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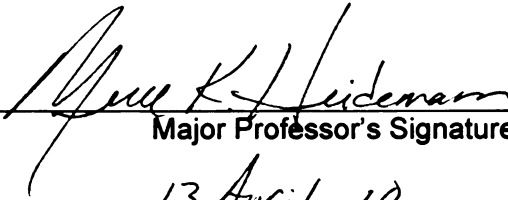
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**IMPROVING STUDENT COMPREHENSION OF WEATHER
THROUGH HANDS-ON ACTIVITIES**

By

Kimberly Marie Saffron

A THESIS

**Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of**

MASTERS OF SCIENCE

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ABSTRACT

IMPROVING STUDENT COMPREHENSION OF WEATHER THROUGH HANDS-ON LEARNING

By

Kimberly Marie Saffron

The main goal of this research project is to promote student interest and enhance learning during instruction of a three-week unit on weather. The unit is part of a nine-week elective course for 10-12 graders titled Weather, Climate, and Space. My goal in developing this unit was to make it more student-centered. This was accomplished through developing a series of individual and group hands-on activities for students. Demonstrations, educational videos, lecture, writing assignments, and class discussion were also incorporated. A general survey of likes, dislikes, and learning styles was administered along with a pretest and posttest in order to measure student comprehension of the material presented. After each activity, students were asked to share their thoughts about the activity and if they thought it assisted them in learning the concepts presented in class. For every hands-on activity, the majority of students commented that they felt the activity was helpful to increasing their comprehension of weather. Assessments indicated an increase in student comprehension of weather topics.

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INTRODUCTION

Teaching science today can be challenging. Educators may encounter obstacles relating to class size, lack of materials, discipline, or parental support. Students may have personal issues that affect their ability to learn. Teachers are often required to instruct on specific topics and perform specific activities in order to meet required benchmarks. In addition, uninterested and unmotivated students make effective teaching and learning that much more difficult. Regardless of the situation, there are teaching techniques that can be used to increase student motivation, comprehension and retention of material being taught. To achieve this, classroom material can be taught in a variety of ways to catch and keep the attention of the learners (Williams, 2006). Learning can be guided at times but should also allow for learning through personal experience. Activities should be relevant and meaningful to engage student interest and increase motivation. Students should be given numerous opportunities to develop skills and learn through trial and error. The Constructivist Theory based on Jean Piaget's work, tells us that it is only by direct, active, hands-on exploration and learning from our own errors that a person can optimally learn (Smilkstein, 1991). In addition, students need to take an active role in constantly evaluating their learning strategies and level of understanding. Educators can assist students by encouraging self-evaluation and by providing feedback. By doing so, students become aware of their own learning, feedback becomes more meaningful, and students will have a more effective learning experience (Bransford, et. al, 1999).

I chose to design a unit on weather in order to increase my knowledge of the subject and to increase my repertoire of weather related activities in order to make learning about weather more relevant and interesting for my students and me. Prior to

developing the unit on weather, I taught weather in the class *Weather, Climate, Space* for one semester at West High School in Davenport, Iowa. Unfamiliar to the concepts relating to meteorology and how to convey them to students, the class was mainly teacher-centered. I would lecture for part of class while students took notes from the overhead. At times students would take turns reading the text aloud, work on a worksheet or two pertaining to the class reading, and occasionally watch an educational video relating to the current weather topic. This was boring for me and for the students. Some students would tune out shortly after class began, putting their head down, talking to other students, or finding another activity to keep themselves quietly amused. Students would often complain about the quantity of worksheets they were responsible for completing. It quickly became clear to me that I needed to change my teaching approach in order to get my students attention and increase student comprehension of weather topics. I needed to get them actively participating, increase their motivation, and get them excited about weather. I decided to begin developing a weather unit that included various activities including more hands-on activities for students.

In order to determine the best teaching strategies, one must understand how the human brain “learns”. As the human brain gathers information from the world, it seeks to detect patterns in order to make sense of the world and to build what are called “programs” (Hart, 1999). A program is a sequence of steps or actions, intended to achieve some goal. The human brain creates and stores a program for everything. A program may be as simple as responding to a question with a “yes” or “no,” or it may be more complicated such as solving a physics problem using various types of mathematical computations and reasoning. On a daily basis, we take in information from our

surroundings, decide what it is we are sensing and what the reaction will be. When we interpret something new, our brain searches for previous programs or knowledge of a similar nature or alters an existing program to accomplish the new task at hand. Students are normally “motivated to learn, if they feel that what they are learning will give them a better understanding of the world (by grasping patterns) and how it works (gaining more control over it by building programs)” (Hart, 1999). Learning is also influenced by a number of factors including physical environment, physical and emotional state of the student, and a student’s cognitive ability. For this reason, students should be given various opportunities within the classroom to “practice” hands-on science, allowing them to become engaged in relevant and interesting problem solving. Educators can promote learning by arranging “the conditions of the learner's environment so that the processes of learning will be activated, supported, enhanced, and maintained” (Hart, 1999).

Science is not just about gaining knowledge about the world around us or memorizing facts; it involves ways of thinking and doing (American Association For The Advancement of Science, 1990). For this reason, students should be given as many opportunities inside and outside of the classroom as possible to experience the kinds of thoughts and actions that are typical of various science fields. Students should be able to practice asking questions, make observations, collect specimens and data, measure, and analyze. By giving students opportunities to experience, manipulate and observe the real world or simulations of the real world, learning becomes relevant, rewarding, and engaging. (Carbone and Power, 2004). This supports true learning as, “most people will not learn anything unless it is relevant to them” (Jensen 1997). The brain does not adapt to senseless tasks. Learning similar concepts in various contexts also increases the

probability of task transfer into new environments (Jensen 1997).

When planning lessons, educators should take into account that every student is unique. Each student that comes into the classroom has a background, prior knowledge, skills, abilities, styles and values that are specific to him/her (Linder, 2003). Teachers should take this into account when preparing lessons and activities in order to make them more relevant and meaningful to students. This requires that teachers discover what students already know about the topic at hand. “Prior knowledge fundamentally influences whether and how a student will gain an accurate or deep understanding of the topic” (Jensen, 2005). This can be accomplished by asking students questions or having students write down what they already know. This allows the educator to challenge false beliefs. Then by asking students to make connections to accurate information real learning begins (Jensen, 2005).

The likelihood that any given classroom contains a group of individuals with identical intelligence strengths and preferred methods of learning is highly unlikely. Some students may excel linguistically, while others may be more logical/mathematical, kinesthetic, musical or a combination of these (Viens, 1999). By incorporating multimodality teaching techniques, such as lecture, demonstrations, media, various types of hands-on activities, discussions, individual and group work, teachers provide varying opportunities for students to draw on their strengths maximizing learning opportunities. When teachers identify students' learning styles and plan activities that support these styles of learning, students will be motivated to learn and get “caught up in the learning experience” (Williams, 2006). Brain research has also demonstrated that, “the more locations in the brain that are engaged in learning and memory, the better the learning and

the sharper the recall” (Jensen, 2005). In other words, various activities that allow students to use a variety of senses and become emotionally involved will assist in activating multiple memory pathways within the brain.

Ideas about Teaching Weather

Weather is the state of the air in the atmosphere at a particular place at a particular time. Weather is constantly changing as the gasses in the troposphere move to distribute heat energy from the sun. Understanding meteorological phenomena can be difficult as students must be familiar with physical science concepts such as temperature, density, the nature of gases, air pressure, and the water cycle to name a few. (Papadimitriou and Londridou, 2001). To increase understanding of atmospheric processes, students should have the opportunity to relate theoretical concepts to personal experiences (Carbone and Power, 2004). This can be accomplished through daily weather observations and actively exploring explanations for what they see. In a study by Carbone and Power (2004), when students kept a daily weather journal, their observations became more detailed and with time, included explanations. Utilizing real time weather data via the computer allowed for students to become familiar with concepts such as monitoring, data collection and analysis, visualization, bias with data sets, and the importance of databases to support research and learning. In addition, allowing for personal experience increased interest in the local environment, reinforced concepts in meteorology, introduced fundamental science concepts, lead to refined personal observations and allowed students to understand how meteorological phenomena vary over space (using various collection stations). If maximal learning is going to occur, including hands-on activities that

include personal experiences are great ways to encourage synthesis, improve comprehension, and make learning exciting.

Reading and interpreting meteorological maps can be another challenge for both teachers to teach and for students to learn (Meyer, 2006). Abstract thinking is required to visualize and comprehend three-dimensional weather phenomenon from a two-dimensional map in a textbook or on the overhead. Atmospheric pressure, for example, is one of the more prominent features on a surface weather map that students struggle with (Meyer, 2006). One strategy to better visualize and understand meteorological concepts and processes is to construct a 3-D surface weather map. In addition to the final product being a learning aid for students, there is a degree of physical input, emotional involvement, and active thinking involved with the task of building the map. Without this “doing” or “acting,” along with immediate feedback, substantial learning of new or changed programs will not occur (Hart, 1999).

As I developed my unit on meteorology, I utilized a constructivist approach as much as possible. My biggest goal was to incorporate more hands-on activities that would allow students to become actively engaged in the learning process, improve comprehension, and have fun at the same time. True learning only occurs with personal hands-on learning through trial and error. In addition, I took into consideration students’ prior knowledge and utilized a variety of teaching modalities in order to support varying learning styles and interests to make lessons more personal. As I continue to teach my unit on weather, I expect to incorporate more activities to enhance and improve the unit. If a variety of teaching resources are utilized with a focus on hands-on activities, then I expect students in Weather, Climate, Space will be more engaged in learning and

improve their comprehension of weather.

School Profile

West High School is a public school for ninth through twelfth grades located in Davenport, Iowa. For the second count of the 2008-2009 school year enrollment was at 1930 students. Of those students 469 (24.3%) were identified as students of color. Just under half of the enrolled students (45.7%) or 882 students qualified for free or reduced price lunch.

To examine and compare student's ability in a variety of subject areas, the Davenport School district uses what is called the Iowa Tests of Educational Development or ITED. Reviewing ITED science and reading assessment data collected each school year from 2006 to 2008, shows that the number of students proficient in these areas have decreased in reading and science comprehension for the ninth and tenth grades. For 2008, the ninth grade scores are slightly above district average. For the eleventh grade, reading scores declined and science scores increased. Although not part of the ITED, the ACT score for twelve graders remained unchanged at 20.5 for all three years.

(<http://www.davenportschools.org/schools/profiles/west.pdf>)(Table 1)

Table 1—2006-2008 ITED Percent Proficient for Reading, Quantitative Reasoning, and Science--West High School

Grade	Subject Area	% Proficient		
		2006-2007	2007-2008	2008-2009
9 th grade	Reading	57.2	56.1	54.6
	Quantitative Reasoning	54.2	55.5	56.3
	Science	59.5	60	57.4
10 th grade	Reading	61.9	64.7	55.3
	Quantitative Reasoning	60.9	61.1	57.6

	Science	65.6	65.1	58
11 th grade	Reading	70.6	69.6	67.7
	Quantitative Reasoning	66.3	72.3	65.4
	Science	67.0	70.5	73.3

Table 1 continued

Although overall ITED scores have increased over time, the scores did not improve enough to meet the annual mandated objectives (AMOs) set by the Iowa Department of Education for the 2007-2008 school year or for the federal No Child Left Behind (NCLB) legislation. For this reason, West High School has been designated as a School in Need of Assistance by the Iowa Department of Education. The Davenport Community School District has also been designated as a District in Need of Assistance. This simply means that West High School has developed a comprehensive school improvement plan (CSIP), with measurable objectives, that outlines what the school and the district are doing to raise student achievement in deficient areas to proficient levels.

Class Profile

West High School is in session for 178 school days per year. There are four terms, each approximately 9 weeks long. Classes are 90 minutes long with the same four classes meeting every day during each term. Weather, Climate, Space (WCS) is a nine - week class that includes learning about space for approximately six weeks and up to three weeks of weather and climate. Students begin the class by exploring characteristics and movement of the Earth and Moon in relationship with other objects in space such as other planets, moons, asteroids, and comets. They then learn about what makes up our universe, classification of galaxies and the life cycle of stars, and the structure and activity of our sun. Students differentiate between asteroids, comets, and meteoroids and

throughout the class identify the tools used by astronomers to study objects in space.

After six or seven weeks, the focus is turned toward weather and climate. First is the examination of the composition of earth's atmosphere, energy transfer, and atmospheric circulation. Next students study humidity, how it is measured, cloud formation and classification. Students learn about the mechanisms that produce weather. They examine air masses, types of fronts, and severe weather. Finally they look at factors that can affect climate and climate change such as global warming and what can be done to reduce human impact on climate change.

The Davenport School District requires three years of science for graduation. When I began the research for my thesis in the summer of 2007, Weather, Climate, Space was a general ninth grade class, meaning that most incoming freshman would take the class sometime during their freshman year. After completing WCS, students would then move on to take biology, then chemistry, physics or an elective science class. During the development of the weather unit, however, the curriculum was altered making biology a general ninth grade science class. Weather, Climate, Space is now offered to tenth through twelfth graders with no prerequisites. Students are generally placed in their science classes based on their interests and/or by teacher recommendation.

The unit was presented to one Weather, Climate, Space class with a total of 26 students: 4 ninth graders, 20 tenth graders, and 2 eleventh graders. Nine were female, 17 were male. Out of 26 students, 4 were identified as students of color. There were 8 special education students in the classroom. During the teaching of the weather unit, three teachers were present and assisted students when needed: the classroom teacher, a special education teacher, and myself. During the presentation of the weather unit, I was

a guest teacher in another teacher's classroom as I was no longer teaching for the district. I was present in the classroom one week prior to beginning the weather unit and remained with the class until the end of the semester.

The data in this study were generated by 13 students (6 female, 7 male) who submitted signed consent forms (Appendix A). Students had an adequate time period to share the forms with their parent/guardian and return it to me in a timely manner. Extra copies were available if original copies were lost.

IMPLEMENTATION

I began the weather unit the fifth week of school. Students completed the unit on space with the classroom teacher and then I began the unit on meteorology with the students. There were initially 13 activities and 3 demonstrations planned for the unit. Due to time constraints, only 5 of the activities and 3 demonstrations were utilized. The unit outline with corresponding planned activities and objectives are located in Table 2. Activities used during the teaching of this unit are marked with an asterisk (*). Each activity will later be described in greater detail.

Table 2—Unit Outline with Objectives

Topics	Activities	Objectives
Ch. 22--The Atmosphere		
Characteristics of the Atmosphere	*Demo: Is Air a Fluid?	Describe the composition of the Earth's atmosphere
Pressure vs. Temperature	*Demo: Crushing Can	Explain how two types of barometers work
Measuring pressure	Activity: Factors Affecting Gasses and their Interactions	Identify the layers of the atmosphere
Layers of the Atmosphere		Identify two effects of air pollution
Temperature Inversions	*Activity: Mapping the Atmosphere	
Solar Energy and the Atmosphere	*Activity: Energy Absorption and Reflection	Explain how radiant energy reaches Earth.
Radiation, Conduction, Convection	Activity: Building a Hot Air Balloon	Describe how visible light and infrared energy warm Earth
Scattering & reflection	*Demo: Conduction & Convection	
The Greenhouse Effect		Summarize the processes of radiation, conduction, and convection

Table 2 Continued		
Atmospheric Circulation Coriolis Effect Global & local winds	Activity: Graphic Organizers	Explain the Coriolis effect Describe the global patterns of air circulation, and name three global wind belts Identify two factors that form local wind patterns
Ch. 23—Water in the Atmosphere		
Atmospheric Moisture Changing forms of water	*Activity: The Water Cycle	Explain how heat energy affects the changing phases of water
Humidity Dew point	*Activity: Determining Relative Humidity	Explain relative humidity and how it is measured. Describe what happens when the temperature of air decreases to the dew point or below the dew point
Clouds & Fog Cloud classification Precipitation	Activity: Clouds in a Jar Activity: Cloud Formation Classroom Activity Activity: Outside Weather Observations	Describe the conditions that are necessary for clouds to form. Identify the three types of clouds Describe four ways in which fog can form.
Ch. 24 Weather		
Air Masses		Explain how an air mass forms. List the four main types of air masses. Describe how air masses affect the weather of North America
Fronts	Activity: Weather Forecasting	Compare the characteristic weather patterns of cold fronts with those of warm fronts. Describe the development of hurricanes, thunderstorms, and tornadoes.

Table 2 Continued		
Weather Instruments		Identify four instruments that measure lower-atmospheric weather conditions.
Forecasting Weather	*Activity: Building a 3-D Surface Weather Map	Explain how a weather map is created.
Ch. 25 Climate		
Factors that Affect Climate Temperature & Precipitation Heat Absorption & Release Topography	Activity: Factors That Affect Climate	Identify two major factors used to describe climate Explain how latitudes determines the amount of solar energy received on Earth. Describe how the different rates at which land and water are heated affect climate Explain the effects of topography on climate
Climate zones		Describe three main types of climates.
Climate Change		Describe four factors that may cause climate change. Identify potential impacts of climate change. Identify ways that humans can minimize their effect on climate change.

The unit began by administering a Pre-unit survey (Appendix B) and Pretest (Appendix C). The survey was given in order to gain insight as to what subject areas students liked/disliked, what their attitudes of science were, what their plans were after high school and what sort of classroom activities they felt helped them to be successful. The pretest was given to check for prior knowledge and to compare knowledge before and after the weather unit was taught. The pretest was a set of twelve open ended questions relating to weather.

Each day begin with a review of what was done the previous day with time to answer any student questions. To increase student participation and in order to check for student comprehension, warm-up questions relating to weather were given and then discussed. Almost every day the students had a hands-on project to work on. Activities such as “Mapping the Atmosphere,” “Energy Absorption and Reflection,” and “Building a 3-D Surface Weather Map” each required two days to complete. “The Water Cycle” and “Determining Relative Humidity” were completed in one day. In addition to the hands-on activities, I incorporated demonstrations, lecture with note taking (using PowerPoint), educational videos, warm-up questions, and review worksheets. At the end of the unit, students were administered a Posttest (Appendix C) identical to the Pretest and a multiple choice Final Exam (Appendix C). Finally they completed a Post-unit survey (Appendix B).

Following is a description of the activities and assessments utilized during the weather unit. A qualitative analysis accompanies each activity description. Student comments for each activity were gathered by a survey proceeding each activity.

Activities

***Is Air a Fluid?* (Appendix D-1)**

This demonstration allowed students to observe how gases in our atmosphere act as a fluid. I did not trust the students in the classroom with matches, therefore, I chose to use it as a demonstration. However, it could also be used as a classroom activity. Either way, it is a simple activity and students commented that they would have enjoyed the opportunity to do it on their own. All but one person commented that they did not find

the demonstration helpful. The comment was: “This whole thing was confusing. I was lost the whole time.” I do believe that with assistance, this student would have been able to gain an understanding of the purpose of the demo.

Crushing Can (Appendix D-2)

In this activity, a small amount of water was placed in a metal pop can and heated until it steamed. The can was immediately turned upside down into a dish of ice-cold water. Prior to the activity the particle theory was reviewed, I walked through the steps of the activity, and students had time to hypothesize what they thought was going to happen to the can. Students enjoyed watching the can get crushed. A few student explanations for the can crushing included “the hot and cold water combining made a vacuum,” “There were less particles in the can than there were outside of it so the can collapsed,” and “The can got hot and then you put the can in iced water and the can caved because particles were moving faster and faster.” I was happy to see that most students understood the effect heat has on particles (Particle Theory). However, many students failed to give a detailed description of why the can was crushed. They missed the concept that when the water was heated, particles moved farther apart and out of the can. Then when the can was quickly cooled, the existing steam rapidly condensed creating an area of lower pressure inside the can due to the low amount of particles. Higher pressure outside the can caused it to collapse. Aside from poorly written explanations with little to no details, this was a great activity to get students making observations, hypothesizing, and writing down their thoughts.

Mapping the Atmosphere (Appendix D-3)

This activity was an independent activity and required students to make a graph, use

various textbooks/notes, and to use their creativity. The objective was to create a 2-D model of the atmosphere including the layers of the atmosphere, their boundaries, and characteristics of each layer. Students then answered questions about the atmosphere. I was planning to have students write a short fictional story using facts about the atmosphere, but ran out of time.

Despite the fact that step-by-step directions were given, many students needed assistance in making their graphs. I suspect that many students failed to read the directions before beginning, as this is a common problem faced in the classroom. After multiple people asked for assistance, I stopped everyone from working and demonstrated how to number and label the axes on the overhead. From that point most students were able to complete their graphs with little assistance. Positive post activity survey comments included that they liked this activity because they got to draw and color and it helped them to visualize the layers of the atmosphere and what they contain. Negative comments about the activity included that it was confusing or that it wasn't fun. All eleven students that participated found the activity helpful in some way.

Conduction, Convection, Radiation (Appendix D-4)

This demonstration aided students in visualizing and differentiating between modes of thermal energy transfer. Conduction was demonstrated by placing a metal strip upside down above a heat source (candle or Bunsen burner) at one end. Prior to the demo, the bottoms of small birthday candles were melted to a metal strip. As the metal was exposed to the heat source, the atoms in the metal gained thermal energy, and one by one the birthday candles fell off of the metal strip.

To model convection, a piece of tissue paper was lit on fire and dropped from arms

length. As the paper burned, it rose up in the air along with the smoke. As it began to cool, it moved outward and down to the ground. To reinforce this principle, I placed a large beaker of cool water on a heat source and added a few drops of food coloring. As the water began to heat up, the food coloring ascended with the less dense warmer water.

To explain radiation, we discussed the different types of electromagnetic radiation and how they affect humans on a daily basis. For example, we feel infrared waves as heat when we are outside on a sunny day. In order to protect ourselves from harmful ultraviolet rays when we are outside, we should use sunscreen and wear sunglasses. Radio waves are used to transmit signals for television and radio stations. X-rays and gamma rays are used for diagnostic purposes in medicine. Gamma rays are also used to irradiate foods, sterilize medical equipment, and treat some types of cancer in a procedure known as gamma-knife surgery. Of all the forms of electromagnetic energy, visible light is the one form that is visible which enables us to see color. The variety of topics relating to radiation is tremendous and can act as a springboard for open discussion.

I thought that the demonstrations were easy to carry out and a great visual for the students. Students especially enjoyed the demonstration of convection when the tissue paper was lit on fire and allowed to float up toward the ceiling. All but one student found the demonstrations helpful in differentiating between modes of energy transfer.

The Water Cycle Activity (Appendix D-5)

The objective for this activity was for students to describe the movement of water within the water cycle and to identify the state of matter of water as it moves through the water cycle. This activity required students to move throughout the classroom. Students were split into nine groups representing nine areas water can move to in the water cycle

(i.e. ocean, clouds, animal, groundwater). Each station had one pre-made die specific to that station, a piece of poster board, and colored pencils. At each station students took turns rolling the die that determined where water moved to next in the water cycle. When the die was rolled, students recorded their roll in their data table and continued to move to the next appropriate station depending on where the die indicated for them to go. They also recorded on their worksheet what state of matter water would be in for each station. While at each station, they drew a picture to represent what the water molecules may look like or what it may be doing at that station.

Overall, I believe students enjoyed this activity. When surveyed at the end of this activity 9 out of 10 students said that the activity was helpful to them and helped them to understand what happens in the water cycle. When asked what they liked about the activity some student comments were “How it showed that water kinda recycles and doesn't really move sometimes” and “not sitting in a chair”. Student negative comments for the activity included comments like “going back and forth” and “It was confusing for a while.” I would agree with the students that as the activity began there was confusion on what exactly to do. Students knew to roll the die and to go to the station that showed up on the die. However, due to the set up of the classroom with lab tables, it was difficult for students to move around the classroom and to locate the appropriate station they were moving to next. Quickly making a map on the board with the nine stations relative to each other proved helpful. When at a station, students also didn't know if they were supposed to draw a picture of the current station they were at or where they were going to go next (determined by a roll of the die). Half way through the activity, I had students omit the drawings just to get through the die rolling and movement around the classroom.

I did not have the students go back and finish the drawings due to a lack of time but feel it would be worthwhile to do in the future. To wrap up, we discussed their results to see where water seemed to move the most/least, and how for many people, water seemed to stay in one location for two to three rolls of the die.

Energy Absorption and Reflection (Appendix D-6)

Students utilized the scientific method in this activity to develop a hypothesis, test their hypothesis by making observations and collecting data, analyzing the results, and drawing conclusions. It was the most formal investigation students participated in during the weather unit. Students were put in to groups of three to four individuals and each student was given a different responsibility. The objective was to observe characteristics of different materials and determine which are conductors or insulators. Students chose two materials from a selection of wood, sandpaper, rubber, metal, and various colored cardboard to compare. They were asked, “Which material would keep the interior of a house coolest and why?” We then went outside to measure the surface temperatures and temperatures below the materials being compared. After conducting the experiment, they graphed their data and analyzed the results. Finally, conclusions were drawn determining if their hypothesis was supported and what changes could be made in the future to improve their data collection.

Students commented they enjoyed going outside, working in groups, and found the investigation helpful to understanding the concept of absorption and reflection. From my observations, I felt giving each group member a responsibility assisted in keeping things moving more coherently and it kept students engaged in the activity. Some students had difficulties reading the thermometer or recorded data in Fahrenheit instead

of Celsius. For the future, I would like to include more materials to give students more of a selection from which to choose.

Determining Relative Humidity (Appendix D-7)

Using a sling psychrometer and relative humidity chart, students determined the relative humidity of the classroom. This was done with two thermometers, a small piece of cloth, rubber band, and a container of room temperature water.

Students worked in groups of two for this activity. Overall the activity moved smoothly and all students commented that they found the activity helpful. Five out of twelve students commented they felt unclear on some things. The most difficult aspect of this activity was reading the relative humidity table and understanding the meaning of the the numbers. Dry-bulb temperature was located on the y-axis of the relative humidity table; difference in temperature was on the x-axis. Finding the correct number on the side and top and then following them to where they meet was difficult for some students. The relative humidity was also given as a whole number rather than as a percent. This was confusing for students so additional time was taken for explanation. Further applying the concept of dew point with this activity, 7 out of 11 students left the conclusion question blank “Is the air in your classroom close to, or far from the dew point? Explain your answer.” The next day we reviewed the activity and answers together.

Building a 3-D Surface Weather Map (Appendix D-8)

Using identical copies of a weather map, students constructed a layered 3-D weather map illustrating the differences in high and low pressure across the United States. First the maps were glued to cardboard. The number of maps needed depends on the number

of varying isobars the map contains. Our map had five layers. Students began with a base map. Next students looked for the lowest pressure isobar and cut along the lowest isobar line. This was then glued to the base. The process was continued with each new isobar reading until the range of isobar readings had been complete and all the corresponding layers had been glued down. Once the 3-D map was constructed, students answered questions relating to the pressure systems on their map.

Eight out of nine students found the activity helpful. Students enjoyed the activity because it was hands on and engaging. Working with partners was enjoyable for some people yet for others it made the task more difficult. For example, one student commented he didn't like that "I had guys who don't know what to do." Another comment was "partner yelling b/c I messed up." Despite the comments of frustration, there were many positive comments. In the future I will make groups no bigger than two people instead of three or four to cut down on bickering and to make it a more personal activity.

The biggest challenge students had with this activity was cutting out the appropriate isobars at the appropriate times. One group had a final 3-D map that had the areas of high and low pressure reversed. Other groups at times would accidentally cut out the wrong area of pressure for the particular level. Again, limiting a group to two people may alleviate these issues but may increase the amount of time needed to complete the activity.

Assessments

Students were given the following assessments during the weather unit:

1. Pre- and Post-unit Surveys (Appendix B)

The surveys were used to anonymously gather general information from students. Queries about most and least favorite classes, education plans after high school and students preferred methods of learning were included in the Pre-unit survey. The Post-unit survey was used to collect any comments the students had about the weather unit after it had been taught, what activities they liked/disliked, if the teaching approach used was helpful in increasing their understanding of weather and if their perceptions of science had changed after the unit.

2. Unit Pretest and Posttest (Appendix C)

The Pretest and Posttest were identical instruments used to gather information regarding students' prior knowledge and to compare to knowledge gained at the end of the unit. Tests were graded based on answering part or all of each question correctly. Questions varied in point value. If the question was left blank, no points were given. Grades on the Pretest and Posttest did not affect students overall grade in the class.

3. Classroom Activities (Appendix D)

Students were graded based on participation in the activities, work generated from the activities, and how well they were able to answer questions pertaining to the concepts of each activity. Each activity varied in point value.

4. Student Assessment of Activities (Appendix B)

After participating in each activity, students were asked to comment on what they liked and disliked about the activity. They also indicated if the activity was very helpful,

somewhat helpful, or not helpful. Data gathered were used to evaluate the effectiveness of each activity performed and student interest. Some student comments were utilized in the preceding section that details each activity. These assessments were anonymous and not graded.

5. Final Exam (Appendix C)

The final exam was a series of 42 multiple-choice questions relating to the concepts covered during the weather unit. Each question was worth one point.

RESULTS/EVALUATION

Pre/Posttest Evaluation

All students were administered an identical Pretest and Posttest (Appendix C) comprised of twelve open ended questions regarding concepts covered in the weather unit. Although overall scores were much lower than I expected, there was an improvement in scores from the pretest to the posttest with the exception of student 6 whose score remained the same (Figure 1). The average pretest score was 8.2% and the average posttest score was 26.8%, a difference of 18.6%. Although scores were extremely low, I anticipate it was partially due to the nature of the testing method used. Questions ranged from defining a term to describing a process and explaining why it occurs. Every question required recalling information and conveying knowledge or thoughts in writing. This seemed to be difficult for many students throughout the course of my teaching experience in this classroom. I believe that if a student was unsure about an answer, they left the response section blank. The majority of questions scored with a zero on the pretests and posttests were left blank. Raw data for students are located in Appendix F.

Student Response Scores for Pretest & Posttest

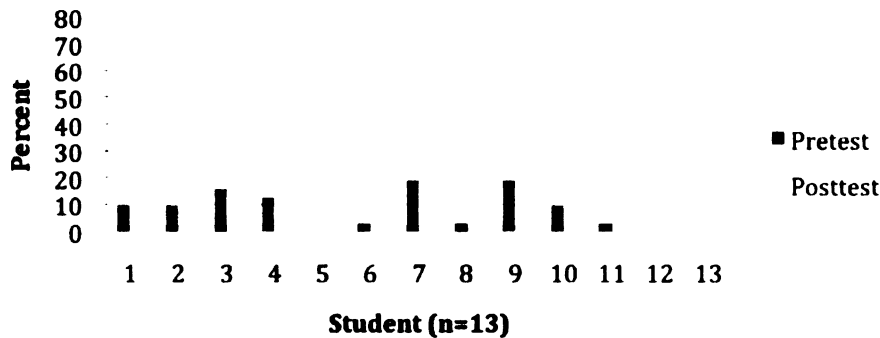


Figure 1—Student Response Scores for Pretest & Posttest

Analyzing student improvement between the pretest and posttest questions, there was some level of improvement for all questions except for question 10, which remained unchanged (Figure 2). Questions 5, 9, and 12 had the highest level of student improvement with five students raising their score for questions 5 and 9, and six students raising their score for number 12. Students demonstrated the least improvement on questions 7, 10, and 11. As mentioned, no one showed improvement on question 10. Only one student improved their score on question number 7 and 11.

Student Improvement between Pretest & Posttest

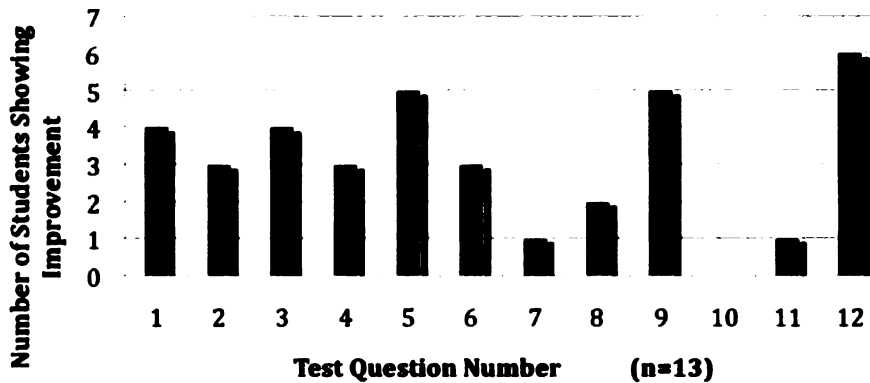


Figure 2—Student Improvement between Pretest and Posttest

For questions 5, 9, and 12, I anticipate that students were able to improve their scores with these questions the most as we spent an adequate amount of time engaging in activities that utilized these concepts. In addition, these concepts were either repeated throughout the unit or covered near the end of the unit making it fresh in the students' minds.

Question 5 required students to list and describe the three different kinds of energy transfer. Students performed well on this question, as it was a concept that was demonstrated with the Conduction and Convection demo and discussed multiple times throughout the unit. Question 9 required students to list four instruments scientists would use to measure lower-atmospheric conditions. During the weather unit, students were able to familiarize themselves with these instruments while collecting data for a few of the activities and during classroom discussion. Question 12 asked what closely spaced isobars on a weather map indicate about the wind. The last activity in the unit was to construct a 3-D weather map. This assisted students in learning about isobars, how wind

is measured, how wind is represented on a map, and how these measurements are used to predict weather.

For questions 1, 2, 3, 4 and 6, there was improvement in scores, but I expected to see higher scores as we spent time addressing these concepts in lecture and through classroom activities. Question 1 asked students to list the visible and invisible components of our atmosphere. Question 2 asked students to explain the cause of atmospheric pressure. To address this concept, we read in the textbook as a class and I performed the *Crushing Can* demonstration. Students participated prior to the demonstration by hypothesized what would happen and why. Afterwards, students wrote down if their hypothesis was correct and why or why not. As a class, we discussed why the can was crushed. Question 3 asked students to list a characteristic of each of the four layers of the atmosphere, which they had done when they had created a 2-D map of the atmosphere in *Mapping the Atmosphere*. Question 4 asked students to describe how visible light and infrared energy warm the earth. Time was spent in class discussing this and students took notes. I did have an activity (*Factors that Affect Climate*) that addressed this topic I would have liked to incorporate but did not have time. For question 6, students were to describe the path a water molecule may take in the water cycle in five sentences. I expected that students would do well on this question given that they participated in a classroom activity teaching the water cycle. My only thought is that they could not recall the vocabulary words associated with water transformation and/or did not feel like writing a paragraph.

Question 8 asked students to describe the conditions necessary for clouds to form. I am not surprised that students did not do well answering this question as little to no time

was spent on cloud formation and types of clouds. I initially planned on going outside so that students could identify clouds and I planned on utilizing the *Cloud Formation Classroom Activity*, but ran out of time. Had students had time and been involved in the activities, I believe they would have been able to correctly answer this question.

Questions 10 and 11 were about air masses and weather patterns associated with pressure systems. Only one student was able to improve their score for question 11 and no one answered question 10 correctly. Although we did spend time in class reading about air masses and taking notes, I anticipate students would have done better had we had time to do the planned hands-on activity *Weather Forecasting*.

After spending a day in class on the topic of relative humidity and incorporating a hands-on activity, I expected more than one student to answer question 7 correctly. Many students did attempt to answer the question and some answers were on the right track. In hindsight, students spent most of the class time interpreting the relative humidity chart and how to use it. Little time was spent on interpreting how relative humidity is affected by temperature changes and question 7 required students to understand this relationship.

In general, I feel students could have put forth more effort in answering the pretest and posttest questions. Based upon student work completed in class and my personal observation, I believe students knew how to correctly answer the questions but for some reason chose to leave many answers blank resulting in low pretest and posttest scores. Knowing that the Pretest and Posttests were not worth points and did not affect their overall grade in the class may have been a factor for not putting forth much effort. In addition, as a guest teacher in their class, my expectations and teaching methods were

different than that of their classroom teacher. Normally, the class was teacher-centered. Students would listen to the teacher, take notes, and individually complete a few worksheets. When I began instructing, students had to adjust to working in groups and using new scientific tools and processes. They needed to think independently and apply basic knowledge to higher-level orders of thinking. As with any newly learned skill, it initially feels awkward and unfamiliar. It takes time to adjust and to get use to. I believe this was the case for the students in this study. Students were probably accustomed to the multiple-choice exams given by their science teacher, therefore, making the fill in the blank questions unfamiliar and more challenging to answer. With time and experience answering fill in the blank questions, I believe the students would have achieved higher pretest and posttest scores. This idea is further supported by the 54.1% student average on the multiple-choice final exam. This average was much higher than the 26.8% average posttest score. The final was a multiple-choice exam that tested students on the same concepts as the pre/posttest questions in addition to other weather related topics covered in class.

Pre-/Post-Unit Survey Evaluation

I was curious to know students perceptions of science class prior to working with them. They were given an initial survey asking 1) What was their favorite class, 2) What was their least favorite class, 3) What were their plans after high school, 4) What helps them to learn (Appendix B). Results indicated the majority of students (eight out of thirteen) favored classes outside of the academic core (math and science) including art/music, gym, and industrial arts (Figure 3). Science was ranked as the least favorite

class subject with four students indicating it as the least favorite class. Math and English followed close behind with three students indicating it as the least favorite and social studies was listed by two students.

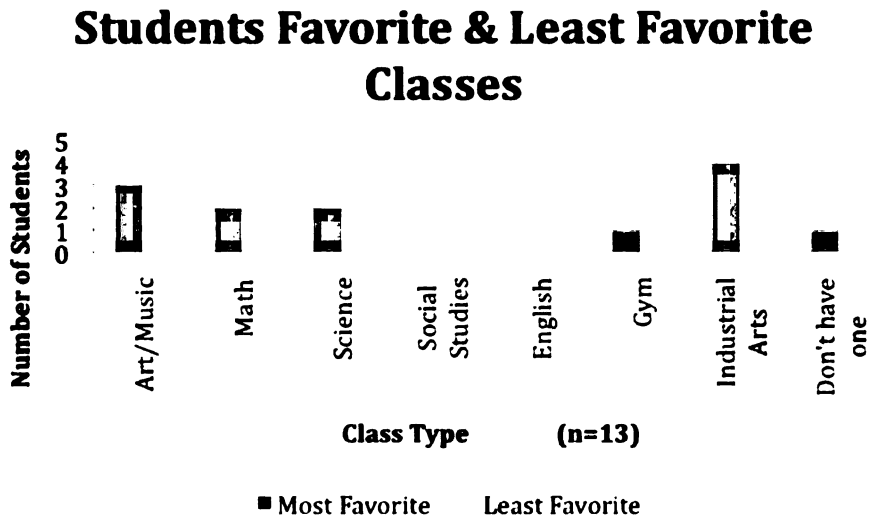


Figure 3—Students Favorite and Least Favorite Classes

According to survey results, most students indicated that they were planning on attending some sort of higher level of education. Out of thirteen students, five plan on attending college. Three students indicated they “hope” they will go to college or “maybe go to college”. Three students plan on attending a vocational school. One student would like to go to college but plans on taking some time off before enrolling. Only one student stated they did not know their plans.

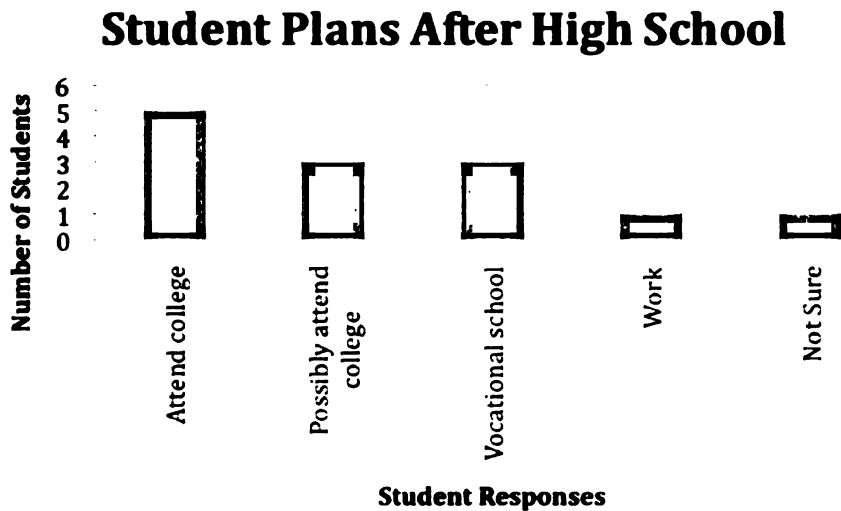


Figure 4—Student Plans after High School (n=13)

Student responses to what helps them to learn science indicated that the majority (8 out of 13) of students feel that learning using hands-on activities helps the most. A few students also stated that working in groups was helpful. Three students did not know what types of methods helped them to learn (Figure 5).

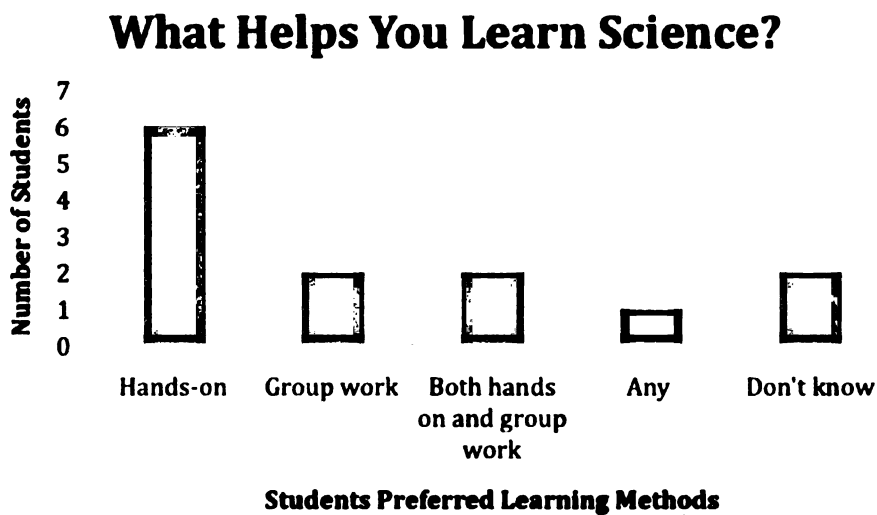


Figure 5—Student Responses to question 2 on Post survey (n=13)

After the final exam was administered, students were given a survey to collect information regarding their thoughts and feelings on the weather unit. First students were asked their opinion of how the weather unit was taught. Their comments are as follows:

“Good”

“I liked it because we did a lot of hands on stuff”

“Good, I liked it”

“I thought it was taught very well”

“Ok, it was a bit confusing”

“It was easier than the space unit”

“It was good”

“I think it was taught pretty good”

“Helped us learn how the weather works”

“It was taught well”

When asked if the weather unit changed their perceptions of science class, seven out of ten students said “no”. Only one said “yes”, one said “somewhat”, and one student did not respond to the question. The one student who said “yes,” said it changed their perception “Because this was fun” (Figure 6).

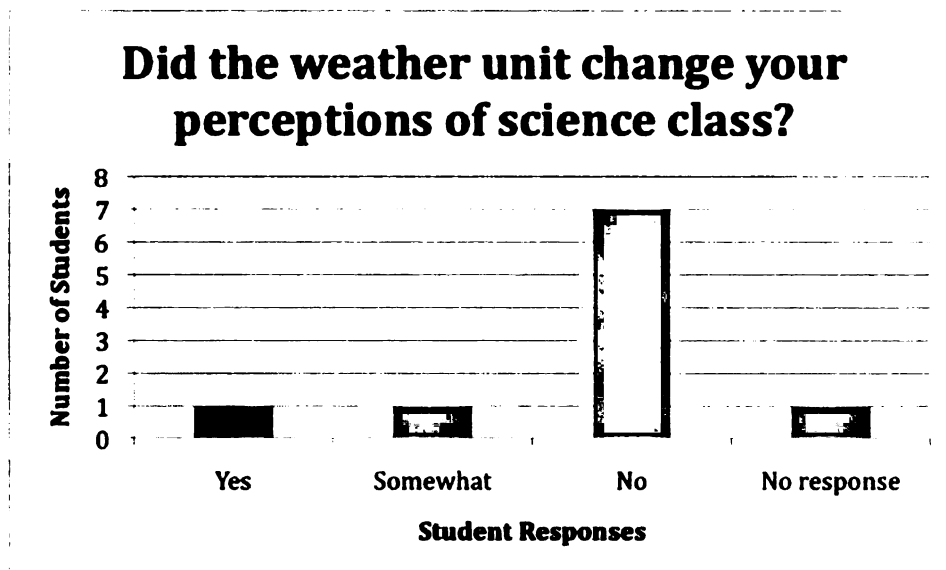


Figure 6—Student responses to question 3 on Post survey (n=10)

When asked if students thought the hands-on activities helped to increase their understanding of weather, all but one student agreed (Figure 7).

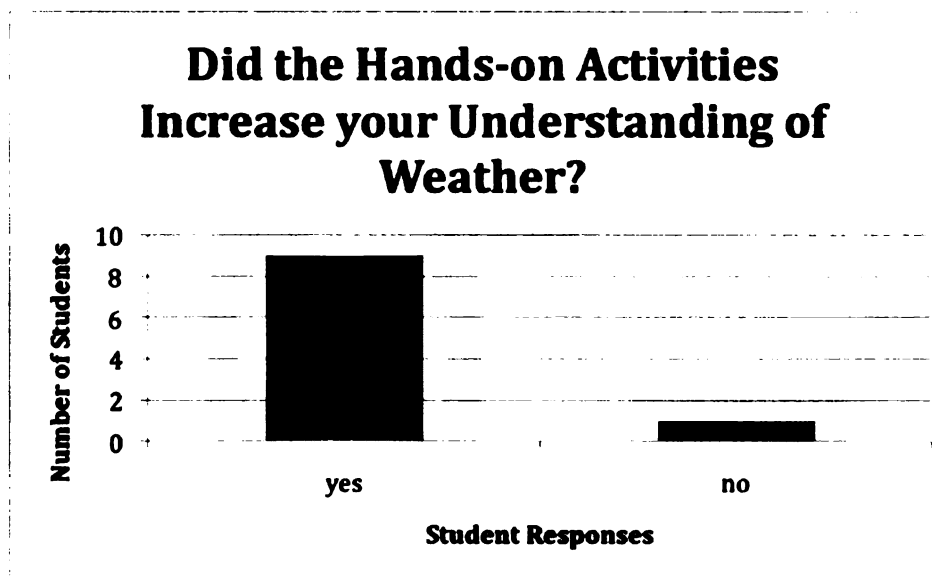


Figure 7—Student responses to question 4 on Post survey (n=10)

Three students also made the following comments in addition to responding “yes” for question 4 on the post survey:

“Because it showed what was going on”

“Some were easy and hard”

“I like hands-on activities”

From the student comments, I believe the students felt the hands-on activities were effective in increasing their comprehension of weather. Having a variety of activities at various difficulty levels challenged students and gave them the opportunity to visualize, investigate, and apply the weather concepts they were learning. The majority of students in the science class may have indicated they preferred classes other than science, but they did specify they learn best through hands-on activities and all but one student indicated the hands-on activities increased their understanding of weather.

Evaluation of Student Assessment of Activities

Students were asked to evaluate each activity after it was completed. They had the option to circle the following for each activity: the activity did not help, helped a little, or helped a lot. They were also able to comment on what they liked and disliked about the activity along with writing comments or questions. Student responses to the classroom activities and the level of helpfulness for each activity are indicated below (Figure 8).

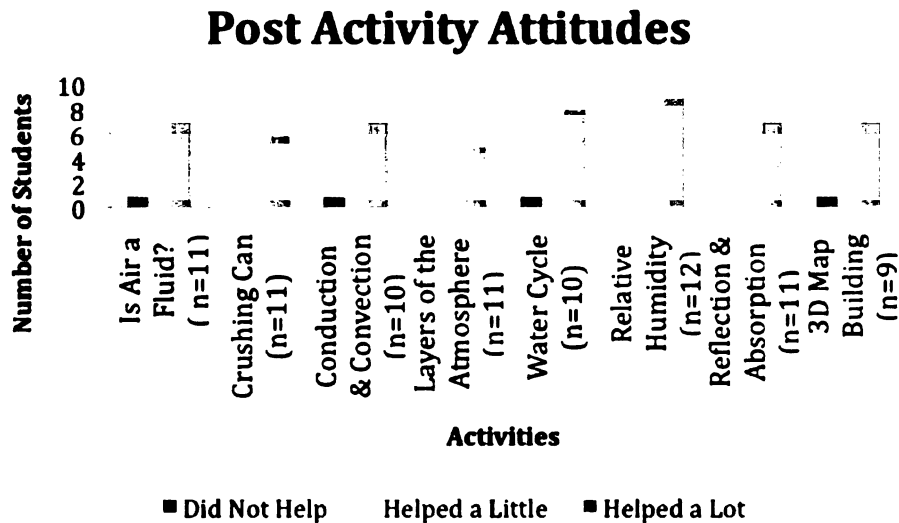


Figure 8 –Student Post Activity Attitudes

The majority of students indicated they found every activity helpful to increasing their comprehension of the ideas being taught. For the activities “Is Air a Fluid?,” “Conduction and Convection,” “The Water Cycle,” and “Building a 3-D Surface Weather Map,” only one student that participated in each activity commented that the activity did not help their understanding. With student attitudes primarily positive concerning the activities performed in class, I would have expected pretest, posttest, and final exam scores to be much higher. Again, reasons for such low scores may be attributed the fact that I was a guest teacher, the pre/posttests were not worth a grade, students did not take the weather unit seriously, and in general, many of the students involved in this study were academically poor students who typically perform poorly in science.

I can only attribute such low scores to the students having difficulties recalling information or facts learned in class.

It is interesting to me that the majority of students felt the water cycle activity “helped a lot” and that it was one of the top rated activities. With this activity being rated

as highly as it was, I would have expected higher posttest scores on the question relating to the water cycle. Only three students improved their score on this question and six students left the question blank on both the pretest and posttest. Reviewing student scores from the actual activity worksheet indicated students understood the material. However, five students left the same question blank on the activity worksheet that was identical to the question on the pre/posttest. Student comments for the activity included that they enjoyed moving around the classroom, rolling the dice, and that the activity was fun. When doing this activity again, I will make sure that students have mastered the vocabulary associated with phase change and the hydrologic cycle prior to the activity. I will also reinforce the vocabulary proceeding the activity and practice writing skills using new vocabulary if needed.

Students also found the relative humidity activity to be very helpful and among the top rated. As I watched the students learn how to determine relative humidity using the chart in their book, many students struggled to do it properly. After practice and a few examples though, students were able to measure the relative humidity of the classroom using their thermometers. Although all students mastered reading the relative humidity chart (evident by good scores on activity worksheets and observation), many students were unable to properly answer question 7 on the pretest/posttest relating relative humidity, temperature change, and precipitation. I was very pleased to see that many students attempted to answer the question relating to relative humidity on the posttest. However, only one student actually improved their score on this particular question and four students still left the question blank. When doing this activity again, I will spend more time discussing scenarios in which variables are changed and how they change one

another.

CONCLUSION/DISCUSSION

The application of the weather unit within the classroom was very helpful in conveying concepts to students and in making learning interesting and engaging for students. All but one student commented that the hands-on activities increased their understanding of weather in the post unit survey (Figure 7). Throughout the weather unit, students constantly commented on how they liked learning through hands-on activities, working with partners or in groups, and that it was a nice change from mundane note taking and daily worksheets. Although the pretest and posttest scores were much lower than I anticipated, the posttest average (26.8%) was 18.6 % higher than the pretest average (8.2%) (Figure 1) indicating increased student comprehension of weather topics. I attribute the low scores to the fact that it was not worth points and because the questions were fill in the blank. This idea is supported by the 54.1% student average on the weather unit final exam, which was multiple-choice and counted toward their final grade in the class.

Presenting the weather unit as a guest teacher in another teacher's classroom created challenges for me as an educator. I did not have the close teacher-student relationship I normally have with a classroom of my own. Normally with time, I am able to learn my students' strengths and weaknesses, what helps them to succeed, and which students work well together in order to minimize behavior problems and maximize time on task. Had this been my own classroom, I feel I would have been able to teach more effectively and the students may have achieved greater success. I do feel it was beneficial that I spent a week in the classroom prior the presentation of the weather unit. This gave me time to break the ice and interact with students, even if it was minimal. However, I still

did not know the students as well as I would have preferred.

The Pre-unit survey assisted in gathering information about the students (Appendix B). In general, I was not surprised students indicated math and science as their least favorite class (Figure 3). Through talking with students in the past, science is a class that many students struggle with. However, I was surprised the majority of students disliked core classes and preferred music, gym, or vocational education classes. Working with such a homogenous group of students that disliked or struggled with science before was new to me. I was surprised at the number of students that indicated they would “possibly go to college,” “work,” or that they were “not sure” (Figure 4). There is such an emphasis today on the importance of education and earning a higher education degree to sustain an average quality of life. I expected to see more students who planned on attending a college or vocational school. When I asked students their preferred method of learning, I was not surprised that the overwhelming answer was “hands-on” (Figure 5). In my six years of teaching secondary science, students are typically always excited about participating in a lab or other hands-on activity. It was also apparent to me through observation, student achievement in the class, and Pre-unit survey comments that these students needed a teaching approach that would get them excited about science and engaged in learning. One thing I would like to incorporate in the future is a self-survey that would allow students to analyze their learning preferences. It was interesting to me that two students indicated they did not know what type of learning style worked best for them.

My summer research resulted in a number of activities and demonstrations, some which were implemented this year. As I began presenting the unit on weather, it became

apparent to me that I would have to omit some activities due to a lack of time. I spent much more time than I anticipated repeating directions, assisting students with questions, and addressing student behavioral issues. Meeting the accommodations of special education students in the classroom also required additional time for students to complete work. Since many of these issues were unforeseen, I took each day one at a time, and as the unit progressed, omitted activities that I thought would be too time consuming with what time we had left. Near the end of the unit, I simply ran out of time to complete the remaining activities. I omitted the following activities: Factors Affecting Gases and Their Interactions, Building a Hot Air Balloon, Graphic Organizers, Clouds in a Jar, Cloud Formation Classroom Activity, Outside Weather Observations, Weather Forecasting, Factors that Affect Climate. Although these activities were not utilized for this study, I would still like to try them in future lessons. They are engaging activities that would increase student interest, science related skills, weather knowledge, and promote teamwork and cooperation. In hindsight, the one activity I regret not having students do is to make outside weather observations. I initially planned on doing this for one week near the end of the unit but omitted it as we neared the end of the semester with many more activities planned and little time. This activity would have been a simple way to grab student attention, introduce and prepare students for upcoming topics, and put students in an environment where they would personally experience what it is we would be discussing and learning as a class. In the future, I would like to begin weather observations on day 1 of the weather unit.

For the activities that were utilized in class, the majority of students commented they found their participation in each activity assisted them in increasing their knowledge of

weather or weather related processes (Figure 8). I too found the activities to be helpful to student comprehension although there are some things that I would alter for the future. Instead of using *Is Air a Fluid?* as a demonstration, I would have groups of 2-4 students perform it as an activity. It is an inexpensive activity to perform and I feel students benefit more from the personal experience. As a guest teacher not really knowing the students, I felt hesitant allowing students to use fire in the classroom. With *Energy Absorption and Reflection*, I would like to incorporate more of a variety of materials for the students to test their hypothesis. I would also like to take time to compare different group results as a class. Comparing data from different groups would allow the students to see results for all the materials tested and not just what they chose for their group. This time could also be used to discuss inconsistent data, problems that arose during the lab, and answer any questions students may have had. I think the *Water Cycle Activity* would go more smoothly if it were done in a larger area such as the gym, cafeteria, or even outside. Students did not have enough space to move around and were confused about the location of the stations. In the future I would give each student a map of the stations to fix this problem. The cardboard used in *Building a 3-D Surface Weather Map* was very difficult for students to cut and required more time than I anticipated. When I do this activity again I will try to find Styrofoam, which cuts easier, or better cutting materials. Instead of having every group construct the same 3-D weather map, I would use five to seven different weather maps so that afterwards, students could visualize how the areas of high and low pressure move over the U.S. over time. It could also be used to lead into a discussion or activity on air masses. I would not change the *Relative Humidity Activity*, although I would spend more time discussing the connection between

temperature change, relative humidity, and dew point. Students were able to determine the relative humidity of the class but when it came time to applying that knowledge to temperature change and dew point, many students were unable to do so. When I teach the weather unit again, I would also like to focus more on safe handling of lab equipment, graphing, and giving students more opportunities to make connections by applying knowledge learned in class. I feel students would have benefitted if we had concentrated on these issues but trying to complete so many activities with so little time made it difficult. Quality is better than quantity so I will probably eliminate some activities when I teach the unit again unless I have more time. In general, each activity was useful in that it allowed students to learn through personal experience. Students were able to practice skills, have ownership of their work, and learned through trial and error.

In conclusion, I found the preparation, presentation, and analysis of the weather unit very educational and rewarding. I have experienced first hand that a person learns the most through personal experience and trial and error. There is much that I have learned about conducting research, teaching, writing a thesis paper, and myself that I would not have learned without the personal experience. The weather unit could use some alterations but the hands-on activities that were utilized were engaging and increased student comprehension of weather. Students enjoyed the activities and learning about weather and I enjoyed teaching about it too.

APPENDICES

APPENDIX A—CONSENT FORM

Improving Student Comprehension of Weather through Hands-on Activities Parent Consent and Student Assent Form

I am currently enrolled as a graduate student in Michigan State University's Division of Science and Mathematics Education (DSME). My thesis research is on incorporating more hands-on activities into the weather unit for Weather, Climate, and Space.

Data for the study will be collected from standard student work generated in the course of teaching this unit such as pre and post tests, activities, quizzes and surveys. I am asking for your permission to include your child's data in my thesis. Your child's privacy is a foremost concern. During the study, I will collect and copy student work. These assignments will have the student's name removed prior to use in the study. All of the work being collected will be stored in a locked cabinet until my thesis is finished. In addition, your child's identity will not be attached to any data in my thesis paper or in any images used in the thesis presentation. Your child's privacy will be protected to the maximum extent allowable by law.

Participation in the study is completely voluntary. Students who do not participate in the study will not be penalized in any way. Students who do not participate in the study will still be expected to participate in class and complete assignments. Students who participate in the study will not be given extra work to complete. You may request that your child's information not be included in this study at any time and your request will be honored. Participation in this study may contribute to determining the best way to present weather concepts to high school students.

If you are willing to allow your child to participate in the study, please complete the attached form and return it to me by Friday Sept. 19, 2008. Please seal it in the provided envelope with your child's name on the outside of the envelope. The envelopes will be stored in a locked cabinet and opened after the unit is completed. Any work from a student who is not to be included in the study will be shredded.

If you have any questions about the study, please contact me by email at ksaffron78@hotmail.com or by phone at (563) 386-5500. Questions about the study may also be directed to Dr. Merle Heidemann at the DSME by e-mail at heidema2@msu.edu by phone at (517) 432-2152, or by mail at 118 North Kedzie, East Lansing, Michigan 48824. If you have any questions or concern regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact-anonymously, if you wish- Peter Vasilenko, Ph.D., Director of the Human Subject Protection Programs at Michigan State University, by phone at (517) 355-2180, by e-mail at irb@msu.edu, by fax at (517) 432-4503, or by mail at 202 Olds Hall, East Lansing, MI 48824.

Thank you,

Mrs. Kim Saffron
Science Teacher

Improving Student Comprehension of Weather through Hands-on Activities
CONSENT FORM

I voluntarily agree to allow _____ to participate
in this study. (print student name)

Please check all that apply:

Data Use

_____ I give Mrs. Saffron permission to use data generated from my child's work in science class to be used in the thesis project. All data from my child will remain confidential.

_____ I do not wish to have my child's work used in this thesis project. I acknowledge that my child's work will be graded in the same manner regardless of participation in the study.

Photograph Use

_____ I give Mrs. Saffron permission to use pictures of my child during her work on this thesis project. My child will not be identified in these pictures.

_____ I do not wish to have my child's picture used at any time during this thesis project.

(Parent/Guardian signature)

(date)

I voluntarily agree to participate in this thesis project.

(Student signature)

(date)

APPENDIX B--SURVEYS

PRE-UNIT SURVEY

Directions: Answer the following questions to the best of your ability.

- 1. What is your favorite subject in school? Why?**
- 2. What is your least favorite subject in school? Why?**
- 3. What do you plan on doing after high school? (college, vocational school, work)**
- 4. What types of classroom activities help you learn?**
- 5. What do you find most difficult when learning science?**
- 6. What do you enjoy the most when learning science?**
- 7. Do you enjoy hands-on activities in science class?**

POST-UNIT SURVEY

Directions: Answer the following questions to the best of your ability.

- 1. In general, what do you think about how the weather unit was taught?**

- 2. Did the weather unit change your perceptions of science class? How?**

- 3. Did you think that the hands-on activities helped to increase your understanding of weather?**

- 4. What was your favorite activity? Least favorite? Why?**

POST-ACTIVITY SURVEY

Name _____ Activity _____

Directions: Answer the following questions as completely as possible. Your feedback is much appreciated.

Objective of the activity:

1. Assuming you put forth effort, please circle how you felt the activity helped you to learn the objective for this unit.

Did not help, I'm still confused Helped a little, I'm still unclear on a some things

Helped a lot, I get it! Helped a lot, I'm still unclear on a few things

2. What did you like about the activity? Why?

3. What did you dislike about the activity? Why?

4. Any other questions or comments you may have?

APPENDIX C—ASSESSMENTS

UNIT PRETEST/POSTTEST

Name _____ Date _____

How much do you know?

Directions: Answer the following questions as completely as possible.

1. What are the visible and invisible components of our atmosphere?

Visible-

Invisible-

2. Explain the cause of atmospheric pressure.

3. What makes each main layer of our atmosphere unique? (Write your answer on the line next to each layer of the atmosphere.)

Thermosphere	
Mesosphere	
Stratosphere	
Troposphere	

4. Describe how visible light and infrared energy warm Earth.

Visible light-

Infrared energy-

5. List and describe three kinds of energy transfer.

a. _____ --

b. _____ --

c. _____ --

6. As a water molecule, you find yourself in a puddle in the local grocery store parking lot. Explain how you got there and where you might go next. (Write your answer in five sentences, please.)
7. Explain what would happen to a sample of air whose relative humidity is 95% if the temperature decreased.
8. Describe the conditions that are necessary for clouds to form.
9. What are four instruments scientists use to measure lower-atmospheric conditions?
- | | |
|----|----|
| 1. | 3. |
| 2. | 4. |
10. What is an air mass and how does it form?
- An air mass is.....
- An air mass forms.....
11. Compare the characteristic weather patterns associated with a high-pressure system to a low-pressure system.
12. What do closely spaced isobars on a weather map indicate about the wind?

APPENDIX D—ACTIVITIES

Name _____

Is Air a Fluid?

Prelab Questions:

1. What are some physical properties of a fluid?
2. Do you think air is a fluid? How could it be demonstrated?

Materials (for each group of 2-4 students):

Baking soda

Vinegar

500 ml beaker or glass jar of similar size

candle (small such as a votive candle)

matches

strip of poster board or cardboard about 12" x 3" (old file folders work well)

Procedure:

1. Fold the poster board or cardboard lengthwise.
2. Place the candle on a countertop and light the candle.
3. Put about a tablespoon of baking soda in the beaker.
4. Pour about $\frac{1}{4}$ cup of vinegar in the beaker with the baking soda.
5. When the fizzing slows down, hold the poster board at an angle so that one end is near the candle flame and the other end is slightly higher.
6. Pour the gas produced in the beaker down the poster board.

Observations:

1. What happened when you mixed the vinegar and baking soda together in the beaker or glass jar? Any idea why you saw a change?
 - a. What happened?
 - b. Explanation.

2. What happened to the candle when you “poured” the gas produced in the beaker or glass jar into the funnel? Any idea why you saw a change?
 - a. What happened?
 - b. Explanation.
3. Extension: Can you think of any real world applications with what you just demonstrated?

Adapted from: Windows to the Universe team (2008). *Is Air a Fluid?*. Retrieved March 22, 2010, from <http://www.windows.ucar.edu>

Crushing Can Demonstration—Teacher Page

Objective:

To examine the influence of pressure differences

Materials:

Aluminum pop can, hot plate or hot stove, large beaker or bowl of cold water, beaker tongs or hot pad holder, safety goggles

Procedure:

1. Fill large beaker or bowl half full with ice-cold water.
2. Pour enough water into the pop can to cover the bottom (15-20 mL)
3. Heat the pop can with water on a hot plate.
4. When you see the water in the can begin to boil and see steam coming from the top, quickly pick up the pop can with tongs and turn it upside down into the cold water.

Conclusion:

The atmosphere exerts pressure in all directions. The can was crushed due to a greater pressure outside the can than inside the can.

Great link for the classroom—Includes a real life example and picture of this principle.

<http://www3.delta.edu/slime/cancrush.html>

Adapted from <http://www.atmos.washington.edu/2002Q1/101/demos/demo5.htm>

Name _____

Can Demonstration—Student Worksheet

1. (Prior to the demonstration) Describe the can in general considering the particle theory of matter.

2. Is air considered matter? Why or why not?

3. **Predict** what effect the heat energy will have on the particles of air within the can.
What will happen when the can is immersed in the ice water?

Mapping the Atmosphere

Materials: graph paper, rulers, colored pencils/crayons

Procedure: Read and follow the directions below to complete a diagram of the layers of the Earth's atmosphere.

1. Each horizontal line on the grid represents 10 km. On the left side of your grid, label every 20 km from 0 km to 400 km.
2. Use different colors to identify the boundaries of the troposphere, stratosphere, mesosphere, and thermosphere. Shade in the area on the grid.
3. Use pictures to put items *a* through *i* in the correct atmospheric layer.

a. airplane	f. magnetosphere
b. aurora	g. space satellites
c. meteor showers	h. clouds
d. living things	i. ozone layer
e. ionosphere	j. exosphere

Rubric:

Numbered axis correctly	.5 pt.
Labeled axis	.5 pt.
Marked each layer correctly	4 pts.
Color each layer	2 pts.
Draw <i>a</i> to <i>i</i> on grid (in correct layer)	10 pts.
Neatness	3 pts.

Total possible points 20

Enrichment Questions (answer on back of graph):

1. In what layers of the atmosphere do the temperatures increase with height?
2. What happens to pressure as altitude increases?
3. Most aerosol sprays are banned in the United States. Which layer of the atmosphere does this ban protect? Explain your answer.
4. You are scheduled for a flight and a mild thunderstorm is approaching. Would this affect your flight? Explain your answer
5. During a jet flight over the North Pole and toward a region in the middle latitudes, a pilot adjusts the altimeter. Why is this adjustment necessary?

Conduction & Convection Demonstration

Teacher Page

Modeling Conduction

Conduction is the transfer of energy as heat from one substance to another by direct contact.

Materials:

Bunsen burner, 6-10 small wax birthday candles, metal strip, ring stand (2)

Preparation and Procedure:

1. Prior to the demonstration, individually melt a small amount of wax on the bottom of each birthday candle. Place the bottom of the candle on the metal strip and allow it to adhere to the metal strip. Place candles about a centimeter from one another.
2. Position a Bunsen burner on the countertop between two ring stands.
3. Turn the metal strip with the birthday candles upside down and place between the two ring stands to hold the strip in place. The metal strip should be an inch or so above the Bunsen burner flame. Make sure to place the Bunsen burner closer to one end of the metal strip so that as the metal heats, the candles fall off in a row.

Modeling Convection

Convection is the movement of matter due to differences in density that are caused by temperature variations; can result in the transfer of energy as heat.

Materials:

Tissue paper and matches

WARNING: Tissue paper burns very quickly. Make sure to have a large area to perform this demonstration and remove all flammables.

1. Light the corner of a 8 x 11 sheet of tissue paper and toss it in the air in front of you.
2. Observe the movement of the tissue paper ashes and smoke.

Water Cycle Classroom Activity

Objectives: Students will describe the movement of water within the water cycle and identify the states of water as it moves through the water cycle.

Materials:

Student activity sheet

9 large pieces of paper

Copies of water cycle table (optional)

Markers/colored pencils

Water station dice (print at <http://response.restoration.noaa.gov/watercyclegame>)

Procedure:

1. Divided students into nine groups and disperse throughout the class to each of the nine stations: Clouds, Plants, Animals, Rivers, Oceans, Lakes, Ground Water, Soil, and Glaciers. There should be a die for each station, a large piece of paper, and markers.
2. Explain to students that they will be representing a water molecule moving through the hydrologic cycle. Students should take turns rolling the die and moving to the next appropriate station based on what the die says. If it says "Stay," they roll the die again.
3. For each station visited, students should record the station name and state of matter they are in (solid, liquid, gas) on their activity sheet. They should also draw a picture on the water station poster that represents what they look like or what the water molecule may be doing at that particular station. They should also write a brief description of their drawing on their activity sheet.
4. Remind students not to move on to a new station until all steps explained in #3 are completed.
5. Repeat steps 2-3 until everyone's data table is complete.

Adapted from "The Incredible Journey", Project WET Curriculum & Activity Guide. Pages 161-165. 2005.

Name _____

Water Cycle Activity

What places can water go as it moves through and around the Earth?

Directions: As you roll the die and move around the room, keep track of where you have been by writing down the stations, state of matter for that station, and an explanation of your drawing.

Data Table

Water Station	State of Matter	Explanation of Drawing

Analysis:

1. As you moved around the room, did you ever return to a station you had previously been at? If so, which station?

2. Give some reasons why water might move in the following ways:
 - a. From soil to plants

 - b. From clouds to lake

 - c. From animal to clouds

 - d. From animal to soil

 - e. From river to ocean

3. Were there any water stations you remained at for 3 or more rolls? If so, which station? Why do you think water would remain in this stage of the cycle for so long?

4. As a water molecule, you wake up in a puddle in the school parking lot. Explain how you got there and where you might go next. (Write your answer in five sentences please.)

Name _____

Energy Absorption & Reflection

Objectives:

1. To determine what types of material will keep the interior of a house the coolest.
2. Explain which properties of that material determine whether it is a conductor or insulator.

Materials:

You will need four different pieces of material for this activity. The four different colored pieces of cardboard count as individual materials.

(All material pieces should be 4 cm x 4 cm x 1 cm)

Cardboard, (4 pieces)

Paint, black, white, and light blue tempera

Metal, sandpaper, rubber (beige or tan), wood

4 Thermometers

watch

Ask a Question & Form a Hypothesis:

1. Which material do you think would keep the interior of a house the coolest?
2. What characteristics of the material caused you to choose it? (composition, color, texture, transparency, mass, volume, specific heat)

Test Your Hypothesis

3. Determine which material absorbs the most energy and which material keeps the surface below them the coolest. Write down how you would test this and have your teacher approve your design.

4. Record your data in the table below.

Material	Color	Surface temperature (°C)	Temperature below surface (°C)	Difference in Temperature (°C)

Analyzing Results

1. Make a bar graph using your data. Put materials you tested on the x-axis and range of temperatures on the y-axis.

2. Which material:

- had the highest temperature on the surface?
- had the highest temperature below the surface?
- had the lowest temperature below the surface?
- had the lowest temperature on the surface?

3. Do you think the color of the materials affected whether they absorbed or reflected solar energy? Why or why not?

Drawing Conclusions

4. Using your results, which material would you use for the roof of your house? Was your hypothesis supported by your results?

5. What properties does the material have that would make it useful for roofing your house?

6. Do you think the material you chose would keep the inside of a house warm in colder weather? Why?

7. If you were to do this experiment again, what would you change in your experimental design? Why would you make these changes?

Extra Credit

8. What parts of the Earth's surface absorb or reflect solar energy? Which areas of Earth's surface absorb the least energy? Explain your answers.

Name _____

Determining Relative Humidity

Objective:

Using a sling psychrometer (made up of two thermometers) and relative humidity chart, you will determine the air's relative humidity.

Materials:

2 thermometers, small piece of cloth, rubber band, container of room temperature water.

Procedure:

1. Dampen the cloth in the water and wring it out. You don't want it to be soaking.
2. Rubber band the wet cloth to the bulb of one of the thermometers. This is your "wet-bulb" thermometer.
3. Put the two thermometers back to back and attach them to the handle.
4. Swing the thermometers back and forth for a minute.
5. Record the temperature on the wet-bulb and dry-bulb thermometers.
6. Subtract the wet-bulb temperature from the dry-bulb temperature and record the temperature difference.
7. Use a Relative Humidity table to determine the relative humidity of the classroom. Look at the left-handed column labeled "Dry-Bulb Temperature." Find your recorded dry-bulb temperature. Next find your recorded difference in temperature across the top row of the table. Where this row and column meet, is your relative humidity expressed as a percentage.

Data:

Dry Bulb Temperature = _____

Wet Bulb Temperature = _____

Temperature Difference= _____

Conclusion:

1. What is the relative humidity in your area today? _____
2. Drawing Conclusions: Is the air in your classroom close to or far from the dew point? Explain your answer?
3. Applying Conclusions: If you wet the back of your hand, would the water evaporate and cool your skin?

Adapted from Holt's Earth Science (© 2008 Pages 596-597)

Name _____

Building a 3-D Surface Weather Map

Materials: (for Each Group of Students)

Surface weather map (can print at www.hpc.ncep.noaa.gov/dailywxmap/index.html)

Foam core board (30" x 40") or precut pieces of foam board

Exacto knife or scissors

Safely goggles

Glue

Procedure:

1. Glue copies of the weather map on your pieces of foam board. All maps should be the same size.
2. One of the maps will be your base map.
3. On the second map, find the lowest pressure on the map (it likely has a L for low pressure). Cut along the isobar (line of equal air pressure) that circles the low pressure. You will now have a hole(s) in your map. Put this map on top of your base map.
4. On the third map, find the isobar representing the next lowest surface pressure (it will be the next isobar outwards from the center of the low pressure). After cutting you should have an even bigger hole in your map. Stack this map on top of the other two. You may begin gluing your maps together if you would like.
5. Continue with this procedure until your three-dimensional map is complete.

Adapted from *A New Perspective on Surface Weather Maps* by Steve Meyer. Science Activities 42 no4. 2006.

Directions: Refer to your weather map when answering the following questions.

Questions:

High Surface Pressure

1. Where is surface pressure greatest on this map?
2. What does it mean when there is high pressure over a particular area?
(Hint: Think about the amount of air molecules.)
3. Describe the vertical movement of air in the center of a high pressure system.
4. What kind of weather do we normally expect if pressure is high? Why?
(Hint: Think about how clouds form.)
5. Describe the horizontal movement of air around a high pressure system.

Low Surface Pressure

6. Where is surface pressure the least on this map?
7. What does it mean when there is low pressure over a particular area?
(Hint: Think about the amount of air molecules.)
8. Describe the vertical movement of air in the center of a low pressure system.
9. What kind of weather do we normally expect if pressure is low? Why?
(Hint: Think about how clouds form.)
10. Describe the horizontal movement of air around a low pressure system.

Winds

11. a. Where are the fastest wind speeds found on your map?
b. Why are they found there?

APPENDIX E—OMITTED ACTIVITIES

Cloud Formation Classroom Activity

Objective: Role play how clouds are formed.

Materials:

Balloons (half as many as there are students), Garbage bags (1 for every 5 students)

The Activity:

1. Ask students times when they have observed condensation. What do they think water condensed in the upper atmosphere would look like? Explain that they are going to participate in an activity that demonstrates how water droplets form in the upper atmosphere. Explain that as molecules move around the atmosphere, they may collide with one another keeping their energy. If they do not collide, they slow down.
2. Have students count off by fives. Pick a number to be the “condensation nuclei.” Give them a garbage bag. Everyone else is an “air molecule.”
3. Spread out everyone in the room. Air molecules should be at arm’s length. They must keep one foot in place at all times, but can pivot about that foot. *(In reality, air molecules move around freely, bumping into one another. However, for this activity movements will be limited.)*
4. Explain the rules to the students:

When the teacher claps hands = increase space between others by taking two steps away from each other. *(Explain that the clapping represents air rising further into the atmosphere. At higher altitudes there is less pressure, and molecules move further apart. Therefore, the molecules are not pressed together making it harder for them to transfer heat energy to each other.)*

Students should try to keep balloons from touching the ground. Each time they hit a balloon, they should say “energy!” *(This represents kinetic energy being transferred between air and water molecules, keeping heat levels constant.)*

Condensation nuclei should gather fallen balloons in their bags. (Energy has been lost from the water molecule.) When two or more balloons are collected it becomes a water droplet.

5. Begin the activity clapping your hands about every minute. When most balloons are collected, stop the activity and ask students what all the water droplets represent (a cloud). Explain that the water droplets are too heavy to float in air.

6. Designate one side of the room as Earth's surface; have water droplets represent precipitation falling to the ground by moving to that wall. Have everyone else make the sound of thunder by stomping their feet. You can also flash the lights to represent lightning.
7. To check for understanding, have students diagram the formation of a cloud.

Name _____

Building a Hot Air Balloon

Hot air is not as dense as cool air. Convection is the transfer of heat by the movement or flow of a substance from one position to another. In this activity you will build and release a hot air balloon to observe the process of convection.

Materials:

Tissue paper (16 sheets, 24" x 30" or 20" x 24", various colors)

Balloon cutting pattern

Scissors

Rubber cement

Fishing line for tether (50 ft. roll)

Pipe cleaners (2)

Propane stove and chimney apparatus (2 coffee cans put together works great!)

Flight data sheet

Building Your Balloon

Using the tissue balloon pattern instructions, draw and cut out a pattern and set it aside. Pattern and directions can be found online at <http://eo.ucar.edu/webweather/tonact6.html>

Observations

- How did your air balloon turn out? Did it have a successful flight?
- If your balloon flew, why did it eventually come down?
- If your balloon didn't fly well, what do you think went wrong?
- How could you make your balloon better next time?
- Which time of day would this activity work better? Explain.
- What did you like about this activity? Why?
- What did you dislike about this activity? Why?

Adapted from <http://eo.ucar.edu/webweather/tornact6.html>

Name _____

Clouds In A Bottle

Materials:

Clean 2-liter bottle
1 Fizz keeper (can be found at the grocery store)
small amount of water
matches

Procedure:

1. Place a small amount of water in the bottom of the bottle. Approximately $\frac{1}{4}$ of an inch should be enough.
2. Light a match and drop the match into the bottle. The match should go out. Quickly place the Fizz keeper on the bottle.
3. Pump the Fizz keeper about 80 times. Release the Fizz keeper and clouds should form within the bottle.

Questions:

1. After you pumped the Fizz keeper and opened the bottle, what happened when you opened the bottle with the water and match in it?
2. Why was the match needed for the cloud to form?
3. Did the cloud form when you applied pressure or when you released pressure? Did the cloud form when temperatures rose or fell? Why?
4. Once you have a cloud in our bottle, make it disappear. Describe how you did this.

Adapted from: Windows to the Universe team (2008). *Three Clouds Activity*. Retrieved March 22, 2010, from <http://www.windows.ucar.edu>

Name _____

Factors Affecting Gasses and Their Interactions

Purpose:

To investigate the qualitative and quantitative relationships between factors affecting the behavior of gasses.

Background Information:

There are four factors that describe the condition of a gas- pressure, temperature, volume and number of particles. Using air as a representative gas, you will make observations about the relationships between these factors.

Materials:

Pressure pumper and 2 liter bottle.

Thermometer

Electronic balance

Variable volume indicator (stoppered syringe)

Sensitive pressure sensors (your sense of touch)

Procedure:

1. Set the volume of the syringe at 7.0 cc (mL) using the tip of the plunger as the indicator. Record this volume.
2.
 - A. Gently squeeze the bottle approx. 1/3 of the way together. Do not crease the thermometer strip or the bottle. Tightly seal the cap and record the temperature.
 - B. Pump the pumper until the bottle just returns to its original volume (10-20 pumps) and record the temperature. Record the syringe volume again.
 - C. Open the cap and listen for any escaping gas. Record results.
3.
 - A. Make sure the syringe volume is at 7.0 cc. Record the mass of the bottle and initial temperature. Note the firmness of the sidewall of the bottle.
 - B. Pump 50 strokes on the pumper. Record the volume of the syringe and note the firmness of the bottle.
 - C. Repeat step 3.B. for a total of 400 strokes.
 - D. Record the final temperature. Record the final mass of the bottle.
4. Carefully release the pressure by loosening the cap and observe the syringe volume and temperature. Wait 30 seconds and record the syringe volume and temperature.

Data:

1. Initial syringe volume: _____

2. A. Initial temperature: _____
 B. Final temperature: _____
 Final syringe volume: _____
 C. Released gas? Y or N. _____

3. A. Initial bottle mass: _____
 Initial temperature: _____
 Firmness: _____

B. and C. :

Pump Strokes

Syringe Volume

Firmness

50

100

150

200

250

300

350

400

- D. Final bottle mass: _____
 Final temperature: _____

4. Post bottle temperature: _____
 Post syringe volume: _____

Questions:

Part I.

Refer to Step 2:

1. Did the temperature remain constant?
2. As you put air into the bottle, what happened to the volume of the bottle?
3. The pressure inside and outside of the bottle was the same when you started (equal to atmospheric pressure). Based on your observations, did the pressure increase inside the bottle?

Refer to Steps 3 and 4:

4. As you pumped more air into the bottle what did you notice about the firmness of the bottle?

What can you conclude about the pressure inside the bottle?

5. As more air was pumped into the bottle, what happened to the temperature?

When pressure was released, what happened to the temperature?

6. What was the difference in the mass of the bottle?
7. We will assume that the temperature of the syringe and the bottle were the same. Remember that the syringe contained a gas. As the pressure on the syringe changed, what was the effect on the volume of the syringe?

Part II.

1. Graph pressure as "pumper strokes" versus syringe volume. Draw a best fit curve.
 - A. As the volume decreases by $\frac{1}{4}$, how did the pressure change?
 - B. As the volume decreased by $\frac{1}{3}$, how did the pressure change?
 - C. As the volume decreased by $\frac{1}{2}$, how did the pressure change?

Conclusions:

Write your conclusions as complete sentences.

1. Does air have mass?

How do you know?

As you were pumping, were you really adding more air particles? Y or N? _____

2. At a constant temperature and pressure, how does the number of gas particles affect the volume of a gas?

Is this a direct or inverse relationship? _____

3. At a constant volume, what can you conclude about how the number the number of particles affects pressure of a gas?

Is this a direct or inverse relationship? _____

4. At a constant volume, what is the relationship between temperature and pressure of a gas?

Is this a direct or inverse relationship? _____

5. At a constant temperature, what is the relationship between the volume of a gas (syringe gas volume) and the pressure exerted on it?

Is this a direct or inverse relationship?

Graphic Organizers

Global Wind Comparison Table

1. Fold a sheet of 8 x 11 paper to create a table with five columns and three rows.
2. Label the columns with “Trade Winds,” “Westerlies,” “Polar easterlies,” and “Jet streams.”
3. Label the rows with “Latitude,” and “Direction.”
4. Fill in the table with details about each type of wind.

Types of Clouds Comparison Table

1. Fold a sheet of 8 x 11 paper to create a table with four columns and three rows.
2. Label the columns with “Stratus clouds,” “Cumulus clouds,” and “Cirrus clouds.”
3. Label the rows with “Altitude” and “Shape.”
4. Fill in the table with the altitude and shape of each cloud.

Severe Weather Venn Diagram

1. On a 8 x 11 sheet of paper, draw three overlapping circles.
2. Label the circles with “Hurricanes,” “Cyclones,” and “Anticyclones.”
3. Fill in the diagram with characteristics that each weather event shares with the other weather events.

Adapted from Holt’s Earth Science (© 2008 Pages 563, 585, 609)

Name _____

Outside Weather Observations

Collection Data

	Week 1					Week 2				
Temperature										
Humidity										
Dew point										
Barometric pressure										
Barometric Trend										
Wind Speed & Direction										
Cloud Cover										
Types of Clouds										
Present weather										
Weather Predictions										

Barometric trend

(↑ = rising; ↓ = falling; N = steady)

Cloud cover

(C = clear; CL = cloudy; PC = partly cloudy; O = overcast)

Types of clouds

(S = stratus; CU = cumulus; CI = Cirrus)

Name _____

Weather Forecasting

Purpose:

Using a series of daily weather maps, you will track the movements of weather systems over a period of five days. Using your data, you will predict future weather conditions.

Materials:

Colored pencils

Colored daily weather maps for five consecutive days

Blank map of the U.S. (located at http://eduplace.com/ss/maps/pdg/us_nl.pdf)

Weather observation sheet

Procedure:

1. For each day, collect local weather data (through personal observation and newspaper or internet). Cut or print out each day's weather map and indicate the date on the bottom left corner.
2. Record any outside weather observations and printed data in the weather observation worksheet.
3. Using a copy of the United States, put an L at any locations where low-pressure centers are shown on the daily weather map. Circle the Ls with a colored pencil, and label each circle with the date.
4. Put an H on your map at the locations of any high-pressure centers. Circle the Hs with a second colored pencil, and label each circle with the date.
5. Repeat steps 1-4 using weather maps for the next four consecutive days. Continue using the same copy of the U.S. in order to show how each pressure system moves each day. Make sure you use the same colors on your map each day.
6. Draw arrows to connect the daily positions of each high-pressure center and of each low-pressure center.
7. Using the formula below, calculate the average velocity (in km/day) of each high and low pressure center.

$$\text{Average velocity} = \frac{\text{Total distance traveled}}{\text{Number of days}}$$

Analysis & Conclusion:

1. What direction did the pressure centers over the United States move?
2. What was the average rate of movement (in km/day) of the low- and high-pressure centers? Show your work and make sure to include units!
3. Where do you think the low- and high-pressure centers will be located on the sixth day?
4. Referring to your series of daily weather maps, what do you think the weather in your hometown will be for the sixth day? Write a forecast, and fill in the data table with your predictions of weather conditions.

Evaluating your predictions:

1. Was your prediction about the locations of the low- and high-pressure centers accurate for the sixth day? Why or why not?
2. Comparing your weather prediction to actual weather data, were you correct? What may have caused your predictions to be incorrect?
3. What are the general weather conditions associated with regions of low and high atmospheric pressure?

Adapted from Holt's Earth Science (©2008 Pages 858-861)

Name _____

Factors That Affect Climate

Purpose:

To determine whether land or water absorbs heat faster.

To explain how the properties of water and land affect climate.

Materials:

2 small plastic bowls, heat lamp, small plastic ruler, soil, water, 2 thermometers

Background Information:

Many factors affect climate including the distribution of land and water. Land and water absorb and release heat energy differently therefore they affect the atmosphere differently. In turn, differences between land and water affect climate.

Ask a Question & Form a Hypothesis:

1. How do the properties of land and water affect climate?

Test Your Hypothesis:

2. Fill one bowl with soil and the other with water. Make sure you have the same amount of each substance in each bowl. Place them next to each other on a flat surface.
3. Place a thermometer in the soil and after a minute, record the temperature.
4. Place the other thermometer in the container of water. Each thermometer bulb should be no more than 0.5 cm below the surface of the water or soil.
5. Place the heat lamp 25 cm above both containers.
6. Record the temperature of each sample at 1, 3, 5, and 10 minute intervals in the table below:

Data Table		
Time (minutes)	Temperature of soil (°C)	Temperature of water (°C)
1		
3		
5		
10		
5 (after light off)		

7. Turn off the light. After 5 minutes record the temperature of the soil and water.

Analyze the Results:

1. Which substance absorbed more heat energy?
2. Which substance lost heat energy faster when the light was turned off?
3. Based on your results, what conclusions can you draw about how land and water on Earth are heated by the sun?
4. Do you think being located near a body of water would affect the temperature of the region? Why or why not? How would you be able to test your hypothesis?

Extra Credit

5. If you were to change the angle of your light source, do you think your results would change? Why or why not?

Adapted from Holt's Earth Science (©2008 Pages 652-653)

APPENDIX F—STUDENT DATA

Table 3—Student Points Earned on Pretest and Posttest Questions

Student		1	2	3	4	5	6	7	8	9	10	11	12	13
Q1	Pre-	0	1	0	0	0	0	2	0	1	1	0	0	0
	Post-	0	1	0	2	2	0	2	0	1	2	0	0	2
Q2	Pre-	0	0	1	1	0	0	0	1	0	0	0	0	0
	Post-	0	1	1	1	0	0	1	1	0	0	0	1	0
Q3	Pre-	0	0	2	0	0	0	0	0	0	1	0	0	0
	Post-	1	0	2	0	0	0	4	0	4	4	0	0	0
Q4	Pre-	1	0	0	0	0	0	0	0	0	0	0	0	0
	Post-	1	0	0	0	0	0	2	1	0	2	0	0	0
Q5	Pre-	0	0	0	0	0	0	0	0	0	0	0	0	0
	Post-	0	3	0	0	2	0	0	1	0	4	0	0	3
Q6	Pre-	2	0	0	3	0	1	3	0	3	0	0	0	0
	Post-	5	0	0	3	0	1	3	0	3	4	3	0	0
Q7	Pre-	0	1	0	0	0	0	0	0	0	0	0	0	0
	Post-	0	1	0	0	0	0	0	0	0	0	0	0	1
Q8	Pre-	0	0	1	0	0	0	1	0	1	1	0	0	0
	Post-	0	0	1	0	0	0	1	0	1	1	1	0	1
Q9	Pre-	0	0	1	0	0	0	0	0	1	0	0	0	0
	Post-	0	0	2	0	0	0	2	0	1	4	3	0	4
Q10	Pre-	0	0	0	0	0	0	0	0	0	0	0	0	0
	Post-	0	0	0	0	0	0	0	0	0	0	0	0	0
Q11	Pre-	0	0	0	0	0	0	0	0	0	0	0	0	0
	Post-	0	0	0	0	0	0	0	0	0	0	0	2	0
Q12	Pre-	0	1	0	0	0	0	0	0	0	0	1	0	0
	Post-	1	1	0	1	0	0	1	0	0	1	1	1	1

Table 4—Student Pretest, Posttest, and Final Exam Scores

Student	Pretest Score (%)	Posttest Score (%)	Percent Difference	Final Exam Score (%)
1	9.8	25.8	16	41.7
2	9.8	22.6	12.8	44.4
3	16.1	19.4	3.3	52.8
4	12.9	22.6	9.7	66.7
5	0	12.9	12.9	36.1
6	3.2	3.2	0	33.3
7	19.4	51.6	32.2	75
8	3.2	9.7	6.5	50
9	19.4	32.3	12.9	58.3
10	9.7	71.0	61.3	77.8
11	3.2	25.8	22.6	69.4
12	0	12.9	12.9	30.6
13	0	38.7	38.7	66.7
Ave.	8.2	26.8	18.6	54.1

Table 5 –Student Scores for Classroom Activities

Student	Can Demo	Layers of Atmosphere	Is Air a Fluid?	Lab Pg.570	Water Cycle Activity	R.H. Activity	3-D map
	5	20	5	20	20	20	20
1	3	0	4	17	9	0	0
2	5	20	4	5	14	16	17
3	5	20	5	15	20	15	17
4	5	20	4	20	5	17	18
5	4	20	4	18	18	3	17
6	4	0	4	20	20	17	17
7	5	0	4	20	18	18	0
8	5	20	0	0	15	13	18
9	5	20	4	20	20	15	19
10	5	20	4	20	18	18	17
11	3	20	5	12	18	18	18
12	5	0	3	15	16	0	0
13	0	0	5	20	20	18	19

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