groups:

- **Lab Group 1-** Kurt, Kim, Jill, and Alex
- **Lab Group 2-** Jackie, Amy, and Lisa
- **Lab Group 3-** Harry, Will, and Ralph
- **Lab Group 4-** Rick, Stacey, and Matt
- **Lab Group 5-** Katie, Sara, and Tim
- **Lab Group 6-** Alice, Sam, Keith, and Jenna

Notice that there were no changes made to groups 2 and 4. They were considered strong groups according to the rubric checklist, and there were no noted behavioral problems or switches made utilizing these two groups. In fact, I felt that any change to these two groups would jeopardize the quality the group had achieved.

**Relative Humidity Lab**

The students have completed two units of Earth and Space Science, and are ready to progress to the third unit, Meteorology. I assigned a laboratory activity on Relative Humidity. This was a guided inquiry activity, which required that the students use the scientific method to formulate a problem, hypothesis, variables, and a materials and procedure list. In addition, they had to make calculations as specified in the data chart provided. Then they had to analyze and draw conclusions on the data.

Prior to beginning this laboratory activity, I had a discussion with the class on what comprised the study of weather, of which relative humidity is instrumental. The students seemed interested in the topic of weather; there was a lot of participation. After distributing the lab sheet, I previewed the directions and the Pre-Lab section with the class. Similar to previous activities, they were directed within this activity and reminded by me verbally to "think like a scientist." They were instructed to report to their lab groups, and I circulated.

**Student Sample Lab**

[redacted]

**EARTH AND SPACE SCIENCE**
**RELATIVE HUMIDITY LAB**

DIRECTIONS- In your lab group of 4, think like a scientist and work through the scientific method. Record correct responses for scientific method as indicated below. Remember make precise calculations with proper units as indicated. Record the steps of your procedure. Hint, one person should pour 200mL over their hand. You will also have to record air temperature and time rate. See Data chart below.

**PROBLEM-** How does air temperature affect the evaporation rate?

**HYPOTHESIS-** the warmer the air temperature the quicker it evaporate – colder takes longer

**SUGGESTED MATERIALS-** Beaker
Thermometer
Stop watch

**OTHER MATERIALS-**

**VARIABLES-** air temperature (IV)
evaporation rate (DV)

**PROCEDURE-(List steps)**
1. take air temp
2. fill beaker to 200ml
3. take water temp
4. pour water on hand in a downward position
5. time how long it takes to evaporate

**DATA-**

10/16 **DAY 1** Air Temperature 24°C, water temperature -22°C
Evaporation Time 3:45 sec.

**DAY 2** Air Temperature 22°C, water temperature 21°C
Evaporation Time 3:13 secs.

**DAY 3** Air Temperature 21°C, water temperature 19°C
Evaporation Time 2:56 sec.

**Day 4** Air Temperature ____, water temperature ____
Evaporation Time ____

**ANALYSIS-** Record similar findings and/or differences with data.
The colder the water the faster it evaporates.

**CONCLUSION-** Indicate whether or not your hypothesis was correct, incorrect, partially correct, etc. and explain why.
yes, because each day it was colder the water took less time to evaporate.

*Figure 3.* Lab Relative Humidity

This Lab, similar to the Solar Heating Lab, placed more responsibility on the students to utilize higher-order thinking skills and find solutions to the problems posed. In other words, there was more for them to do and to think of, more than mere data collection. Although data collection practice is important, with some teacher guidance, they have progressed to being able to intelligently problem solve utilizing the scientific method. Thus, with this Lab, they were able to complete more advance inquiry activities; ones that involved more higher order thinking skills.

**Rick:** There is a lot of thinking involved with solving for the problem.

**Teacher:** Yes, Rick, step, by step one needs to think like how a scientist would.

**Jill:** I know what the problem is that we are looking at, but I'm not sure how to word it. Can you help me?

**Teacher:** Well, what experimental problem are we investigating?

**Jill:** What are the effects of air temperature on the evaporation rate?

**Teacher:** You do know, good job!

**Harry:** What about the hypothesis?

**Teacher:** Harry, try it. Remember, it is your proposed answer to the question.

**Harry:** How about the warmer the air temperature, the faster it will evaporate?

I praised his initial intelligent attempt, and we worked on wording the hypothesis into an, “if then” statement to include colder air temperature as well. He successfully completed this on his own.

After these initial questions, the students had few questions, and made good use of the time given. Most of the students worked well, but a few had to be re-focused with a behavioral prompt.

**Weather Observations Lab**

I assigned a lab on weather observations, which was a guided inquiry activity. This required the students to monitor the weather for several days. They were to monitor the weather through the use of handheld instruments while outside, and construct a data chart representing the data they collected. In addition, using specified online sources, and using the electronic weather station data at the high school, the students were to record, and later use the data for further analysis. The students were also responsible for completing a weather map daily and answering analysis and conclusion questions on the results of the data obtained.

Prior to beginning, I instructed them regarding the division of work within each group. One person would be the recorder, one person would measure the outside air temperature and record the amount of precipitation located in the rain gauge, one person using a cloud chart would determine the type of clouds present, and amount of cloud cover, and one person would measure the wind speed, wind direction, and humidity of the air using the digital equipment. I explained that if a group had less than four members, that each day, a different person would need to double-up with the data collection jobs. Students seemed to understand. There were no questions.

When students heard that we were going outside, even though I reminded them prior to this period, I heard all kinds of comments.

**Pastiche of Student Comments**

**"It's gonna be cold."**

"I'M GONNA PUT MY HOODIE UP, THEN I'LL BE WARM."

*"Oh good! We're going outside, yeeees!"*

**"I'm going to freeze."**

"It's going to be sooooooo cold."

**"GOING OUTSIDE IS COOL!"**

*Figure 4.* Classroom Comments Related to Weather Observation Lab

I reminded the students that each person had a job to do, and some had two jobs, but it should not take more than a few minutes and then we would come back inside. Once inside, the recorder for the day went to the end of the hallway to collect the weather data from the school's electronic weather station. Meanwhile, I reminded the students that the other group members should be looking up data from the on-line sites as specified on the lab sheets. Then, before leaving class that day, all group information should be shared. The students appeared to understand.

**Katie:** Tim, I think that because of the low pressure, that's why there was rain.

**Tim:** Katie, yeah you're right, that whole pressure thing, I think it has to do with the air evaporating, right? (I was near this group, passively listening to the science talk occurring. But, now there was some assertiveness, where Tim was confident enough to ask a question. He was looking at me, and waiting for a response).

**Teacher:** Tim, if the pressure were high, would the air sink, or rise?

**Tim:** There it would sink.

**Teacher:** Right! And if it sinks, do we have clouds formed?

**Tim:** No, and with no clouds, no rain, right?

**Teacher:** Makes sense, right?

**Tim:** Yeah. So that means I was right, if air has a lower pressure, it does evaporate, and we can get clouds, and rain. I am right!

**Teacher:** You thought it through logically, it makes sense right?

**Tim:** It does, thanks!

**Teacher:** Katie your point makes sense, do you understand what Tim was saying?

**Katie:** Yeah, there are clouds that form when we have a low pressure system, and then we get some type of precipitation.

## Hometown Connections

Overall, all went well with the Weather Observation Lab. A few students, Rick, Harry, and Lisa, needed reminding to be quiet when passing through the hallway to go outside. Also, when outside, students needed to be reminded to spread out and collect their piece of the data. The students seemed to like feeling like a scientist; this lab inquiry activity also had connections to their city. After all, they were gathering data from their city, not someplace else. I had to remind students also that they needed to complete a weather map for the day, which was on a sheet in their lab packet. I told them if they needed a library pass to finish this up during study hall they should see me. I had three students ask for a library pass that day.

## Interpreting Weather Maps Activity

I assigned a group activity where students were to read information on weather maps and answer analysis and conclusion questions on the interpretation of them. This activity, similar to the Lab on Weather Observations, was a guided inquiry activity, where students were getting practice with the analysis and conclusion aspects of problem solving. Prior to beginning this activity, I instructed the students to spend approximately five minutes reading on their own before reporting to their lab groups to analyze and conclude on the information.

The students were compliant. Once in their groups, they worked well and had few questions. They seemed to transfer the knowledge learned from the previous Lab, the Weather Observations Lab. They appeared confident. As I circulated the students were on task and I overheard a lot of science talk at the groups.

**Designing a Barometer Lab Report**

The students progressed successfully from inquiry problem solving activities, which were mostly structured inquiry activities, to laboratory experiments, which were mostly guided inquiry. They successfully completed a group project, which was mostly open inquiry, and this would be another milestone; they would be completing a lab report, which was an open inquiry activity, placing the majority of its focus on the scientific method of problem solving and requiring more higher order thinking skills. This required the students to research and find a method of constructing a barometer. Each group was then responsible for bringing in the necessary materials and assembling the device. The design of the device had to function, as students would be asked to later construct a data table and eventually a graph of the data that their barometer read. To aid as the control in testing their design, each day data were obtained they would take a barometric reading from the barometer in the classroom. In addition, they would be analyzing and drawing conclusions on the data that they obtained. Prior to the students beginning this lengthy journey, they had studied the definition of weather and how to interpret weather maps; they had a fairly good understanding of relationships that influenced weather. I reminded them that they were to think like a scientist and work as a team. I reminded them of the importance of brainstorming ideas, researching the topic, and utilizing the scientific method to test their ideas. The students were excited. I could see it on their faces. They were going to actually design and test something that they made.

## Students are Motivated

Over the next few days, the excitement grew. I saw a lot of excitement when the groups remembered to bring in all the needed materials and actually assembled the device. The excitement grew even more when, for the first time, they took measurements from the barometers that they had made. Some of the students even devised a method to represent incremental changes in air pressure, rather than merely recording whether the device showed an increase or decrease. They also recorded the actual air pressure of the room daily by reading the classroom barometer.

Each day the students entered the classroom and expressed eagerness to collect the data. The plan was that after a few days of data collection the students would begin to analyze the results by comparing the two barometers, and the weather conditions. Also, by comparing the data that they obtained with an actual barometer, it confirmed that their devices, although a simpler representation, could measure an increase or decrease daily in the air pressure accurately.

Most of the students were able to deductively reason weather differences associated with low pressure systems versus high pressure systems.

**Amy:** Wow, when the number goes down that means it’s a low pressure.

**Lisa:** Yeah, so that’s why the weather’s not as nice out.

**Jill:** We got the same results; that’s really neat!

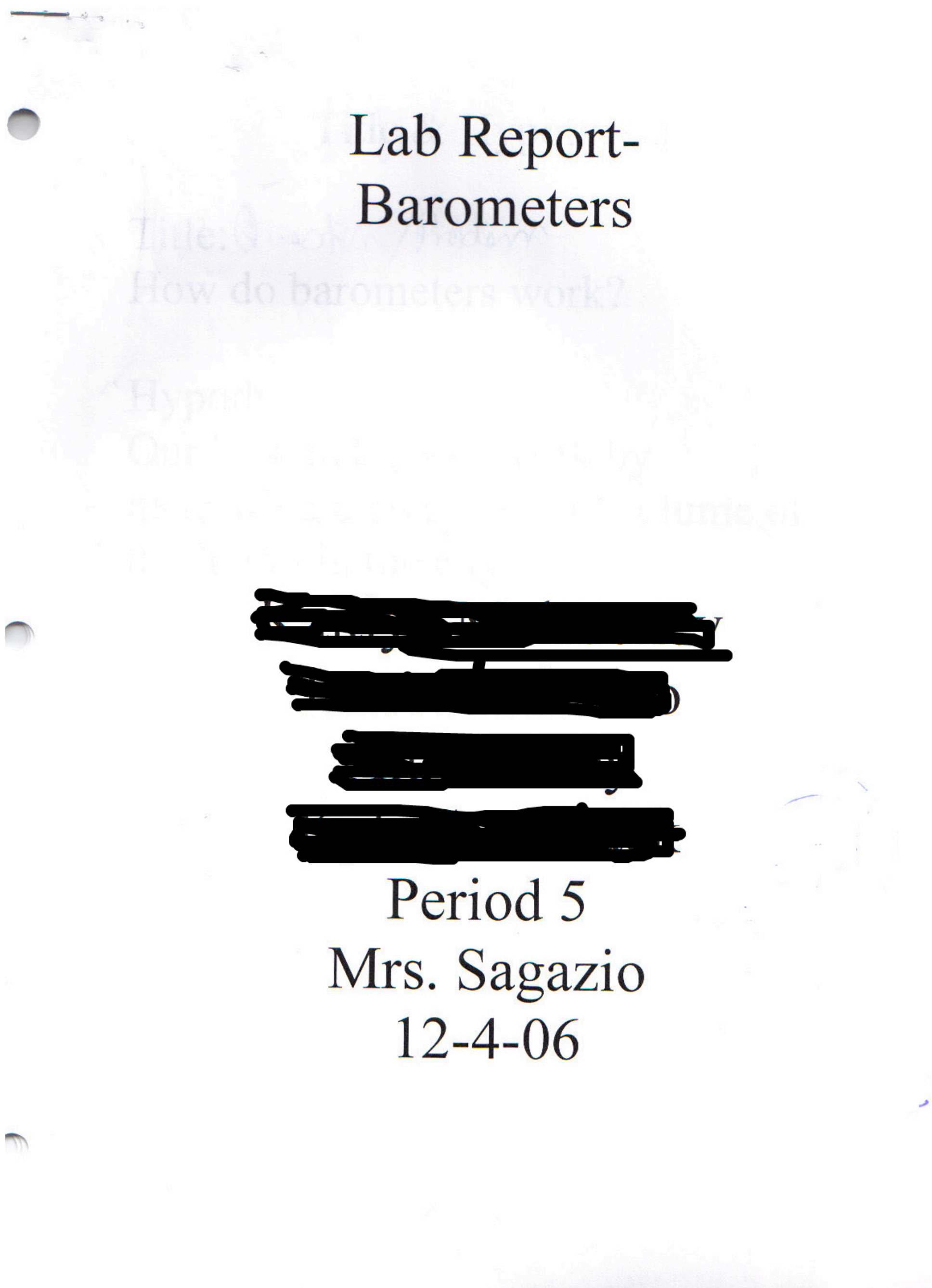
**Stacey:** And when it’s nice outside, the pressure goes up, that’s why our number goes up.

**Ralph:** That is so neat, our barometer actually works!

A few others needed some additional prompting, but were able to then reason appropriately. They were analyzing and making scientific conclusions on the data that they had obtained. Each of the lab groups then took all of their working draft papers and typed up a lab report.

Overall, the students maintained good group organization; all of their group paperwork remained in a group folder, which they returned to the class storage box each day. Within each of the groups, all of the members participated, and helped each other out; they had a common goal and were motivated.

**Student Sample Lab Report Work**



Lab Report-
Barometers

[redacted]

Period 5
Mrs. Sagazio
12-4-06

*Figure 5.* Designing A Barometer Lab Report

# Title & Hypothesis

Title: Question/Problem

How do barometers work?

Hypothesis:

Our barometer will work by measuring changes in the volume of the liquid in the cup.

# Materials

- Plastic Cup
- Soda Bottle
- Water
- Food Coloring
- Ruler

3

# Procedure

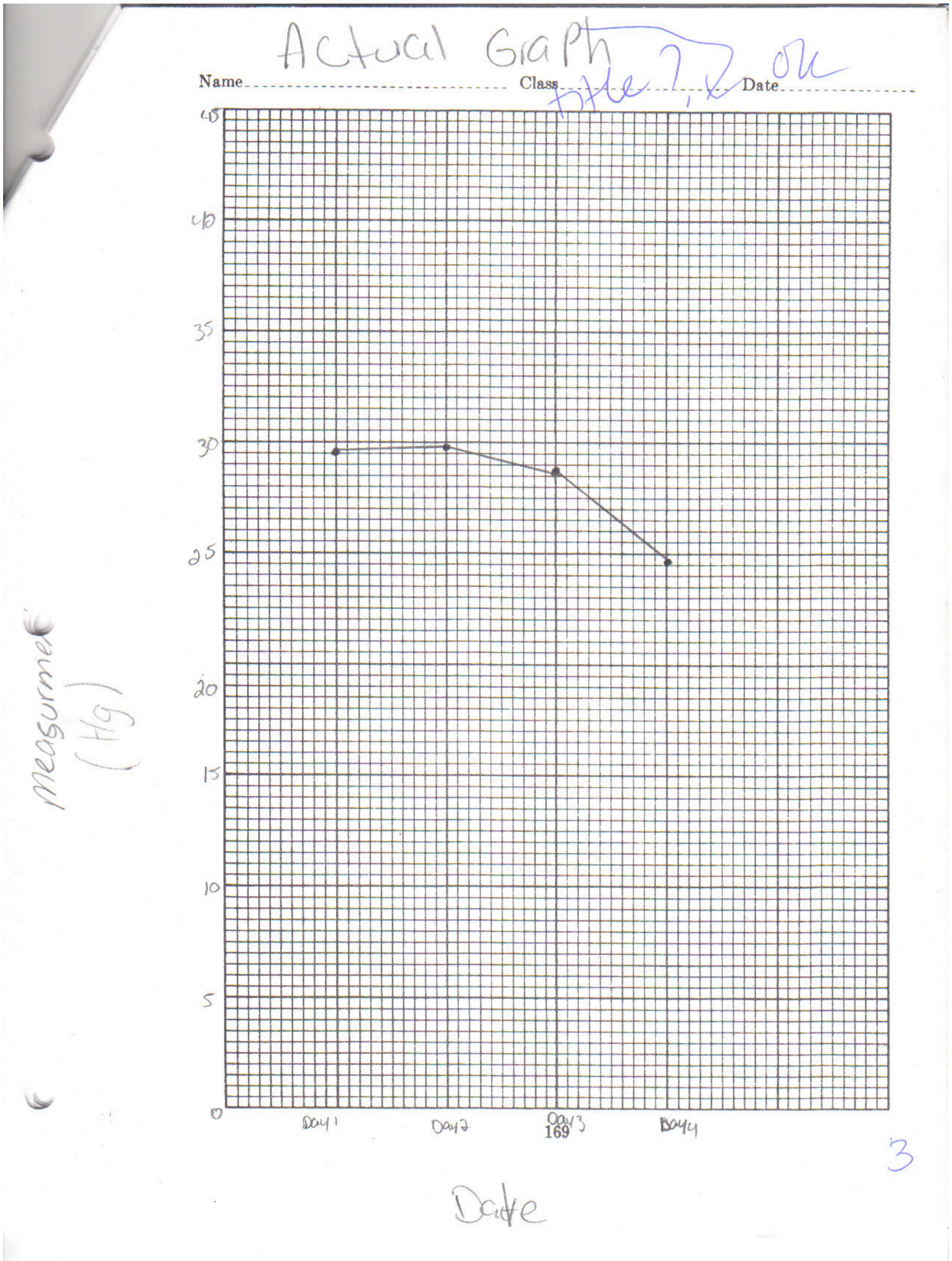
1. Gather materials.
2. Measure water with ruler.
3. Fill the cup with the water.
4. Place plastic soda bottle in cup. Make sure water is covering mouth of bottle. If not add more water.

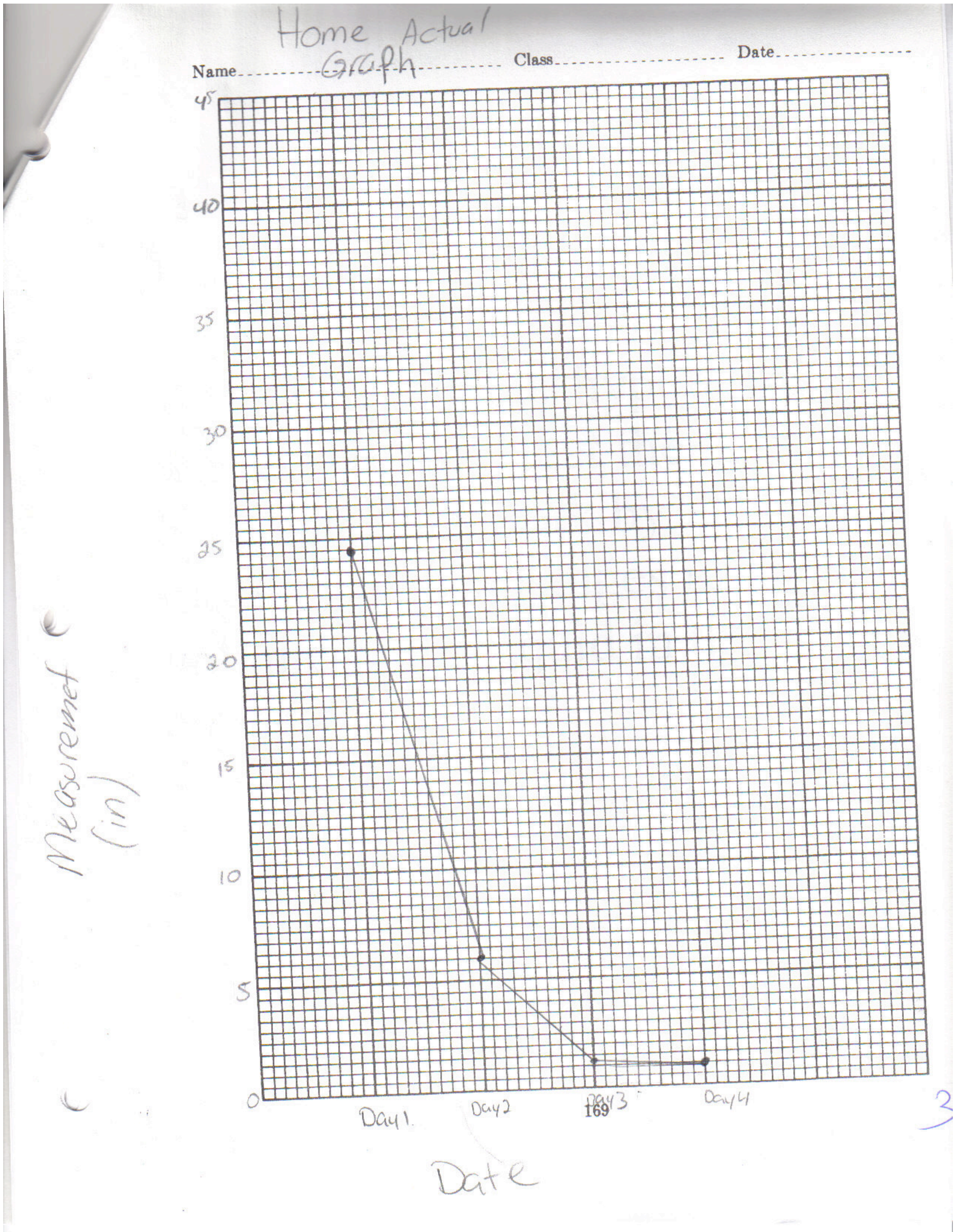
making measurements?

2

| Date | Up/ Down | Actual Measurement (in. of Hg) |
|---|---|---|
| 11/16 Thursday | 24 in. [illegible] | 29. 7 in. of Hg |
| 11/ 17 Friday | 7 in. | 29.75 in. of Hg |
| 11/20 Monday | 2.5 in. | 28.31 in. of Hg |
| 11/21 Tuesday | 2 in. | 24.34 in. of Hg |

3


Actual Graph
Name
Class
Date
title ?, x ok
45
40
35
30
25
20
15
10
5
0
Measurment (Hg)
Day 1
Day 2
Day 3
Day 4
169
3
Date


Home Actual Graph
Name
Class
Date
45
40
35
30
25
20
15
10
5
0
Day1
Day2
Day3
Day4
Measuremet (in)
Date
169
3

# Conclusion

We found that our hypothesis was correct and that the barometer did work by measuring the changes in the volume of the liquid in the cup.

## Factors that Influence Climate Activity

The students were ready to advance to the next and last major unit of Earth Science involved in this study, and that was Climatology. I assigned a structured inquiry activity on the factors which influence climate to begin this new topic area. This required the students to problem solve related to a given geographic situation as to the effect on climate.

Prior to beginning, I taught the students how climate is related to weather, and how it is different. I emphasized the importance of studying climate patterns to assist in solving several global problems. I reminded the students to think like a scientist, and instructed them to report to their lab groups. I circulated. I heard lots of science talk.

**Jill:** You have to look at the arrows, they represent the winds.

**Kurt:** Well, yes you are right but, don't forget the arrows switch direction, don't forget that.

**Alice:** Those are mountains, and the winds blow over the water first, so it will be more humid there, near the water.

**Keith:** Yeah, you are right.

**Lisa:** If the location of that site is in the middle of the island, there is going to be more climate change than near the water; the water acts as a buffer.

**Will:** But why, I'm not sure?

Lisa was able to correctly explain to Will the dynamics involved, and he verbalized and nodded his head that he understood.

The students seemed to like the activity; they were problem solving together. They were on task and feeling comfortable to ask each other relevant questions. They all completed the activity and were able to turn it in by the end of the period.

**Climate Zones Activity**

This activity, a structured inquiry activity, was similar to the previous climate activity, but this required some additional tools. This activity required the students to use colored pencils, two textbooks as reference, and a ruler to label the areas properly.

Prior to beginning, I reviewed with the class the definition of climate and the main points they were to have learned from yesterday's inquiry activity on factors that influence climate. I instructed them on the focus of this assignment and the tools that they would need. Then I instructed them to report to their groups. I circulated. The students worked well. Some common questions arose regarding the shading and aligning of latitudinal coordinates, but no major areas of confusion or panic were evident. The activity went smoothly.

**Cooling and Heating Rates of Land Compared to Water Surfaces Lab**

I assigned this laboratory activity, a guided inquiry activity, on comparing the differences in the heating and cooling rates of solids compared to liquids.

They were required to gather the necessary supplies, which I had reviewed: beakers, thermometers, light source, ring stand, timer, soil and water. They were to follow the established procedure carefully and document the results, identify the parameters of the experiment, analyze, and conclude.

Prior to beginning this lab experiment, we had discussed differences in the states of matter as related to heating and cooling, but not the specifics. They were to test for these in this lab experiment. I instructed the students to report to their lab groups. I circulated.

Questions arose with regard to the parameters of the experiment, particularly identifying all of the constants of the experiment. As with the other previous lab experiments, students were able to identify approximately two constants, but beyond that they needed some teacher-directed questions to help guide their understanding.

**Sam:** Mrs. S, we have the amount of soil and water as a constant, but what else could we come up with?

**Teacher:** Think Sam, what else are you keeping the same, that which you are not testing for?

**Sam:** How about the type of thermometer that we are using?

**Teacher:** Sam, you are keeping that the same, you are using the digital thermometer, good. How about the rest of you, can you help Sam out? (I was looking at the other lab group members: Alice, Keith, and Jenna).

**Alice:** Well, I'm thinking about the lab station that we are at.

**Teacher:** Good! (The students from this group were smiling. By affirming their responses, they seemed more self-confident).

The experimental set-up was more involved than most; there was more group conversing to determine what was the best set-up, especially in considering the constants. Many groups needed my assistance in this area. They would need more scaffolding to identify more experimental constants.

**Lab-Why is it Hotter at the Equator than at the Poles?**

I assigned a laboratory experiment, a guided inquiry activity, on comparing differences in angles on the heating of a surface. This required the students to read two pages, one on background information, and one on the proposed procedural set-up. They also had to identify the constants in this experiment, record and graph data from their experiment, and answer analysis and conclusion questions.

Prior to beginning, I reviewed with the class the major parameters of the experiment, and the importance of identifying and maintaining the constants of an experiment. In addition, I instructed them to properly document these constants in the lab. The tools unique to this experiment were reviewed, and then I instructed them to report to their lab groups. I circulated.

There were few questions on the constants for this experiment. I observed the lab groups recording several constants correctly, and measuring to assure that they would be maintained. Students within the group were reinforcing each other with regard to technique and procedure. All aspects of this lab experiment seemed to flow more smoothly compared to the previous Lab on Cooling and Heating Rates. They had been properly scaffolded for this Lab. There was greater self-confidence, and less confusion. They were prepared and motivated to succeed.

## End Study Cooperative Group Progress

Similar to the first half of this study, I monitored each group for a total of three times during the last two units of Earth and Space Science, Meteorology, and Climatology. Changes were made based on the formative assessments from the Cooperative Group Checklist, and behavioral situations warranting a change in the group structure. The following table represents the Group Cooperative Assessments for units 3 and 4, which is the conclusion of this study.

Table 2

*Cooperative Group Assessment for Units 3 and 4*

| | | | |
|---|---|---|---|
| | **Group 1** | | |
| **Kurt** | Sometimes | Sometimes | Sometimes |
| **Kim** | Frequently | Frequently | Frequently |
| **Jill *** | Frequently | Frequently | Frequently |
| **Alex** | Sometimes | Sometimes | Frequently |
| | **Group 2** | | |
| **Jackie** | Sometimes | Sometimes | Sometimes |
| **Amy** | Sometimes | Sometimes | Frequently |
| **Lisa** | Frequently | Frequently | Frequently |
| | **Group 3** | | |
| **Harry** | Sometimes | Sometimes | Frequently |
| **Will** | Sometimes | Sometimes | Sometimes |
| **Ralph** | Frequently | Frequently | Frequently |
| | **Group 4** | | |
| **Rick** | Not Yet | Sometimes | Not Yet |
| **Stacey** | Frequently | Frequently | Frequently |
| **Matt *** | Frequently | Frequently | Frequently |
| | **Group 5** | | |
| **Katie** | Frequently | Sometimes | Frequently |
| **Sara** | Sometimes | Frequently | Frequently |
| **Tim** | Sometimes | Sometimes | Sometimes |
| | **Group 6** | | |
| **Alice** | Sometimes | Sometimes | Sometimes |
| **Sam** | Sometimes | Sometimes | Sometimes |
| **Keith** | Frequently | Frequently | Frequently |
| **Jenna *** | Frequently | Sometimes | Frequently |

*Note. * Indicates student has changed groups.*

Unlike Harry, who has shown improvement, Rick has demonstrated more attention seeking behaviors: silly and disruptive behavior within the group, which has warranted that he work with only one other person. The other person that Rick has been assigned to work with is a strong individual who is cooperative, but dedicated to his work. The other group change at this point is Stacey, who was relocated to a well-established group, Group 5, away from Rick.

Within any given classroom it is inevitable that some distractions are going to occur and how they are handled, by the teacher can make all the difference. Because of all the inquiry-based activities, where I frequently circulate within the classroom and talk with the students, I feel that I have really gotten to know my students well. Knowing them well has made a big difference in knowing how to best handle situations involving them.

Overall, the groups through careful monitoring and guidance have finally learned how to work well with each other, and the two new groups will, in anticipation, be equally or more productive.

**Science Survey**

I reminded the students of my study, and instructed them to complete a Science Survey to provide me with more information. I reminded them to answer each question honestly, insisting that by answering the questions honestly that would provide more benefit. My survey consisted of 10 questions, which asked the students about their attitude toward learning science with regard to method of instruction. The rating system that was utilized involved a scale of one through five, where the range went from a rating of one, where they agreed little or did not agree, to a rating of five, which represented that they agreed strongly.

Table 3

*Attitude Rating for Science Survey*

| Question | Overall Average Attitude Rating |
|---|---|
| 1. Do you enjoy learning Science? | **3** |
| 2. Do you think that by doing labs; they help you learn science better? | **4** |
| 3. Do you think that learning science through receiving notes, and lecture and discussion, helps you learn science better? | **2** |
| 4. Do you think that bookwork, meaning: you reading, taking your own notes, and completing review worksheets helps you learn science better? | **2** |
| 5. Do you think that completing projects helps you learn science? | **3** |
| 6. Do you feel that some notes and discussion before a lab, activity or project helps you understand the topic better? | **4** |
| 7. Do you think that working by yourself for labs, activities, and projects helps you learn science better? | **2** |
| 8. Do you feel that working with other students (where the teacher picks the groups) for labs, activities, and projects, helps you learn science better? | **3** |
| 9. Do you think that working with other students (where you can pick your own groups) for labs, activities, and projects, helps you learn science better? | **4** |
| 10. Do you learn science better by "doing" (being active), rather than by "watching" (sitting and watching the teacher show you)? | **4** |

*Note. 18 students responded to the survey.*

This survey indicated that students overwhelmingly preferred to be active learners. However, even though they felt that they learned more by being active learners, they indicated the importance of guided inquiry: having some teacher-led notes and discussion before completing the inquiry-based activity. This was supported with regard to what I observed in my field note observations and reflections. The need for direction, for scaffolding by the teacher, encouragement, and circulation of the teacher to the various groups was essential for the students to remain on-task, motivated, and performing academically well.

**End of Study Interview**

From this study I have learned many things, aside from the academic and attitudinal value of implementing active, inquiry-based learning within the science high-school classroom for On-Level students. I have learned that inquiry-based learning supports a classroom environment where communication between teacher and students, and students and students is critical. Communication helps to foster a cooperative environment in order to develop higher-order thinking skills. My end-of-study interview allowed me the valuable opportunity to gain additional feedback from my students. Communication is essential for true learning. I interviewed each student individually. I sat at my desk and provided a seat for each of my students to sit as they explained to me the answers to my questions. I completed this interviewing process over a series of days in mid-December, while my students were engaged in normal classroom activities. I completed however many I could each day without jeopardizing the quality of instruction for the day.

Table 4.

*Science Interview Questions.*

| **Questions- Science Education Interview** |
|---|
| 1. Explain how you feel that you learn science best. |
| 2. Do you feel that you enjoy science more when you do activities/projects/labs? |
| 3. Other? - |

I interviewed 19 students, taking notes on what they verbalized. Afterwards, I analyzed all comments. Overwhelmingly, there were 44 positive comments that were categorized as student-centered, compared to 12 comments that were categorized as teacher-centered. In addition, I tallied 16 positive responses for the types of inquiry-based activities.

Table 5

*Number of Student Responses Related to Inquiry-Activities*

| **Type of Inquiry-Based Activity Positively Mentioned** | **Number** |
|---|---|
| 1. Labs | 16 |
| 2. Projects | 13 |
| 3. Activities (problem-solving) | 12 |
| 4. Group | 10 |
| 5. Hands-On | 4 |

There were no negative comments regarding the use of inquiry-based activities, but rather comments directed more as to personal preference as related to individual science learning.

## DATA ANALYSIS

Throughout my action research study, I remained focused on my research question. My research question was: What are the observed and reported experiences when inquiry-based activities are integrated into the high school science curriculum for an On-Level class?

### Analysis During Data Collection

During data collection I managed my field log daily as explained in MacLean and Mohr (1999). I recorded notes, which were my observations. Later that day, utilizing a two-column numbered format, I typed my observations from the notes that I had taken that day. I was self-reflective as to the data that I obtained (Holly, Arhar, & Kasten, 2005).

I used a field log, formal survey, individual group interview, and student work, such as: inquiry-based graded activities, including a rubric for a project-based inquiry activity. In addition, I formatively assessed my students' cooperative group growth by utilizing a rubric for Cooperative Group Activities.

As I collected data, I noticed a focus with regard to my research question. Through this focus and examining other Methodological Memos completed during my research, other sub-questions arose. Three of these sub-questions included:

1.What are the observed and reported experiences with regard to frequency of circulation in order to progress check within the groups?

2. What are the observed and reported experiences pertaining to student's behaviors and reactions to group work?

3. What are the observed and reported experiences with regard to the type of inquiry-based activity: guided inquiry, group activities, lab-based activities, and group project-based activities used in the classroom?

Writing these research sub-questions was useful in contributing to my further analysis of the data that I collected. The data that I collected provided a means for my analysis and interpretation of my research question and sub-questions. Through the coding of my field log, the use of a graphic organizer, and writing theme statements I was able to make more detailed connections regarding my study.

**Analysis Through Educational Theorists**

Throughout this research investigation several educational researchers were instrumental in assisting me in my understanding of the analysis of the data I had obtained.

According to Dewey (1997), "Everything depends upon the *quality* of the experience which is had" (p. 27). In my research study, I examined the effects of choosing experiences, which are inquiry-based positive educational experiences, to facilitate my students' development of higher order thinking. My desire is for all students to learn, including the group that my study addresses, On-Level Earth and Space Science students. The experiences I chose were meaningful, in an attempt to foster positive future experiences in science, and perhaps other areas as well. I designed experiences, which I believe, scaffolded the students from their cognitive level to a higher level of thinking.

Throughout my study, I carefully documented my observations to further assess the quality of the experience designed for my students. In addition, through assessing students' quality of work, survey, and interview, I obtained additional feedback regarding the quality of the experience.

Freire (2003) contributed understanding to the analysis of my study by emphasizing the importance of inquiry. "For apart from inquiry, apart from the praxis, individuals cannot be truly human" (Freire, 2003, p. 72). Therefore, using inquiry-based activities in the classroom is substantiated according to Freire as a means for individuals to truly learn. Freire emphasized the importance of students being active learners, or participants in the learning process. For to be human, "truly human," (Freire, 2003, p. 72), one must experience to learn. In fact, Freire describes inquiry further, in terms of "invention and re-invention" (Freire, 2003, p. 72). In my study, I had my students do many science, inquiry-based activities: laboratory activities and experiments, cooperative group activities, and projects, which in essence involves as Freire emphasizes, “invention and re-invention” (Freire, 2003, p. 72). All of this was used to triangulate my data, as expressed in Holly, Arhar, and Kasten (2005).

In relation to utilizing inquiry-based activities where the students were involved in groups, Delpit (2002) had made valuable suggestions, which I benefited from knowing. “Furthermore, by not listening, teachers cannot know what students are concerned about, what interests them, or what is happening in their lives. Without that knowledge it is difficult to connect the curriculum to anything students find meaningful” (Delpit, 2002, p. 43).

In my study, where inquiry-based activities were implemented, listening was vital. In fact, within my classroom I needed to be an active and passive listener. Active listening occurred when I was with a group or an individual and was listening and actively engaged in their concerns, questions, and related comments. As a passive listener, when I was listening, but not an active participant in the conversation, I was able to assess and document group concerns and dynamics. In addition, I had the responsibility to foster a classroom environment where the students within their groups and the class as a whole were respectful and listened to each other. All of these considerations as expressed in Delpit (2002), aided in my analysis of the data.

Vygotsky (1978) was important regarding his explanation of the difference between rote skills and the development of higher-order thinking skills, which is something I desired for my students. “This situation recalls the development of a technical skill such as piano-playing: the pupil develops finger dexterity and learns to strike the keys while reading music, but he is in no way involved in the essence of the music itself" (Vygotsky, 1978, p. 105-106).

My students participated in cooperative lab groups to complete inquiry-based activities, where the emphasis was on developing their higher-order thinking skills. By developing these skills, students should develop a more positive "essence" of science. I attempted to meet my students at their zone of proximal development, which could be at a lower level on Bloom's taxonomy of cognitive development. My goal was to expand to the next level, ultimately fostering their development of the "essence" of science.

## Analysis After Data Collection

After the collection of data was complete, I organized the data through writing codes for what I documented in my log. I then organized my codes into bins. My bins were then used to construct my theme statements.

I reviewed again my field log notes: both observations and reflections, student work samples, survey results, and interview results, and maintained the importance of triangulating the data, as expressed in Holly, Arhar, and Kasten (2005). When I recorded in my log, I ensured anonymity of all students; I did this by using pseudonyms and excluding student names from the study. In addition, I kept all research materials locked up in a secure location when not being used to assure confidentiality. All data was destroyed at the conclusion of my study.

## Theme Statements

- **Inquiry-Based Methods-** When inquiry-based methods, including: labs, cooperative group activities, and group projects are implemented, further investigation can be done to determine which yields the best results.
- **Positive Teacher Actions-** Positive teacher actions during inquiry-based activities improves student attitudes and performance within the class, and are necessary to re-direct those students with negative attitudinal behaviors. These include circulating, group changing, think-like-a-scientist prompting, focus prompting, behavioral prompting, discussing, ability level adjusting, encouraging, conferencing and reviewing.
- **Positive Student Attitudinal Behaviors-** Inquiry-based methods can produce positive student attitudinal behaviors such as: being confident, interested, and exhibiting cooperative behaviors.
- **Improved Scientific Thinking Performance-** When positive attitudinal behaviors exist in the inquiry-based classroom, overall performance improves. These include: being on-task, participating, exhibiting student science talking, higher-order thinking, and quality of work improving.
- **Negative Student Attitudinal Behaviors-** Inquiry-based methods can result in negative student attitudinal behaviors such as: being distracted, frustrated, and lacking confidence.

- **Regression of Scientific Thinking Performance-** When negative attitudinal behaviors exist in the inquiry-based classroom there can be a regression of scientific thinking performance. These include: being off-task, exhibiting lower-level thinking, and quality of work decreasing.

**Themes and Bins**

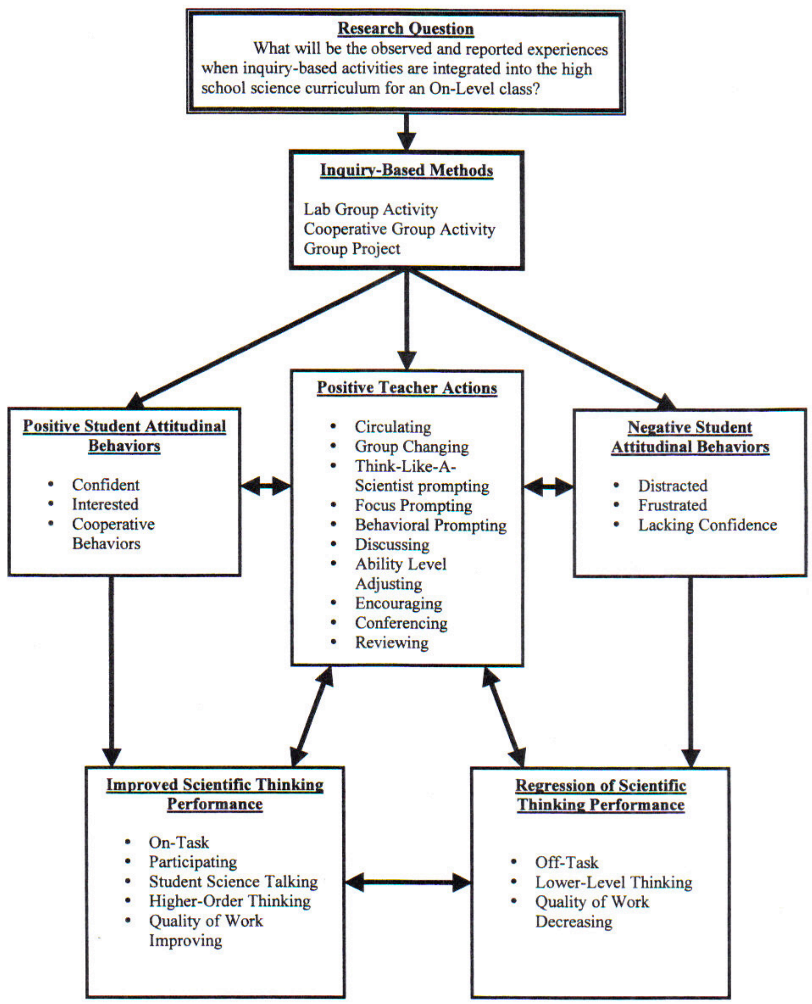



*Figure 6.* Themes and Bins

# FINDINGS

My study began with the following question, "What will be the observed and reported experiences when inquiry-based activities are integrated into the high school science curriculum for an On-Level class?" Specifically, I wanted to see if by using inquiry-based activities students would perform better academically, and if there was improvement of higher-order thinking skills. Further, I wanted to see if student's attitudes toward science were affected by the use of inquiry-based activities.

## Inquiry-Based Methods

When inquiry-based methods, including: labs, cooperative problem-solving group activities, and group projects were implemented, further investigation can be done to determine which idea yielded the best results with regard to academic performance and student preference toward learning science. Science, by definition, involves problem solving and utilizing the scientific method, where students need to be able to design, test, and evaluate their work. Inquiry-based activities have the potential to develop students' higher-order thinking skills (Mysliwiec et al., 2005). Some of the activities, particularly those that I scaffolded for the students, were more advanced with regard to the level of higher order thinking.

I classified and recorded the class average for each type of inquiry-based activity. The first inquiry type was cooperative problem-solving activities. These were largely structured inquiry activities. Within this category there were a total of eight activities completed.

Table 6

*Class Average for Problem-Solving Activities*

| **Cooperative Problem-Solving Activities** | **Class Average** |
|---|---|
| 1. Introduction to Earth and Space Science Activity | 81% |
| 2. Scientific Method Activity | 90% |
| 3. Lab Safety Activity | 87% |
| 4. Structure of the Atmosphere Activity | 87% |
| 5. Layers of the Atmosphere Activity | 73% |
| 6. Interpreting Weather Map Activity | 76% |
| 7. Factors Affecting Climate Activity | 89% |
| 8. Climate Zones Activity | 66% |
| **Class Average Score** | **81%** |

The second inquiry type called laboratory opportunities included seven teacher-guided labs and one lab report. The vast majority of these lab activities were guided inquiry, and the lab report was open inquiry.

Table 7

*Class Average for Laboratory Activites*

| **Laboratory Opportunities** | **Class Average** |
|---|---|
| 1. Lab--Measurement | 83% |
| 2. Lab—Measurement and Graphing | 80% |
| 3. Lab—Solar Heating | 74% |
| 4. Lab—Relative Humidity | 97% |
| 5. Lab—Weather Observations | 70% |
| 6. Lab—Cooling and Heating Rates of Land vs. Water Surfaces | 76% |
| 7. Lab—Why is it Hotter at the Equator than at the Poles? | 90% |
| 8. Designing a Barometer Lab Report | 75% |
| **Class Average Score** | **81%** |

The third category involved a Group Project on the Atmosphere, which was largely open inquiry. The overall average of the class was 82%. In analyzing the three types of inquiry-based activities academically for the class, the students consistently scored a B average in all.

Regarding the affective domain and student attitudes toward the use of inquiry activities, I examined data from my survey and interview. According to my survey, all students surveyed preferred to be active learners. Various studies (Lee & Fraser, 2001; Roth & Bowen, 1995; Wilson, 1996) express consideration for student preference and mention possible learning style factors as playing a role in the effectiveness of active involvement learning.

However, even though they felt that they learned more by being active learners, they indicated the importance of guided, or more structured inquiry. This was supported with regard to what I observed in my field log observations, reflections, and literary research. White and Frederiksen (1998) emphasized the need for scaffolding the curricula to foster student's inquiry development. They expressed the importance of scaffolding to promote learning for all students, especially the lower ability achievers and younger students.

I interviewed 19 students, taking notes on what they verbalized. Afterwards I analyzed all comments. There were 44 positive comments that were categorized as student-centered, compared to 12 comments that were categorized as teacher-centered. The 12 teacher-centered comments were with regard to students verbalizing a preference for some pre-lab or pre-activity or teacher-led discussion, with helpful notes. In the interview, the students were communicating their preference toward learning science. Overwhelmingly, they believed that they learned science best by being an active learner, which is an integral part of inquiry-based activities. Many positive comments were made with regard to specific types of inquiry-based activities (see Table 8).

Table 8

*Inquiry-Based Activities Mentioned in Interview*

| **Type of Inquiry-Based Activity Positively Mentioned** | **Number** |
|---|---|
| 1. Labs | 16 |
| 2. Projects | 13 |
| 3. Activities (problem-solving) | 12 |
| 4. Group | 10 |
| 5. Hands-On | 4 |

Overall, students expressed a preference for student-centered instruction and had commented highest with regard to Labs, which were largely guided inquiry activities. They also commented mostly equally high with regard to Projects and Activities. The use of the term Hands-On also was used, which implies doing, or being an active learner. This could be included with any of the first three items. In addition, the use of the term Group was used in a favorable manner.

## Positive Teacher Actions

Positive teacher actions during the inquiry-based activities improved student attitudes and performance within the class, and were necessary to re-direct those students with negative attitudinal behaviors. These include: circulating, group changing, think-like-a-scientist prompting, focus prompting, behavioral prompting, discussing, ability level adjusting, encouraging, conferencing, and reviewing. Colburn (2004) expressed that for a greater, more in-depth understanding of science and various scientific concepts, inquiry-based teaching provides students the necessary opportunities to "actively grapple with the content" (p. 64), but cautioned the teacher to assist in preparing the students to be developmentally ready for the inquiries to be utilized. Therefore, as the teacher and researcher, I needed to prepare my students and develop a positive classroom environment to foster optimal student progress.

As documented in my field log, I circulated to the various groups and made myself available for questions and assistance with activities. I especially observed a higher frequency of requests for assistance with the first few Activities and Labs. In addition, upon starting the Group Project, there were a lot of questions. My being available for the students seemed to foster their confidence level. Initially, students especially seemed to lack confidence. They would often apologize for asking a question, or ask me to check something that they did before progressing onward. Once I established a trust with the students, which took the first three activities and first two labs, their confidence had developed.

The use of various prompts: behavioral prompts, think-like-a-scientist prompts, and focus prompting, as documented in my field log, provided a reminder for the students to perform to the level of expectation that was clearly expected. According to Polacek and Keeling (2005), questioning, both pre-lab and post-lab, assists the student to both focus and reflect on the laboratory experiment. Experiments may be smaller and less time consuming or independent and more comprehensive. Both can be beneficial to the student (Polacek & Keeling, 2005). Higher order questioning that reflects the scientific processes is the crucial element in both. Prompting was often in the form of questioning or re-phrasing to guide the students' progress.

Group changes were also a positive teacher action, which assured my pro-active dealing with the class group dynamics as necessary. Formative assessments done through the use of a Cooperative Group Checklist, was a helpful monitoring tool.

## Positive Student Attitudinal Behaviors

Inquiry-based methods can produce positive student attitudinal behaviors such as: being confident, being interested, and exhibiting cooperative behaviors.

I observed cooperative behaviors, as documented in my field notes and in the Cooperative Group Checklist. Student confidence increased as they completed more activities.

"Experience does not go on simply inside a person. It does go on there, for it influences the formation of attitudes of desire and purpose" (Dewey, 1997, p. 39). With this quote, Dewey addresses the depth of an experience, meaning that an experience is not a simple event or occurrence, but rather has links to future educational and social development of the student. It does not begin and then abruptly end. Beyond every experience there is an evolving of personal attitudes, hopefully positive attitudes. Attitudes of desire and purpose in one's life are just that, one's life. Therefore, an educational experience lives on long afterwards, shaping and molding opinions and attitudes towards the future.

Regardless of which type of inquiry-based learning, Colburn (2004) mentions several challenges. The challenge of greatest importance was that it be important for the teacher and students to feel comfortable with the activities. The more activities the students completed, the greater their comfort level, as reflected in their increased level of self-confidence.

**Negative Student Attitudinal Behaviors**

Inquiry-based methods can result in negative student attitudinal behaviors such as: being distracted, being frustrated, and lacking confidence. These all were monitored through the use of collecting data for my field log, and monitoring group progress through the use of the Cooperative Group Checklist. Group changes and student conferences were implemented to help improve student performance and quality of work.

**Improved Scientific Thinking Performance**

When positive attitudinal behaviors existed in the inquiry-based classroom, overall performance improved. These included: being on-task, participating, exhibiting student science talking, using higher-order thinking, and improving quality of work. The students were motivated overall with regard to being active learners. They progressed from the use of problem-solving activities to Inquiry-guided labs of increasing difficulty in higher level of thinking, to completing a lab report. In addition to having greater student ownership for learning, Bloom's six levels of cognitive domain are descriptive regarding the desired progression towards reaching the more complex levels (Mysliwiec, Dunbar, & Shibley, 2005). In addition, the students were advanced along to be able to complete and present a group project. In a study by Burbach, Matkin, and Fritz (2004), where active learning techniques were utilized in the classroom, improvement of critical thinking, or higher-order thinking resulted.

**Regression of Scientific Thinking Performance**

When negative attitudinal behaviors exist in the inquiry-based classroom, there can be a regression of scientific thinking performance. These include: being off-task, exhibiting lower-level thinking, and decreasing quality of work. "It is then the business of the educator to see in what direction an experience is heading" (Dewey, 1997, p. 38). This quote means that the educator, who is more experienced, should have the insight to evaluate and design experiences for the benefit of the less experienced youth. Therefore, the educator would provide the necessary direction and necessary conditions for optimal learning experiences for their students.

When students would regress, I needed to utilize behavioral prompts, as documented in my field log.  These were effective in re-focusing the student to being on task.  On a few incidences, mere focus prompts were not enough and group changes were made with regard to the grouping of students.

## NEXT STEPS

After completing my study, I was left with certain questions that I wanted to learn more about. Each of these follow-up questions focused on the three sub questions which arose during my original research question, what are the observed and reported experiences of implementing inquiry-based activities in the high school science classroom for On-Level students.

The first question was: What are the observed and reported experiences with regard to frequency of circulation in order to check progress within the groups? This question arose as I reflected on my daily observations and reflections that I had recorded in my field log. I noticed that when I, the teacher and researcher, was circulating within the classroom to the various groups there was a positive effect on my students. The students seemed comforted knowing that I was there for them, and each time that I was able to be there for them to scaffold them, to reinforce, to assist them in the learning process, this seemed to increase their self-confidence.

Another question, which arose from my study was: What are the observed and reported experiences pertaining to student's behaviors and reactions to group work? As documented in my field log, and in the formative assessments recorded on the rubric for Cooperative Group Assessment, student behavioral progress was monitored, and there were obvious connections between group experiences and student behavior. To monitor their reactions to group work, and their progress with regard to positive and negative behaviors, would provide more information regarding group dynamics.

The third question that was formulated from my original study was: What are the observed and reported experiences with regard to the type of inquiry-based activity: guided inquiry, group activities, lab-based activities, and group project-based activities used in the classroom? In my original study, I was able to examine the students' academic understanding of the inquiry activities through examining the grades they earned. In addition, through the survey and interview I issued, I was able to gain more specific information regarding student preferences for learning. Specifically, information was gained as to individual student preference to the specific inquiry-based activities that I issued. However, greater detail and differences regarding the various types of inquiry-based activities could provide greater insight as to student learning preference.

Therefore, from my original study three related questions arose which could provide the basis for further research in the field of education as related to inquiry-based education.

**REFERENCES**

Beeth, M. E., & Huziak, T. (2001, January). *Inquiry-based research published in I-wonder: The journal for elementary school scientists.* Proceedings of the annual meeting of the Association for the Education of Teachers in Science, Costa Mesa, CA, 2-20. (ERIC Document Reproduction Service No. ED472902)

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., Krathwohl, D. R. (1956). *A taxonomy of educational objectives: Handbook 1: Cognitive domain.* New York: McKay.

Bolliger, D. U. (2004, October). *Investigating student learning in a constructivist multimedia-Ralph learning environment*. Paper presented at the 27th meeting of the Association for Educational Communications and Technology, Chicago, IL. (ERIC Document Reproduction Service No. ED485028)

Bottoms, G. (2002, April). *Raising the achievement of low performing students: What high schools can do.* Paper presented at The High School Symposium: Preparing America's Future, *Washington, DC*, (ERIC Reproduction Service No. ED465091)

Burbach, M. E., Matkin, G. S., & Fritz, S. M. (2004). Teaching critical thinking in an introductory leadership course utilizing active learning strategies: A confirmatory study. *College Student Journal, 38*(3), 1-13.

Carroll, L., & Leander, S. (2001). *Improving student motivation through the use of active learning strategies.* Master of Arts Action Research Project for Saint Xavier University. (ERIC Document Reproduction Service No. ED455961)

Colburn, A. (2004). Inquiring scientists want to know. *Educational Leadership, 62*(1), 63-66.

Delpit, L., & Dowdy, J. K. (2002). *The skin that we speak.* New York: The New Press.

Dewey, J. (1997). *Experience and education.* New York: Touchstone. (Original work published 1938)

Ely, M., Vinz, R., Downing, M., & Anzul, M. (1997). *On writing qualitative research: Living by words.* London: Falmer Press.

Fisher, N., Gerdes, K., Logue, T., Smith, L., & Zimmerman, I. (1998, May). *Improving students' knowledge and attitudes of science through the use of hands-on activities.* Dissertation Theses, Saint Xavier University at Chicago, Illinois. (ERIC Document Reproduction Service No. ED436352)

Freedman, R. (1998, January). *Constructivist assessment practices.* Paper presented at the annual meeting of the Association for Educators of

Teachers of Science, Minneapolis, IL. (ERIC Document Reproduction Service No. ED415118)

Freire, P. (2003). *Pedagogy of the oppressed* (M. B. Ramos, Trans., 30th Anniversity ed.). New York: Continuum. (Original work published 1970)

Grant, M. M., & Branch, R. M. (2005). Project-based learning in a middle school: Tracing abilities through the artifacts of learning. *Journal of Research on Technology in Education, 38*(1), 65-98.

Gupta, G. (2005). Progressive questioning. *Journal of College Science Teaching. 34*(4), 48-51.

Harada, V. H., & Yoshima, J. M. (2004). Moving from rote to inquiry: Creating learning that counts. *Library Media Connection, 23*(2)*,* 22-25.

Harwood, W. S. (2004). A new model for inquiry. *Journal of College Science Teaching,* 33(7), 29-33.

Holly, M. L., Arhar, J. M., & Kasten, W. C. (2005). *Action research for teachers: Traveling the yellow brick road* (2nd ed.) Upper Saddle River, NJ: Prentice-Hall.

Jones-Wilson, M. T. (2005). Teaching problem-solving skills without sacrificing course content*. Journal of College Science Teaching, 35*(1), 42-46.

Lee, S. U., & Fraser, B. J. (2001, March). High school science classroom learning environments in Korea*.* Paper presented at the The National

Association for Research in Science Teaching Annual Meeting, St. Louis, MO. (ERIC Document Reproduction Service No. ED452088)

MacLean, M., & Mohr, M. (1999). *Teacher-Researchers at work.* Berley, CA: The National Writing Project.

Mysliwiec, T., Dunbar, M. E., & Shibley, A., Jr. (2005). Learning outside the classroom: Practical suggestions for reorganizing courses to promote higher-order thinking. *Journal of College Science Teaching*, *34*(4), 36-39.

Polacek, K. M., & Keeling, E. L. (2005). Easy ways to promote inquiry in a laboratory course. *Journal of College Science Teaching, 35*(1), 52-55.

Polman, J. L. (2004). Dialogic activity structures for project-based learning environments. *Cognition and Instruction, 22*(4), 431-466.

Roth, W. M., & Bowen, G. M. (1995). Knowing and interacting: A study of culture, practices, and resources in a grade 8 open-inquiry science classroom guided by a cognitive apprenticeship metaphor. *Cognition and Instruction, 13*(1), 73-128.

Shapiro, W. L. (1999, April). Collaborative problem solving in a large-scale space science simulation. Paper presented at The American Educational Research Association Annual Meeting, Montreal, Canada. (ERIC Document Reproduction Service No. ED431599)

Swaak, J., de Jong, T., & van Joolingen, W. R. (2004). The effects of discovery learning and expository instruction on the acquisition of definitional and intuitive knowledge [Electronic version]. *Journal of Computer Assisted Learning, 20*(4)*,* 225-234.

Trowbridge, L. W., & Bybee, R. W. (1996). *Teaching secondary school science.* Englewood Cliffs, NJ: Prentice-Hall.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

White, B. Y., & Frederiksen, J. R. (1998). Inquiry modeling, and metacognition: Making science accessible to al students. *Cognition and Instruction, 16*(1), 3-118.

Wilson, V. (1996, November). Scholars, active learners, and social butterflies: Preferred learning styles of high school biology I students. Paper presented at the Annual Meeting of the Mid-South Educational Research Association. Tuscaloosa, AL. (ERIC Document Reproduction Service No. ED405366)

Zohar, A., & Dori, Y. J. (2003). Higher order thinking skills and low-achieving students: Are they mutually exclusive? *The Journal of the Learning Sciences, 12*(2), 145-181.

**RESOURCES**


Fearing, J. *Layers of the atmosphere.* Teacher's page. Retrieved September 8, 2006 from<http:// www.geosociety.org/educate/LessonPlans/Layers_of_Atmosphere.pdf.

*Glencoe physical science laboratory manual* (Student ed.). New York: Glencoe/McGraw-Hill.

*Prentice Hall earth science teacher's resource book.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

*Prentice Hall science explorer earth science laboratory manual.* (Student ed.). Upper Saddle River, NJ: Prentice-Hall, Inc.

*Scott Foresman-Addison Wesley science insights exploring earth and space skills worksheets.* Menlo Park, NJ: Addison Wesley Longman, Inc.

Smith, S. P., & Ford, B. A. (2001). *Project earth science: Meteorology*. (2nd ed.). Arlington, VA: NSTA press.

# APPENDIX A

August 28, 2006

Dear Parents and Guardians,

I am currently taking courses towards a Master's degree in curriculum and instruction at Moravian College. These courses assist me in implementing effective teaching methods and reflecting on my own teaching practices.

During this part of the semester, August 28th through December 15th, I am required to conduct a systematic research study of my own teaching. My research will examine the impact of increasing inquiry-based activities (lab work, hands-on activities, and project-based assignments) within the classroom. As a science teacher, I feel that these activities are crucial for student understanding of concepts, and therefore I already utilize these as methods of instruction. What I want to confirm or validate is the benefit of increasing these activities.

I will be gathering information to support my study through student surveys, interviews, work samples, observation and unit tests. All students will have the opportunity to provide feedback to me through these methods. I will only use information collected from students who have permission to participate in the study in any written reports of my research. All of the students' names will be kept confidential, as will the names of teachers and other staff. No names will be included on work samples or in any reports of my study. All research materials will be kept in a secure location in my home. All data gathered during the study will be destroyed at the conclusion of the study.

Since all students will be participating, no student will be singled out as a participant or non-participant. Your child will only be considered a subject in my study if I receive your written permission below. Your child may withdraw from the study at anytime without any penalty. Withdrawal **will not** affect your child's grades. If your child withdraws, I agree that I will not use any data pertaining to your child in any written reports of my research. Please notify me by phone, email, or in writing if your child wishes to withdrawal from the study.

If you have any questions or concerns about my research, please contact me at the school at (610) 250-2481 (phone) or email at sagaziot@easonsd.org . My faculty sponsor is Dr. Charlotte Zales. She can be contacted at Moravian College by phone at (610) 625-7958, or email at crzales@moravian.edu.

If you approve of your child being a participant in my teacher research, please sign and return the bottom portion of this letter. Thank you for your help.

Sincerely,
Mrs. Theresa R. Sagazio

---

I understand that Mrs. Theresa R. Sagazio will be observing and collecting data as part of her research on utilizing inquiry-based activities within her science classroom, and my child has permission to be a participant in the study.

Child's name: [redacted]

Parent/Guardian name [redacted] signature [redacted]

Date: 9/12/06

# APPENDIX B

## Individual Observation Checklist for Cooperative Group Activities

Name of Student______________________________________
Class______________________Date___________Period__________
Description of
Activity____________________________________________
Name of Evaluator____________________________________

**Ratings- + = Frequently**
**/ = Sometimes**
**- = Not Yet**

**Work Habits-** **DATE:____DATE:____DATE:____**

- Performs role in cooperative grp.________________________
- Work done on time ________________________
- Asks for help only when needed________________________
- Takes initiative ________________________

**Persistence-**

- Shows patience ________________________
- Checks work ________________________
- Revises where necessary ________________________
- Quality work ________________________

**Study Habits-**

- Organizes the work ________________________
- Uses time well ________________________
- Prepares daily ________________________
- Records necessary indiv. info. ________________________

**Social Skills-**

- Works well with others ________________________
- Listens to others ________________________
- Helps others w/in group- ________________________
- Converses quietly and effect. ________________________

**Strengths-**

**Not Yet-**

# APPENDIX C

**Science Survey Questions**
***Mrs. Sagazio***

**Directions-**Please circle the number that reflects **your** attitude towards the answer of the question being asked.

1. Do you enjoy learning science?
   **1-little or do not agree 2-somewhat agree 3-agree 4-mostly agree 5- agree strongly**
2. Do you think that by doing labs, they help you learn science better?
   **1-little or do not agree 2-somewhat agree 3-agree 4-mostly agree 5- agree strongly**
3. Do you think that learning science through receiving notes, and lecture and discussion, helps you learn science better?
   **1-little or do not agree 2-somewhat agree 3-agree 4-mostly agree 5- agree strongly**
4. Do you think that bookwork, meaning you reading, taking your own notes, and competing review worksheets helps you learn science better?
   **1-little or do not agree 2-somewhat agree 3-agree 4-mostly agree 5- agree strongly**
5. Do you think that completing projects helps you to learn science?
   **1-little or do not agree 2-somewhat agree 3-agree 4-mostly agree 5- agree strongly**
6. Do you think that some notes before and discussion before the lab, activity or project helps you understand the topic better?
   **1-little or do not agree 2-somewhat agree 3-agree 4-mostly agree 5- agree strongly**
7. Do you think that working by yourself for labs, activities, and projects helps you learn science better?
   **1-little or do not agree 2-somewhat agree 3-agree 4-mostly agree 5- agree strongly**
8. Do you think that working with other students (where the teacher picks the groups) for labs, activities, and projects, helps you learn science better?
   **1-little or do not agree 2-somewhat agree 3-agree 4-mostly agree 5- agree strongly**
9. Do you think that working with other students (where you can pick your own groups) for labs, activities, and projects, helps you learn science better?
   **1-little or do not agree 2-somewhat agree 3-agree 4-mostly agree 5- agree strongly**
10. Do you learn science better by "doing" (being active), rather than by "watching" (sitting and watching the teacher show you)?
    **1-little or do not agree 2-somewhat agree 3-agree 4-mostly agree 5- agree strongly**

# APPENDIX D

## Science Education Interview
**Mrs. Sagazio**

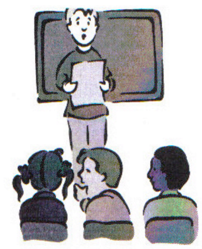
**Questions-**

1. Explain **how** you feel that you **learn science** best.-

2. Do you feel that you **enjoy science** more when you do **activities/projects/labs**?

3. **Other-**

# APPENDIX E



## Earth and Space Science

**Introduction To Earth and Space Science Activity**

A. **Directions-** Within your group, pretend that you are Earth Scientists, and you have the job of teaching others about Earth and Space Science. Brainstorm, and record descriptors of the areas of study that Earth and Space Science encompasses. Each group will share this with the class.

- Each member will record an area of study that comprises Earth and Space Science
- Take each members contribution and adhere to a "mini-poster"
- Each member will share with the class what they brainstormed.
- Speak loudly, and clearly
- List the group members, and area of study that each came up with on this sheet.
- After each group shares their "mini-poster" with the class, poster needs to be turned in as well.

**Group Members- Idea**

1.
2.
3.
4.

# APPENDIX F

## Earth and Space Science

**Scientific Method Activity**

A. **Directions-** Within your group, pretend that you are scientists, and think like them. You will be given a situation, and you need to solve the situation using the scientific method. Complete the outline as indicated below. Each group will share this with the class.

B. **Situation-** You live next to a large hillside that is exposed land (no plants, just soil) and every time that it rains, you notice a lot of soil is washed away. You are a team of scientists that are asked to logically figure out the problem, and then make a proposal to fix the problem.

C. **Scientific Method-**

1. **Problem-**
2. **Hypothesis-**
3. **Experiment-**
   - **Materials List-**
   - **Procedure-**
   - **Variables-**
4. **Analysis-** Explain how you would figure this out.
5. **Conclusion-** Explain how this would be determined.

# APPENDIX G

**EARTH AND SPACE SCIENCE**

**Lab Safety Activity**

**Directions-** Within your group, each member should sketch on the paper provided a picture depicting a laboratory safety rule. Beneath the picture, the rule should be written. Collectively, all individual sketches will be joined to make one group poster. Each member of the group will explain his/her different rule in a brief sharing with the entire class. Everyone will submit this sheet at the end of the group "mini" presentation.

- Be creative
- Use colored pencils/markers
- Use tape/glue to adhere all "mini" posters into one big one
- Use text
- Use computer
- Speak loudly when explaining your lab safety rule

**Group Members-** Record names of people in your group and safety rule each person will address.

1.

2.

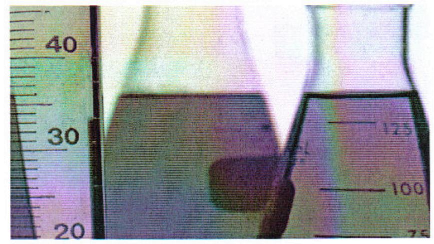
3.

4.

**Conclusion-**

1. Summarize the importance of Laboratory Safety in the classroom. Mention several lab safety rules that your group covered.

# APPENDIX H




## Measurement Lab

**Purpose-** This lab will help you to learn how to correctly measure length and mass, and make the necessary metric conversions. In addition to making measurements, you will apply your knowledge and problem-solve.

**Measuring Length-** Using a metric ruler measure each item precisely. Use decimals. Remember to write the units for each measurement.

| Object | cm | m | km |
|---|---|---|---|
| 1. Ruler- | | | |
| 2. Pencil- | | | |
| 3. Eraser- | | | |
| 4. School ID- | | | |

**Measuring Mass-** Using a balance, measure each of the following items precisely, and then make the necessary metric conversions. Think about what the **conversions** mean mathematically.

| Object | G | dG | mG | hG |
|---|---|---|---|---|
| 1. paper clip- | | | | |
| 2. pencil- | | | | |
| 3. eraser- | | | | |
| 4. watch- | | | | |
| 5. ruler- | | | | |

**Analysis and Conclusion-** Think like a Scientist and logically answer the following questions regarding measurements.

1. **What is meant mathematically by the conversion 1G = 1000mG?**

2. **Why does it take 1000mG to equal a Gram?**

3. **Explain what is meant when it is said that to convert from a larger unit to a smaller unit one must multiply. Why not divide?**

4. **If you were working in a lab, and were asked to find the equivalent amount in kG given 2 G, how would you solve for that problem?**

5. **If you were using a metric ruler and measured an item to be 4.3 cm, explain what that would mean.** (*hint- explain what 4 represents and what 3 represents)*

6. **What unit would you use to measure the mass of a grasshopper? Why?**

7. **What unit would you use to measure the mass of a human? Why?**

**8. When we measure mass we use a balance, how is that different than calculating weight?**

9. **From the data obtained when measuring length, which item had the greatest length? The least?**

**10. From your mass measurements, which item represented the least mass? Does this result surprise you? Explain.**

# APPENDIX I

## THE STRUCTURE OF EARTH'S ATMOSPHERE ACTIVITY

**EARTH AND SPACE SCIENCE**

**Directions-** Within your lab group, pretend you are a scientist collecting necessary background research on the topic of the structure of the Earth's atmosphere and your task is to complete the following.

1.) **Investigate and Sketch-** Find out what layers comprise our atmosphere. Then make a sketch of the layers as they exist. You may use the available textbooks, and laptop computers to assist you in this endeavor.

   a) **Label each layer**
   b) **Label elevations for each layer**
   c) **Draw in a minimum of 1 item located in each layer (Ex. Airplane, satellites, etc.)**

2.) **Define-** For each layer write a definition.

3.) **Share-** Within your group discuss your individual results.

# APPENDIX J

## Layers of the Atmosphere

**By Jack Fearing, Lincoln Junior High School, Hibbing, Minnesota**

**Teacher's Page**
**Objective:** To discover how the atmosphere can be divided into layers based on temperature changes at different heights, by making a graph. Students must read the background material, plot data points, and determine where layers begin and end from their comprehension of the reading material.

**Grade Level:** 6-10

**Time Required**: 35 - 45 minutes

**Materials:** No additional materials are needed.

**Background:** Students should know how to plot data on a graph with negative numbers. Go over the instructions carefully, reading the background paragraph aloud. Watch them carefully during the activity, making sure graphing is correct. They may need help understanding that they find the layer divisions based on what they read in the text.

**Evaluation**: Students should be graded on the correct plotting of the points in the table onto the graph. They should also label eight items on the graph: troposphere, tropopause, stratosphere, stratopause, mesosphere, mesopause, thermosphere and ozone layer.
Questions:
1. The variations in temperature changes.
2. troposphere: decrease
stratosphere: increase
mesosphere: decrease
thermosphere: increase
3. tropopause: about 12-18 km — about –60
stratopause: about 46-54 km — about –2 to 0
mesopause: about 85-90 km — about –90
4. The temperature increases in the stratosphere due to ozone layer capturing ultraviolet radiation. The temperature decreases in the mesosphere since there is no ozone and the amount of air is decreasing.
5. As solar energy hits the earth's surface, it is converted into heat. That heat radiates upward from the earth's surface. The farther away from the warm earth's surface we go, the less heat we feel until we hit the ozone layer in the stratosphere. The temperature of the troposphere therefore decreases steadily until the stratosphere.

By Jack Fearing, Lincoln Junior High School, Hibbing, Minnesota

Edited by Christine McLelland, Subaru Distinguished Earth Science Educator, 2002-2003, Geological Society of America, 3300 Penrose Place, Boulder, CO 80301
**Student's Pages follow:**

Name ________________________

# Layers of the Atmosphere

By Jack Fearing, Lincoln Junior High School, Hibbing, Minnesota

**OBJECTIVE:** To discover how the atmosphere can be divided into layers based on temperature changes at different heights, by making a graph.

**BACKGROUND:**
The atmosphere can be divided into four layers based on temperature variations. The layer closest to the Earth is called the troposphere. Above this layer is the stratosphere, followed by the mesosphere, then the thermosphere. The upper boundaries between these layers are known as the tropopause, the stratopause, and the mesopause, respectively.

Temperature variations in the four layers are due to the way solar energy is absorbed as it moves downward through the atmosphere. The Earth's surface is the primary absorber of solar energy. Some of this energy is reradiated by the Earth as heat, which warms the overlying troposphere. The global average temperature in the troposphere rapidly decreases with altitude until the tropopause, the boundary between the troposphere and the stratosphere.

The temperature begins to increase with altitude in the stratosphere. This warming is caused by a form of oxygen called ozone ($O_3$) absorbing ultraviolet radiation from the sun. Ozone protects us from most of the sun's ultraviolet radiation, which can cause cancer, genetic mutations, and sunburn. Scientists are concerned that human activity is contributing to a decrease in stratospheric ozone. Nitric oxide, which is the exhaust of high-flying jets, and chlorofluorocarbons (CFCs), which are used as refrigerants, may contribute to ozone depletion.

At the stratopause, the temperature stops increasing with altitude. The overlying mesosphere does not absorb solar radiation, so the temperature decreases with altitude. At the mesopause, the temperature begins to increase with altitude, and this trend continues in the thermosphere. Here solar radiation first hits the Earth's atmosphere and heats it. Because the atmosphere is so thin, a thermometer cannot measure the temperature accurately and special instruments are needed.

**DIRECTIONS:**
1. Table 1 contains the average temperature readings at various altitudes in the Earth's atmosphere. Plot this data on the graph on the worksheet, and connect adjacent points with a smooth curve. Be careful to plot the negative temperature numbers correctly. This profile provides a general picture of temperature at any given time and place; however, the actual temperature may deviate from the average values, particularly in the lower atmosphere.

**TABLE 1**
Average Temperature Readings at Various Altitudes

| Altitude (km) | Temp (°C) | Altitude (km) | Temp (°C) |
|---|---|---|---|
| 0 | 15 | 52 | -2 |
| 5 | -18 | 55 | -7 |
| 10 | -49 | 60 | -17 |
| 12 | -56 | 65 | -33 |
| 20 | -56 | 70 | -54 |
| 25 | -51 | 75 | -65 |
| 30 | -46 | 80 | -79 |
| 35 | -37 | 84 | -86 |
| 40 | -22 | 92 | -86 |
| 45 | -8 | 95 | -81 |
| 48 | -2 | 100 | -72 |

2. Label the different layers of the atmosphere and the separating boundaries between each layer.

3. Mark the general location of the ozone layer. You should place eight words on your graph in the correct locations: troposphere, tropopause, stratosphere, stratopause, mesosphere, mesopause, thermosphere and ozone layer.

**QUESTIONS:**
1. What is the basis for dividing the atmosphere into four layers?

2. Does the temperature increase or decrease with altitude in the:

troposphere? ______________ stratosphere? _________________

mesosphere? ______________ thermosphere? ________________

3. What is the approximate height and temperature of the:

tropopause: ________________ ______________

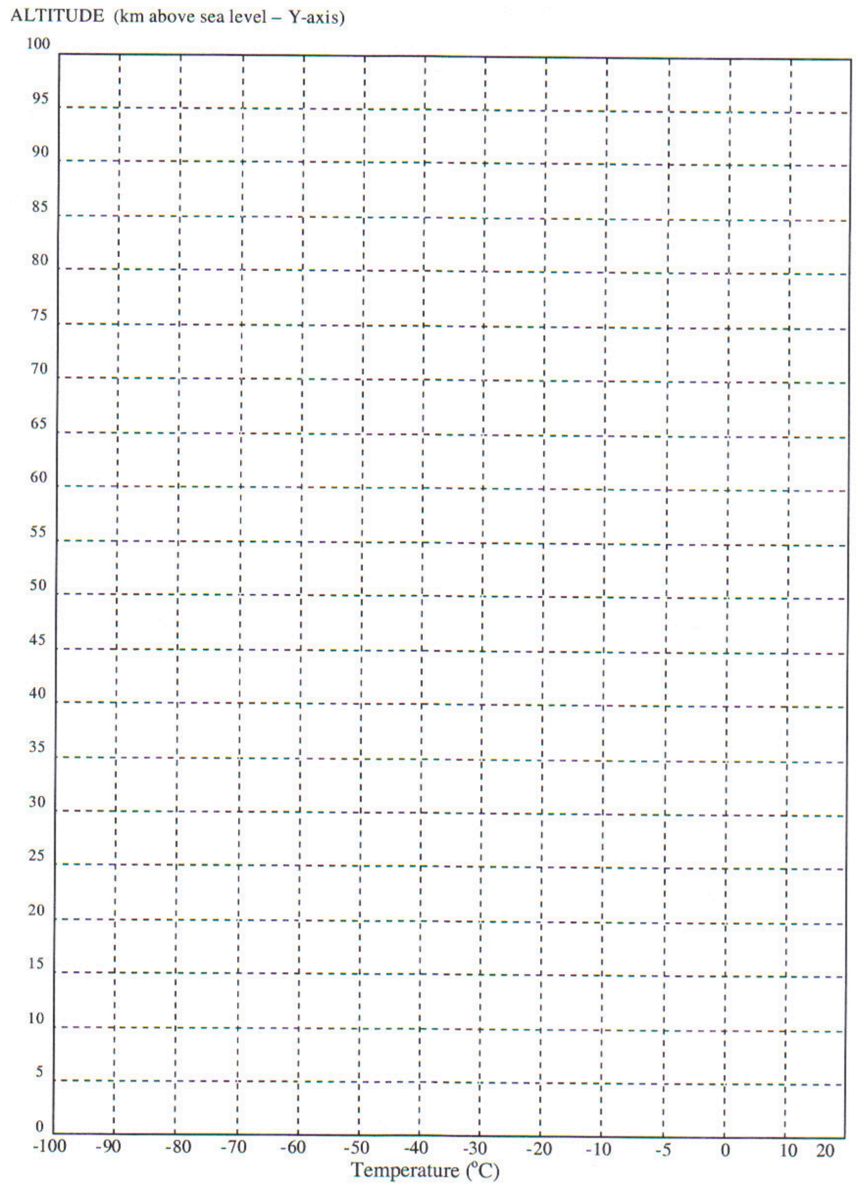
stratopause: ________________ ______________

mesopause: ________________ ______________

4. What causes the temperature to increase with height through the stratosphere, and decrease with height through the mesosphere?

5. What causes the temperature to decrease with height in the troposphere?

**Graph of Temperature at Various Altitudes**



# APPENDIX K

PROJECT- Earth's Atmosphere
Earth and Space Science
Mrs. Sagazio

A. Directions - Within your group, research your topic and prepare an oral presentation of your topic. You must utilize visuals within your presentation; Power Point, posters, transparencies, handouts, models, etc. are acceptable examples of visuals. Your presentation should be 5-7 minutes in length, including participation from all members. Use note cards with a prepared introduction, body and conclusion. Be certain to speak clearly and loudly, and maintain good eye contact.

*Topics*- Daily winds, Seasonal Winds, Hydrologic Cycle, Global Winds, Jet Stream, and Layers of the Atmosphere.

B. Due- ____________

C. Worth-____________

D. Group members and their individual jobs-

______________________________________________

______________________________________________

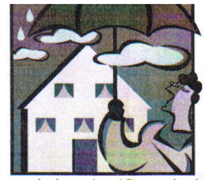
______________________________________________

______________________________________________

______________________________________________

E. Notes-

# APPENDIX L



## EARTH AND SPACE SCIENCE
### RELATIVE HUMIDITY LAB

DIRECTIONS- In your lab group of 4, think like a scientist and work through the scientific method. Record correct responses for scientific method as indicated below. Remember make precise calculations with proper units as indicated. Record the steps of your procedure. Hint, one person should pour 200mL over their hand. You will also have to record air temperature and time rate. See Data chart below.

**PROBLEM-**

**HYPOTHESIS-**

**SUGGESTED MATERIALS-** Beaker
Thermometer
Stop watch

**OTHER MATERIALS-**

**VARIABLES-**

**PROCEDURE-(List steps)**

**DATA-**

**DAY 1** Air Temperature________________, water temperature____________

Evaporation Time_________

**DAY 2** Air Temperature_______________, water temperature_____________

Evaporation Time_______________

**DAY 3** Air Temperature_________________, water temperature____________

Evaporation Time________________

**Day 4** Air Temperature_________________,water temperature_____________

Evaporation Time_________________

---

**ANALYSIS-** Record similar findings and/or differences with data.

**CONCLUSION-** Indicate whether or not your hypothesis was correct, incorrect, partially correct, etc. and explain why.

# APPENDIX M

Name ________________________________ Date ____________ Period _______

## Weather Observations

**Complete the following:**

A. Complete the Weather Observation Data Sheet for 3 days

B. Use the current weather map at www.weather.com, to draw, in color, the weather map for each observation day.

C. Answer the questions on this page.

---

1. What is the relationship between the type of pressure in an area and the general weather conditions?

2. What does a warm front look like, how about a cold front?

3. A mixed red and blue line on a weather map is what type of front?

4. Wind is caused by?

5. In what direction is the general movement of weather in the US?

6. What is the relationship between the type of front moving through an area and the general weather it brings with it?

7. How similar were the **current conditions** on the 3 websites you used? Were there any major differences?

8. How similar were the **predicted conditions** on the 3 websites you used? Were there any major differences?

9. What type of trends in the US weather did you notice when drawing you weather maps? Was there any severe weather occurring any where in the US during your observations?

Name ________________________________ Date ____________ Period _______

Weather Observations Data Sheet

**Day #1 Date** ___________

**#1 Record the current conditions from the following:**

**National Weather Service**, http://weather.noaa.gov/weather/current/KABE.html

| Conditions | Wind | Temperature | Relative Hum | Air Pressure |
|---|---|---|---|---|
| | | | | |

**Weather Channel,** www.weather.com/weather/local/18045

| Conditions | Wind | Temperature | Relative Hum | Air Pressure |
|---|---|---|---|---|
| | | | | |

**Weather Underground**
http://www.wunderground.com/US/PA/Easton.html?bannertypeclick=big2

| Conditions | Wind | Temperature | Relative Hum | Air Pressure |
|---|---|---|---|---|
| | | | | |

---

**#2 Record the forecast from the following**

**National Weather Service**, http://weather.noaa.gov/weather/current/KABE.html

| | Today | Tomorrow | 3-Day | 5-Day | 7- Day |
|---|---|---|---|---|---|
| **Weather** | | | | | |
| **High Temp** | | | | | |
| **Low Temp** | | | | | |

**Weather Channel,** www.weather.com/weather/local/18045

| | Today | Tomorrow | 3-Day | 5-Day | 7- Day |
|---|---|---|---|---|---|
| **Weather** | | | | | |
| **High Temp** | | | | | |
| **Low Temp** | | | | | |

**Weather Underground**
http://www.wunderground.com/US/PA/Easton.html?bannertypeclick=big2

| | Today | Tomorrow | 3-Day | 5-Day | 7- Day |
|---|---|---|---|---|---|
| **Weather** | | | | | |
| **High Temp** | | | | | |
| **Low Temp** | | | | | |

Name ________________________________ Date ____________ Period _______

Weather Observations Data Sheet

**Day #2 Date** ___________

**#1 Record the current conditions from the following:**

**National Weather Service**, http://weather.noaa.gov/weather/current/KABE.html

| Conditions | Wind | Temperature | Relative Hum | Air Pressure |
|---|---|---|---|---|
| | | | | |

**Weather Channel,** www.weather.com/weather/local/18045

| Conditions | Wind | Temperature | Relative Hum | Air Pressure |
|---|---|---|---|---|
| | | | | |

**Weather Underground**
http://www.wunderground.com/US/PA/Easton.html?bannertypeclick=big2

| Conditions | Wind | Temperature | Relative Hum | Air Pressure |
|---|---|---|---|---|
| | | | | |

---

**#2 Record the forecast from the following**

**National Weather Service**, http://weather.noaa.gov/weather/current/KABE.html

| | Today | Tomorrow | 3-Day | 5-Day | 7- Day |
|---|---|---|---|---|---|
| **Weather** | | | | | |
| **High Temp** | | | | | |
| **Low Temp** | | | | | |

**Weather Channel,** www.weather.com/weather/local/18045

| | Today | Tomorrow | 3-Day | 5-Day | 7- Day |
|---|---|---|---|---|---|
| **Weather** | | | | | |
| **High Temp** | | | | | |
| **Low Temp** | | | | | |

**Weather Underground**
http://www.wunderground.com/US/PA/Easton.html?bannertypeclick=big2

| | Today | Tomorrow | 3-Day | 5-Day | 7- Day |
|---|---|---|---|---|---|
| **Weather** | | | | | |
| **High Temp** | | | | | |
| **Low Temp** | | | | | |

Name ________________________________ Date ____________ Period _______

Weather Observations Data Sheet

**Day #3 Date** ___________

**#1 Record the current conditions from the following:**

**National Weather Service**, http://weather.noaa.gov/weather/current/KABE.html

| Conditions | Wind | Temperature | Relative Hum | Air Pressure |
|---|---|---|---|---|
| | | | | |

**Weather Channel,** www.weather.com/weather/local/18045

| Conditions | Wind | Temperature | Relative Hum | Air Pressure |
|---|---|---|---|---|
| | | | | |

**Weather Underground**
http://www.wunderground.com/US/PA/Easton.html?bannertypeclick=big2

| Conditions | Wind | Temperature | Relative Hum | Air Pressure |
|---|---|---|---|---|
| | | | | |

---

**#2 Record the forecast from the following**

**National Weather Service**, http://weather.noaa.gov/weather/current/KABE.html

| | Today | Tomorrow | 3-Day | 5-Day | 7- Day |
|---|---|---|---|---|---|
| Weather | | | | | |
| High Temp | | | | | |
| Low Temp | | | | | |

**Weather Channel,** www.weather.com/weather/local/18045

| | Today | Tomorrow | 3-Day | 5-Day | 7- Day |
|---|---|---|---|---|---|
| Weather | | | | | |
| High Temp | | | | | |
| Low Temp | | | | | |

**Weather Underground**
http://www.wunderground.com/US/PA/Easton.html?bannertypeclick=big2

| | Today | Tomorrow | 3-Day | 5-Day | 7- Day |
|---|---|---|---|---|---|
| Weather | | | | | |
| High Temp | | | | | |
| Low Temp | | | | | |

Data Sheet

# Weather Map

Date:

# APPENDIX N

Name ______________________________ Date _________ Period ________

## Barometer Lab

***During this lab activity, you will research, build, and collect data from a barometer. You will run an experiment using your barometer and write up your results in a formal lab report. This lab will be worth 85 points.***

**Requirements**

**Step #1 –** Research how to build a homemade barometer, utilizing the Internet. Print a set of **instructions** and **list of materials** that you will need to construct your barometer. Bring this set of instructions and all the materials listed on your materials list to class on the due date.
**Due _________ Worth: 10pts**

**Step #2 – Build** a working barometer, using your collected materials and instructions.
**Due _________ Worth: 10pts**

**Step #3 –** Develop a **title** and **hypothesis** for your barometer experiment.
**Due _________ Worth: 5pts**

**Step #4 –** Design a **data table** to collect your experiment's data.
**Due _________ Worth: 5pts**

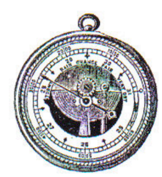
**Step #5 – Collect** data from your barometer and make observations about the **daily** weather for 10 class periods (2 weeks).
**Due _________ Worth: 10pts**

**Step #6** – Write up a **materials list** for your experiment.
**Due _________ Worth: 5pts**

**Step #7** – Write up a **procedure** for your experiment, including construction of your barometer and data collection.
**Due _________ Worth: 5pts**

**Step #8** – Results, create your **final data table** and **graph** to display your findings.
**Due _________ Worth: 5pts**

**Step #9** – Write the **conclusion** for your experiment.
**Due _________ Worth: 5pts**



**Step #10** – Put it all together into the **final draft of your lab report**.
**Due _________ Worth: 25pts**

*Lack of class participation will result in a deduction of 5 points per day.
*Each member of the group is expected to contribute to the project, and no credit will be given to students who do not help their fellow group members complete the project.

# APPENDIX O

LAB – COOLING AND HEATING RATES OF LAND COMPARED TO WATER SURFACES

DIRECTIONS- Complete the following. Measurements should be precise.

MATERIALS-
Heat source (lamp)
Soil
Beakers
Thermometers x2
Clock or Timer

PROCEDURE
1. Place the same volume of soil & water in 2 different beakers. Record volume in Data – Observations.
2. Place a thermometer in the soil and record temperature in Data – Observations.
3. Place thermometer in the water and record temperature in Data – Observations.
4. Place both containers under heat lamp, turn it on and allow it to remain on for exactly 10 min. Record temperature of soil and water in Data – Observations.
5. At end of 10 min. heating cycle, turn off the lamp, and remove it immediately.
6. Record the temperature of both soil and water every minute for 10 minutes. Enter data in the Data-Observations.

DATA – OBSERVATIONS

1. volume of soil -------------.
2. Volume of water -------------.
3. Soil temperature (original)-----------.
4. Water temperature (original)-----------.
5. Soil temperature - after 10 min. of light-------------.
6. Water temperature – after 10 min. of light -----------.
7. Soil temp. ( Every min. for 10 min. ) 1.----------2.---------3.----------4.----------5.---------6.----------

   7.------------8.------------9.-------------10.-------------.
8. Water temp. (Every min. for 10 min. )1.---------2.---------3.----------4.-----------5.----------6.----------

   7.------------8.-------------9.-------------10.-------------.

CONCLUSION

1. What do your results indicate?

2. How do your results relate to concepts, such as; land and sea breezes ?

# APPENDIX P

## PROJECT PRESENTATION RUBRIC
## Earth and Space Science
## Mrs, Sagazio

TITLE________________________

POINTS________________________

DATE OF PRESENTATION__________

**Content Knowledge:**

**Topic**

| 5(13-12) | 4(11) | 3(10) | 2(9-8) | 1(7) |
|---|---|---|---|---|
| *able to cover all | * covers most | * some | * small | * none |

**Questions**

| 5(13-12) | 4(11) | 3(10) | 2(9-8) | 1(7) |
|---|---|---|---|---|
| * answers all | * most | *some | *few | * none |

**Visuals**

| 5(13-12) | 4(11) | 3(10) | 2(9-8) | 1(7) |
|---|---|---|---|---|
| * depicts underst. | * most | * some | *small | *none |

**Presentation:**

**Eye contact**

| 5(13-12) | 4(11) | 3(10) | 2(9-8) | 1(7) |
|---|---|---|---|---|
| *majority time | * good | * fair | *some | *none |

**Speech**

| 5(13-12) | 4(11) | 3(10) | 2(9-8) | 1(7) |
|---|---|---|---|---|
| *clear/loud | * good | * fair | * some | *none |

**Flow**

| 5(13-12) | 4(11) | 3(10) | 2(9-8) | 1(7) |
|---|---|---|---|---|
| *smooth entirely | * mostly smooth | * fair | * some | *none |

**Summary Sheet**

| 5(20) | 4(18) | 3(16) | 2(14) | 1(11) |
|---|---|---|---|---|
| *contains all | *most | *some | * small | *none |

TOTAL________________________________

# APPENDIX Q

MORAVIAN COLLEGE
A SMALL NATIONAL TREASURE
1742

Department of Education
1200 Main Street
Bethlehem, Pennsylvania 18018-6650
TEL 610 861-1558
FAX 610 861-1696
WEB www.moravian.edu

May 12, 2006

Dear [redacted]

During the 2006 Fall Semester I will be taking courses towards a Master's Degree in Curriculum and Instruction at Moravian College. These courses will help me stay in touch with the most effective ways of teaching in order to provide the best learning experience for the students.

Moravian's Program requires that I conduct a systematic research study of my own teaching practices. The focus of my research this semester is assessing student performance through increasing inquiry-based activities as a mode of instruction within the science classroom. This study will take place the fall semester of 2006.

As part of my study on the use of inquiry-based activities, I will be gathering information to support my study through student surveys, interviews, work samples, observation and unit tests. There are no anticipated risks in this study.

All students in my classroom will be involved in the use of inquiry-based activities as part of the earth and space science curriculum. However, participation in this study is entirely voluntary and will not affect the child's grade in any way. Any student may withdrawal from the study at any time. If a child is withdrawn, or the parent or guardian chooses not to have them be a part of the study, I will not use any information pertaining to that child in my study.

All student names will be kept confidential. The name of any student, faculty member, or cooperating teacher will not appear in any written report or publication of the study or its findings. Only my name and the name of my sponsoring professors will appear in this study. Minor details of the student's writing may be altered to ensure confidentiality. All research materials will be secured in a protected location.

My faculty sponsor is Dr. Charlotte Zales. She can be contacted at Moravian College by phone at (610) 625-7958 or e-mail at crzales@moravian.edu.

If you have any questions or concerns about my in-class project, please feel free to contact me. If not, please sign and return the bottom portion of this letter. Thank you for your help.

Sincerely,
Theresa R. Sagazio
Theresa R. Sagazio

---

I attest that I am the principal of the teacher conducting this research study, that I have read and understand this consent form, and received a copy. Theresa Sagazio has my permission to conduct this study at Easton A[redacted]

Principal's signature: [redacted]

Date: 5/16/06

# APPENDIX R

1 7 4 2

MORAVIAN COLLEGE

August 18, 2006

Theresa R. Sagazio
12 George Avenue
Nazareth, PA 18064

Dear Theresa R. Sagazio:

The Moravian College Human Subjects Internal Review Board has accepted your proposal: "Inquiry Based Activities for Lower Ability Groups in the Science Classroom." Given the materials submitted, your proposal received an expedited review. A copy of your proposal will remain with the HSIRB Chair.

Please note that if you intend on venturing into other topics than the ones indicated in your proposal, you must inform the HSIRB about what those topics will be.

Should any other aspect of your research change or extend past one year of the date of this letter, you must file those changes or extensions with the HSIRB before implementation.

This letter has been sent to you through U.S. Mail and e-mail. Please do not hesitate to contact me by telephone (610-861-1415) or through e-mail (medwh02@moravian.edu) should you have any questions about the committee's requests.

Debra Wetcher-Hendricks
Chair, Human Subjects Internal Review Board
Moravian College
610-861-1415

1200 MAIN STREET • BETHLEHEM, PENNSYLVANIA 18018-6650 • (610) 861-1300