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A Hands-on Approach to Teaching Weather and Climate in an Eighth Grade Classroom.

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A HANDS-ON APPROACH TO TEACHING WEATHER AND CLIMATE IN AN EIGHTH GRADE CLASSROOM

By

Susan Jennifer Tate

A THESIS

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in partial fulfillment of the requirements
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Abstract

This study details the design and implementation of a five-week unit on weather and climate taught to eighth grade students. The goal of this unit was to increase student interest and performance by creating student-centered lessons, eliminating reliance on the textbook, incorporating meaningful hands-on activities and engaging demonstrations, providing opportunities for cooperative learning, integrating math and technology into the lessons, and checking student understanding with embedded assessment. These strategies were designed to improve instruction of topics covering the atmosphere and air, heat transfer and temperature controls, wind formation and types, moisture in the air, air masses and fronts, and climate. Data for this study were collected from four instruments of assessment: a pre-test, a post-test, activity extension questions and a writing/publishing project. Quantitative data from these tools, along with qualitative data collected from a post-unit survey indicate that the goals of the unit were successfully met.

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I. Introduction

According to the American Association for the Advancement of Science, science in the classroom is something to be performed, not simply studied (cited in Knezek, 2000). This statement was the central reason that I selected my 8th grade science unit on weather and climate for improvement. When working this unit, my students were exposed to lessons that were textbook centered, ineffective, and lacking in opportunities for them to be active, inquisitive learners. The goal of this improved unit was to increase student interest and performance by implementing lessons that were learner-focused, eliminating reliance on the textbook, developing hands-on activities and engaging demonstrations, and by allowing students more opportunities to work in cooperative learning groups. In addition, I was seeking to integrate math and technology into my lessons, and to determine the students' understanding throughout the unit by embedding assessment within the lessons.

In a teacher-centered classroom, students often sit passively while the teacher actively works at providing them with knowledge, whereas a learner-focused classroom is characterized by students who are mentally engaged and actively participating in the act of learning (Thomason, 1998). Teachers then become facilitators, whose role it is to assist the students in understanding the material and it application to the world (Ritchie, 2000). One of the duties of the teacher is to promote the idea that knowledge is not a fixed possession, rather it is a tool that students need for constructing viewpoints in alternate situations (Anfara, 2000). In order to be an effective educator, the teacher must use real-world examples that pertain to the lives of their students, and encourage them to apply what they have learned to other scenarios. To do this, teachers may need to guide the students by illustrating and clarifying these interconnected relationships (Ritchie, 2000).

One way that a teacher can develop a more learner-centered approach in their classroom is by eliminating reliance on the textbook. The curriculum can be more flexible when teachers use alternate sources for planning lessons (Ediger, 2001). Students, especially those in the middle grades, are better served by this flexibility. According to Paul Hickman of the Center for the Enhancement of Science and Mathematics Education at Northeastern University in Boston, "young children can learn facts from text but find it hard to learn ideas from them" (Raloff, 2001). Unfortunately for many students, lesson reliance on a textbook often leads to boredom or frustration, and some students lose their curiosity and enthusiasm for science.

As teachers move away from the textbook, they can replace the old text-driven lessons with new hands-on activities, which put the learner in a more active role (Knezek, 2000). Instead of the teacher telling the students the information, the students are put in the position that they must investigate and find the answers empirically (Raloff, 2001). This helps the student construct their own world-view (Dalton, 1997), and develop better abstract thinking skills (in The Futurist, 1999). Hands-on activities provide opportunities for meaningful learning, since middle school students learn best from these methods. Putting students in small groups and allowing them to experiment within a given set of parameters feeds their need for social interaction with their peers (Raloff, 2001), which benefits all students. In fact, students who are characterized as poorly motivated often report that they learn best when they can work on hands-on activities and projects that allow them to make decisions (Muir, 2001). Studies show that these types of activities also benefit students with learning disabilities (Dalton, 1997). Since these students often have language difficulties or problems with written expression, the fact that hands-on activities target multiple modalities helps them to better learn and retain information. Because hands-on activities benefit all types of children in a classroom, educators will almost certainly have the full support of their building principals (Nabors, 1999). With administrative and parental support, and promising research that points to its effectiveness, it is easy to see why a teacher would make the transition away from textbook lessons toward hands-on, student-centered activities.

In addition to developing lessons that center around hands-on activities, teachers can improve their instructions by encouraging students to work in cooperative learning groups. Many of the activities utilized in this unit plan gave the students opportunities to work with their peers. Cooperative group discussion provides an opportunity for science students to simply explore the topic at hand (Anfara, 2000). Furthermore, when students have the chance to develop concepts by communicating in turns with the other members of their group, they are also developing a problem-solving framework for future use (Dalton, 1997). Cooperative learning is a valuable tool because students "must learn to include and communicate with one another" (Walsh, 2000). This puts the students into what she refers to as the "oral discovery space", in which the students develop their own thinking by talking about it with others. Both students and teachers can benefit from the development of this problem-solving framework through cooperative learning.

Another hallmark of exemplary middle school instruction is curriculum integration. The importance of this was cited in the Benchmarks for Science Literacy by the American Association for the Advancement of Science when they praised the benefits of the integration of science with mathematics and technology (Cawley, 2002). The National Middle School Association extends that praise by observing that curriculum that is integrated helps students "connect school experiences to their daily lives outside the school, and…encourages them to reflect on the totality of their experiences" (Anfara, 2000). Integration was the goal of this unit when lessons were implemented that included graphing, calculating, drawing, and computer research and design. Asking students to find the connections between these different activity components not only helps them to reflect on the material, but it also challenges them to become fully engaged in an activity (Walsh, 2000). When students are engaged, active, curious learners, they become open to all of the possibilities that the curriculum offers.

When this unit plan was designed, opportunities to check for student understanding as they work, embedded assessment, were incorporated into the lessons. Types of embedded assessment include using questions at the beginning of an activity to assess prior knowledge, having whole class discussions to guide student understanding, and asking the students to use drawing to diagram or model the main ideas of the activity (Treagust, 2003). An example of embedded assessment taken from this unit would be when the students were asked to predict the outcome of convective layering within an aquarium by drawing what they expected to see. The goal of embedded assessment is to find out where the students are in their understanding so that instructional modifications can be made to elaborate, illustrate, and clarify student misconceptions. In addition to the informal tools of assessment that were mentioned above, a more formal assessment tool that a teacher can utilize is a scoring rubric. A rubric is a device that is designed by the teacher to guide the students in an activity, and to evaluate their finished work. In esse

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essence, the rubric eliminates anxiety and confusion by informing the student of the criteria for the assignment (Bednarski, 2003). Whether a teacher incorporates formal assessment strategies, such as rubrics, or informal embedded assessment into their activities, students ultimately benefit from this aspect of instruction.

Based on the current pedagogical research previously mentioned, this unit was redesigned to be learner-centered. Opportunities for meaningful, hands-on activities, cooperative learning, curriculum integration and embedded assessment were incorporated to maximize student success. This was designed to benefit the students, and to also assist the teacher out of the rut of teaching textbook-driven lessons.

A. Scientific Background: Weather and Climate

Weather is something that surrounds each and every one of us every single day. It is something that influences a person's fishing trips, commutes, weekend plans, possibly their livelihood, and sometimes even their wedding. Weather is also something that by the time most people reach adulthood, they think they know more than the meteorologist on television. Weather is all of these things, and in a scientific sense, it is also a dynamic system that resides in our atmosphere, driven by four key elements: air density/pressure, heat, wind and moisture. Trends in this dynamic system over time are referred to as climate.

Earth's atmosphere, a thin layer of gases that surrounds the planet, is composed primarily of nitrogen and oxygen. The bulk of these gases, which most people refer to simply as air, reside in the layer closest to Earth, the troposphere. This layer is also referred to as the layer of weather. The troposphere is followed by the remaining layers:

the stratosphere, the mesosphere and the thermosphere. All of the air in the atmosphere is constantly pushing down on Earth's surface, and this is referred to as air pressure. Air pressure is related to the density of the air; if air is more dense, it will have higher air pressure. The three main factors that determine density of the air are temperature, elevation and the amount of water vapor in the air. In an open container, like our atmosphere, as temperature rises, density decreases due to the fact that the molecules in the air spread out as they collide with one another. Likewise, density will decrease as elevation, or altitude, increases. This is because there are fewer air molecules as you rise through the troposphere. Finally, the amount of water vapor in the air affects density due to the fact that a molecule of water has less mass than a molecule of oxygen or nitrogen. So when water vapor is added to a parcel of air, it displaces an equal number of molecules out of the parcel, thereby reducing the overall mass and the density.

The primary factor that drives the system of weather is thermal energy that the Earth receives from the Sun. This thermal energy is transferred through the vacuum of space by a process known as radiation. Once this solar radiation heats the surface of the Earth, some of that thermal energy is conducted directly to the air above it. Another method of heat transfer, convection, distributes the thermal energy throughout Earth's atmosphere. Convection is also one of the ways that heat is transferred through water. The amount of radiation that reaches the Earth at any particular location is called insolation (incoming solar radiation). Insolation is affected most by latitude and the Earth's tilt on its axis, although there are daily fluctuations in insolation as well. The temperature of a particular location is affected by other factors besides insolation. Due to heat capacity differences in land as compared to water, coastal locations tend to have fewer temperature extremes

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than inland locations. Another factor that can affect the temperature of coastal locations is the temperature of a nearby ocean current. Locations along the east coast of the United States are warmed slightly by the Gulf Stream current, which is a warm water current originating near the equator. Temperatures can also be affected by altitude, cloud cover and surface albedo, or reflection. In terms of climate, scientists are most concerned about the effect that increasing levels of carbon dioxide will have on Earth's temperatures. This feared trend, known as global warming, is influenced by the greenhouse effect of our atmosphere. Since solar radiation has enough energy to penetrate Earth's atmosphere, it is able to reach and heat the Earth's surface. Terrestrial radiation, which is energy that is re-radiated by the Earth, lacks the necessary energy to be transmitted through the atmosphere back into space. The process by which this energy is trapped within our atmosphere is known as the greenhouse effect.

The next component of weather, wind, is closely related to air pressure and heat. In fact, wind is caused by differences in air pressure due to unequal heating of different locations on Earth. Some winds are transient, shifting daily due to localized heat changes. These winds are referred to as local winds, and they include winds associated with high and low-pressure systems, sea and land breezes, and special types such as a monsoon or Chinook. Other wind patterns are established by large convection cells that develop from rising air at the equator and sixty degrees latitude, and sinking air at thirty degrees latitude and the poles. Instead of blowing due north or south, these global wind belts, including the trade winds, prevailing westerlies and the polar easterlies, are curved slightly by the Coriolis effect, which is caused by Earth's rotation on its axis.

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The last component of weather, water, can be present in Earth's atmosphere in gas, liquid or solid states. Water vapor is the term for gaseous water, and the amount of it in the air can be expressed in one of two ways. The relative humidity value indicates as a percentage the amount of water vapor in the air compared to the amount the air could hold at that temperature. This value will vary throughout the day as the air temperature rises and falls. The other value is referred to as the dew point temperature. This is the temperature to which the air must decrease in order for the air to become saturated, which means that the water vapor would start to condense into liquid water such as dew or fog, or solid water such as frost. Clouds will also form when a rising parcel of air cools to the dew point temperature. The three primary types are large puffy cumulus clouds, smooth gray stratus clouds and wispy cirrus clouds. When cloud droplets start to join together, they form larger drops of liquid water that can no longer remain suspended in the cloud. These droplets then fall to the ground as precipitation which, depending on the state of matter when it reaches the ground, can be classified as rain, sleet, hail or snow. There are some climate factors that will influence the amount of precipitation that an area receives. Locations on the windward side of a mountain tend to have heavy precipitation because the air rising up the side of the mountain cools to the point of saturation and then loses the moisture it carried in the form of precipitation. By the time that the air goes over the summit to the leeward side it is very dry, so when the air sinks and warms as it goes down the leeward face it will actually be evaporating moisture from the ground, thus creating what is known as a rain-shadow desert. Another climate factor that can affect the amount of precipitation that an area receives is nearness to a major body of water. Coastal locations that experience a prevailing wind that blows from across the water tend to get heavy precipitation, since the wind will pick up moisture as it moves across the water and then lose it as the air changes temperature over land.

Weather occurs when the parameters change between two or more different air masses—large bodies of air that have a uniform temperature and moisture content. Continental air masses form over land and tend to be very dry, whereas maritime air masses carry a lot of moisture since they form over water. In terms of temperature, tropical air masses are warmer due to their equatorial origin, while polar air masses are much cooler due to their high-latitude formation. When these air masses meet, the boundary is referred to as a front, which is named according to the air mass that is on the move. In other words, a cold front occurs when a cold air mass pushes underneath a warm air mass. This violent uplift can produce thunderstorms and occasionally tornadoes. A warm front, on the other hand, forms when a warm air mass slides over the top of a cold air mass. Instead of thunderstorms, this type of front usually produces rain showers. When there is no dominant air mass, the front is known as stationary because there is no boundary movement. The fourth type of front that can occur is an occluded front, which forms when a cold front overtakes a warm front. This usually happens with a mature low-pressure system that has tracked over much of the United States.

As stated earlier, climate is the general conditions of temperature and precipitation for an area over many years. In terms of temperature, the Earth is divided into three main climate zones: the tropical zone, the temperate zone and the polar zone. These zones are delineated by isotherms, which produce temperature boundaries. Scientists are always seeking to learn more about past climates in order to make better predictions about where the climates of the planet are heading in the future. Since there is reliable climate data for only the last hundred years or so, scientists must rely on other methods for determining the past climate of an area. Some of these methods include taking sediment cores from old lake beds and identifying trapped pollen, taking ice cores from glaciers or ice caps and analyzing the trapped gases, and taking cores from trees and interpreting the ring pattern as an indicator of the growing season.

As scientists learn more about weather and climate, they will be better able to establish prediction models for systems such as the greenhouse effect and violent storm formation. Forecasts will become increasingly more accurate, and industries that depend on the weather, such as agriculture and tourism, will be able to anticipate and plan for catastrophic weather events. Society, including the armchair meteorologists, will benefit greatly from this knowledge.

B. Demographics

Whitehall District Schools is located in the city of Whitehall—a small municipality in Muskegon County on the shores of White Lake and Lake Michigan. Residents of this district represent a diversity of ethnic and socioeconomic backgrounds. The spectrum ranges from those who can afford to own lake frontage to those who live in the government-subsidized housing project east of town. People in this community have shown a tendency towards tremendous support for their schools, most recently passing a bond request for a twenty-nine million dollar facilities improvement project that will include a new high school. Local businesses and industry have forged powerful partnerships with the school that have offered students the opportunity to apply what they learn in the classroom to the real world.

Whitehall Junior High School has suffered in recent years from a slight identity crisis. Seeking to be a true middle school, WJHS has implemented wonderful programs such as middle school teaming, and administrators would like to have the building house grades six through eight. Currently, the building houses grades seven through nine, although the nine grade classes are administered by the high school which is situated next to the junior high building. During the 2002-2003 school year there were one hundred sixty-four eighth graders and one hundred seventy-five seventh graders, for a total junior high enrollment of three hundred thirty-nine students (K-12 enrollment of 2,200). Of the students in eighth grade, there were seventy-eight females and eighty-six males, with a racial profile of 88.4% Caucasian, 1.8% Native American, 7.3% African-American, 1.2% Asian, and 1.2% Hispanic.

II. Implementation

As stated in the introduction, the goals of this unit were to increase student interest and performance by implementing lessons that were learner-focused, eliminating reliance on the textbook, developing hands-on activities and engaging demonstrations, and by allowing students more opportunities to work in cooperative learning groups. The lessons, activities and demonstrations were developed during the course of research that occurred over a six-week period during the summer of 2002. I started by developing an overview of the unit, and then breaking the main components down into lesson topics. Appropriate activities and demonstrations were then incorporated that best fit the goals of the unit.

The initial timeline established for the teaching of this unit was approximately five weeks. Due to time constraints, vacations and one all-day field trip, the unit was actually taught over the course of twenty-two school days beginning at the end of March, and finishing the first of May. The first two weeks of the unit were taught before a weeklong spring vacation, and the remaining three weeks were taught upon the students' return. In order to keep this unit plan within a manageable time frame (for the students as well as the teacher), some of the activities originally developed during summer research had to be modified or scaled back slightly. For a complete overview of this unit, including the progression of demonstrations, activities, labs and lecture notes, see figure 1.

The unit began with a pre-test consisting of twelve short-answer questions that best represented the material (Appendix A-I). This assessment alone piqued the curiosity of the students since they were not used to taking any kind of test in which their score did

Figure 1

3/24 1. Hand out new textbooks 2. Unit Pre-assessment 3. **Notes**: Atmosphere 4. **Demo**: "Attack of the Killer Peep 5. **Hmwk**: Read sec. 1-2	**3/25** 1. **Discuss**: Peep demo 2. **Activity**: "Balloon Behavior" 3. **Notes**: Air Pressure 4. **Demo**: "Bell Jar Boil" 5. **Hmwk**: Read sec. 1-1	**3/26** 1. **Discuss**: Balloon Behavior 2. **Laserdisc**: Atmosphere 3. **Demo**: "Aquarium Convection" 4. **Notes**: Heat Transfer	**3/27 (1/2 day—flex; 30 minute classes)** 1. **Notes**: Heat Transfer cont., 2. **Activity**: "Flashlight Insolation"	**3/28** 1. **Lab**: "Insolation Investigation"
3/31 1. **Discuss**: Insolation Investigation 2. **Notes**: Temperature Controls 3. **Demo**: Seasons 4. **Demo**: Heat Cap. Of Land vs. Water	**4/1** 1. **Notes**: Temp. Controls cont., 2. **Activity**: Greenhouse Investigation	**4/2** 1. **Activity**: Finish Greenhouse Inv. (graphing) 2. **Read**: sec. 1-3 3. **Notes**: Local Winds 4. **Demo**: "Candle Extinguisher" 5. **Laserdisc**: Wind	**4/3** 1. **Notes**: Global Winds 2. **Activity**: Building an Anemometer	**4/4 (1/2 day—no flex)** 1. **Movie**: "Twister"
4/14 1. **Activity**: Finish Wind Speed Calc. 2. **Demo**: Ping-pong Ball Anemometer 3. **Review**: Previous Topics 4. **Notes**: Moisture In the Air	**4/15** 1. **Notes**: Cloud Formation and Types 2. **Activity**: Cloud Base Height Calculation	**4/16** 1. **Activity**: C.B.H. cont., (graphing and extension questions)	**No class—Field Trip** 1. Van Andel Museum—Dead Sea Scrolls 2. IMAX—Lewis and Clark Movie	**No school—Good Friday**
4/21 1. **Discuss**: Cloud Base Height Activity ?'s 2. **Notes**: Precipitation 3. **Laserdisc**: Clouds and Precipitation 4. **Read**: sec. 1-5	**4/22** 1. Review "Quiz" 2. **Notes**: Air Masses and Fronts 3. **Activity**: Weather Travel Brochures (Location Lottery!)	**4/23** 1. **Research**: Weather Travel Brochure (Computer Lab)	**4/24** 1. **Notes**: Climate 2. **Activity**: "Paleoclimates and Pollen"	**4/25** 1. **Activity**: Paleoclimates cont., 2. **Research**: Weather Travel Brochure (Computer Lab)
4/28 1. **Activity**: Weather Travel Brochures--Design using MS Publisher	**4/29** 1. **Review**: Study Guide 2. **Activity**: Finish Brochures	**4/30 (1/2 day—no flex)** 1. **Review**: Crosswords 2. **Guest Speaker**: Bill Steffen WoodTV 8 Meteorologist	**5/1** 1. Unit Post-assessment	

not count toward their class grade. Most students seemed to take the assessment seriously and gave their best effort. The pre-test was followed by approximately ten minutes worth of lecture notes (Appendix B-I) that presented an overview of Earth's atmosphere. Since the students had been taught about the atmosphere in seventh grade, the information was meant to refresh their memories about the layers and composition of the atmosphere. I finished the first day of the unit with a demonstration designed to catch their attention. Titled "Attack of the Killer Peep®" (Appendix C-I), the demonstration showed how marshmallow candy expands inside a bell jar when the air is removed with a vacuum pump. Some simple inquiry questions were posed to the students in an attempt to solicit observations and explanations. Since I did not elaborate on the function of the bell jar and pump before the demonstration, some students did not understand that the air was being removed. These students tended to believe that there was something inside of the candy that was actively growing. Eventually, students correctly pieced together the correct explanation that the candy passively expands due to a lack of air pressure.

Two additional days were devoted to the topic of air density and pressure. Since student acquisition of this information was integral to further study on heat transfer and wind formation, I repeatedly checked the students' understanding during this time. An additional demonstration (Appendix C-II) utilizing the bell jar to boil water in the absence of heat reinforced the previous day's demonstration with the expanding candy. I took this idea one step further with a student activity titled "Balloon Behavior" (Appendix D-I). In this activity, a balloon was stretched across the opening to an ordinary twenty-ounce pop bottle. Students were told that the bottle would be alternately placed in boiling water and an ice bath. They were asked to draw pictures and make verbal predictions as to what would happen to the air inside the bottle/balloon assembly under these conditions. So that the students would not have to handle boiling water, this activity was modified so that I would perform the experiment in front of the class, with the students encouraged to come up close to watch. This proved to be an important activity for the class because while most of them had a pretty clear understanding of what would happen to the balloon, many were unable to draw or verbalize what was happening to the individual air molecules within the assembly. After spending approximately ten minutes on lecture notes (Appendix B-II), homework for the students that night included activity extension questions (Appendix D-I) that pertained to air pressure and density, and we spent nearly half of the next day's class discussing the activity and follow-up questions.

The next topic covered in this unit was related to thermal energy and heat. Since this was one of the major ideas for the unit, five days of class were devoted to this topic. The first demonstration planned, titled "Aquarium Convection" (Appendix C-III), proved to be engaging. Prior to taking notes on the subject of heat transfer (Appendix B-III), students were asked to make a drawing (prediction) and a verbal explanation as to what would happen when water of different temperatures and colors was released into an aquarium full of room temperature water. Eighth graders tend to get excited anytime they are handed colored pencils and asked to draw, even for science class, and this was no exception. The students were full of anticipation for the demonstration itself, which produced fantastic results. The students were impressed by the distinct layers of color that formed in the tank. The interest generated by this demonstration carried over to the next day's class when the students had an opportunity to do a hands-on investigation about insolation (incoming solar radiation), or the amount of heat energy that reaches a particular location on Earth. During the "Flashlight Insolation" activity (Appendix D-II), students were given a flashlight and some graph paper, and instructed to trace the circle of illumination produced by the flashlight when held at various angles. Students then counted the number of squares on the graph paper that were within this tracing. Students quickly made the connection that the flashlight, like the Sun, emits a constant beam of light, so if the number of illuminated squares increased, the intensity of the light falling on those squares must have decreased. This preliminary activity served as a springboard to a laboratory investigation on insolation (Appendix D-III). The students applied their newfound knowledge from the flashlight activity to a new situation involving a heat source (clip lamp), thermometers and wooden blocks (30°-60°-90° triangles). The students were given rather limited instructions for this investigation, and it was interesting to see how they problem-solved throughout the lab. Working in groups of three, the students taped the thermometers to the wooden blocks so that when placed in front of the heat source, one thermometer would be held at a ninety-degree angle, one at sixty degrees, and one at thirty degrees. Lab groups then recorded the temperature increases of the three thermometers at regular intervals. Watching the students as they recorded data, it became apparent that many students would write down just about anything without questioning the validity of it. Several groups in each class generated data that did not match the expected outcome. If the students were unsure of the expected results, I would remind them of the flashlight activity that they had done the day before. This reminder was usually enough to get the group realizing that their data was flawed. I would then prompt them to do some error analysis and brainstorm some ideas as to why their experimental set-up was producing flawed results. It was very satisfying as a teacher to see the students apply their prior knowledge in this manner. This proved to be a very effective investigation. However, some caution should be taken in linking this lab to the flashlight insolation activity. Some students became confused by the fact that with the flashlight activity, it was the light source that was varied in angle as it was held over the paper, but with the lab investigation the heat lamp was immobile while the blocks were varied in angle. Also, when asked to apply their results from the lab investigation to places on the Earth, some students confused the angle of the block with latitude. In other words, they thought the ninety-degree block corresponded to the polar regions (ninety degrees latitude) instead of the direct rays near the equator. In the future, some pre-laboratory explanation to eliminate this confusion would be in order.

Additional demonstrations and hands-on activities dedicated to the topic of heat transfer and insolation included a demonstration of the reason for seasons (Appendix C-IV), a demonstration of the heat capacity of land versus water (Appendix C-V), and a greenhouse/albedo investigation (Appendix D-IV). The demonstrations were integrated into the presentation of lecture notes on temperature controls (Appendix B-IV), which effectively provided alternative instruction for those students who do not find lecture to be their preferred learning style. As reinforcement of the lecture material on factors that influence the heat received at a particular location on Earth, the students had the opportunity to do an activity in which they made models of the Earth that represented these factors. The "Greenhouse Investigation" (Appendix D-IV) allowed the students to specifically analyze the effects of cloud cover and surface albedo, as well as the heat capacity of land versus water. Students worked in groups of two to construct atmospheric chambers that modeled the greenhouse effect of Earth's atmosphere. After answering a few pre-investigation prediction questions, students placed these Earth models beneath a heat lamp that represented the Sun, and took turns recording temperature readings at regular intervals. Results were recorded in a data table and then graphed. Most students accurately predicted that there would be less of a temperature increase inside the models with simulated cloud cover as compared to the models without cloud cover. The data collected from these models reinforced the previous day's lecture material (Appendix B-IV) during which we discussed how clouds reflect and scatter incoming solar radiation. In terms of the other variables tested, most students felt that the model with the soil would heat up faster than the model with the water. They based this hypothesis on the demonstration that they had witnessed during the previous class period concerning the heat capacity of land versus water. Unfortunately, the thermometers were measuring the temperature above the surface material not in it, so the actual results showed no distinct temperature difference between the two. The same could be said for the dark-colored soil versus the light-colored sand chambers. Again, students were anticipating that the dark-colored soil chamber would show a greater temperature increase than the sand. Instead, the sand chamber showed more of a temperature increase due to the fact that the surface material was reflecting heat back up into the chamber. In the future I would probably modify this investigation by utilizing additional thermometers that measured the temperature slightly below the top of the surface material. Students did enjoy this activity, and the post-investigation discussion proved to be very effective as the class discussed how they had formulated their hypotheses, and why those predictions were sometimes not supported by the data.

By the middle of the second week of this unit, the students entered the classroom each day filled with anticipation as to what "cool" new demonstrations and activities they would be seeing or doing that day. Since they had just spent almost five class periods learning about heat, it was time to shift gears to the closely related topic of wind formation and types. In order to convince them that wind is caused by air moving from an area of high pressure to an area of low pressure (ultimately caused by heat discrepancies), I performed the "Candle Extinguisher" demonstration (Appendix C-VI). Taking advantage of the reaction between baking soda and vinegar, I "poured" carbon

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dioxide down a trough to where it would replace the air above a lit candle, thus cutting off the supply of oxygen and extinguishing the flame. This demonstration is designed so that students can visualize a process that is essentially invisible. Follow-up discussion was very enlightening as I helped the students construct the correct explanation that the carbon dioxide gas was more dense and it moved toward the less dense room air above the candle. This is equivalent to the process by which air that is cooler and more dense moves toward an area that has warmer, less dense air. With that understanding in mind, we moved along to some lecture notes on the different types of local and global winds (Appendix B-V). In order to break up the time devoted to lecture, and appeal to students with different learning styles, I also showed a brief laserdisc clip (Prentice Hall) on wind that reinforced the material.

The primary hands-on activity developed for this section was building anemometers from straws and small drinking cups (Appendix D-V). The straw-cup assembly was designed to rotate around a pin that was stuck into the eraser of a pencil. The goal of this project was for students to construct a functional weather instrument, and to use their completed anemometer to roughly calculate wind speed. I discovered that the higher-achieving students in my class tended to struggle with this assignment the most, while the lower-achieving students excelled at the construction. I knew from past experience that students who love laboratory investigations the most tend to be the students who dislike "book work". I did not expect to see this pattern emerge so clearly on this assignment. Most of the "C" and "D" students worked quietly and efficiently on this project, while most of the "A" and "B" students whined about the difficulty of building the device. In the end, almost everyone successfully built their own anemometer. The students then took their new anemometers outside to measure the wind speed. While the wind was strong the day we tested, it tended to blow in gusts, which was not very useful for our purpose. When they returned to the classroom however, the students did get to work through a sample calculation of wind speed by converting anemometer speed in revolutions per minute to the wind speed in kilometers per hour. I also demonstrated a ping-pong ball anemometer with the classroom fan (Appendix C-VII). The ping-pong ball hanging from the anemometer is displaced a certain number of angular degrees, the number of which can be used to look up the value for wind speed on a chart. Since the students had been working diligently for two weeks on the unit objectives, we finished this topic (on the half-day before spring break) by watching the movie "Twister". Students enjoyed watching this movie with some of their newfound understanding of weather.

After spring break, we reviewed the material that they had learned before vacation. It was apparent that the students' retention was significant. In a few instances where the students did not seem to recall key knowledge, all it took was for me to remind them of a corresponding demonstration or hands-on activity, and they would almost immediately remember the ideas associated with it. This definitely validated the manner in which I was teaching this unit.

Week three of this unit took place during a short week of school, since our eighth graders were going on an all-day field trip Thursday and there was no school scheduled for Good Friday. The new unit topic that we were covering was on moisture in the air (relative humidity, dew point temperature, cloud formation and types, and precipitation) and the major student activity that was planned was an investigation of cloud formation.

The "Cloud Base Height Activity" (Appendix D-VI) involved calculating the dew point temperature of the air, and then using that information along with the air temperature to calculate the altitude of the cloud bases. This calculation is possible due to the fact that both dew point temperature and air temperature decrease at a constant rate as altitude increases within the troposphere. These temperatures decrease at different rates, so when they are graphed as separate lines, the point of intersection is the altitude of the cloud bases. We spent a little more than two class periods working on this activity, and students were very involved in the entire process. They enjoyed going outside and collecting data, and most of them had little trouble producing the necessary graph. I also included some post-activity extension questions (Appendix D-VII) that served as one of the assessments for this unit. These questions asked the students to make predictions and give explanations as to what changes would occur with the height of the cloud bases if either the air temperature or water vapor in the air increased or decreased. The students were also asked to explain the reason that the dew point temperature was used for this activity instead of relative humidity, and to describe the conditions under which fog will form. Even though the students were working with a partner, most of them found these questions to be quite challenging, and the majority of one class period was devoted to them searching for and formulating the answers. After the students had turned in this assignment, we spent the beginning of the next day's class period discussing the results of this activity and the answers to the extension questions. This activity challenged them to think, and tied together most of what we had been studying including air density and pressure, heat, and moisture in the air.

After we finished the material on moisture in the air (Appendix B-VI), I became conscious of the fact that we were in the fourth week of the unit and I still had two time-consuming activities planned for the students. Because of this, the class only spent one day formally discussing air masses and fronts. This included lecture notes on the different types (Appendix B-VII), and a detailed explanation of the forecasting bulletin board (Appendix D-VIII). Students enjoyed the large felt weather map developed as a part of my research that was on the bulletin board, and I gave them opportunities to update the movement of cyclones, anticyclones and fronts each day with felt symbols. Even though we moved on to another activity, we spent a few minutes each day that week looking at weather maps from usatoday.com, talking about frontal development/movement and associated weather, and some students took turns predicting weather based on this information.

The next activity that the students worked on was designed as a major assessment piece for the unit. Since I wanted to incorporate as much technology as possible into this unit, each student was required to make travel brochures (Appendix D-IX) for a particular location using Microsoft Publisher®. These brochures were to address the weather/climate of the location, which the students researched using the Internet. Students were given a scoring rubric (Appendix D-X) to guide them on this activity. We held a "location lottery" in which they drew their location from a pool of approximately forty international choices (Appendix D-XI) that I had selected. A few students complained about the location that they drew, but I instructed them that as the director of the travel board for that location it was their job to "sell it". The brochures were graded based on content, appearance and promotional appeal. Most students rose to the challenge and I was pleasantly surprised by the creativity and quality of the brochures that they produced. The Publisher program, a basic desktop formatting tool, is very user-friendly, and most of the students took right off on it with limited teacher instruction.

The last hands-on activity was one that I had spent a great deal of time working on during summer research, "Paleoclimates and Pollen" (Appendix D-XII). The activity was a simulation of pollen analysis from sediment cores using confetti placed in baggies of different types of sediment (dirt, sand, aquarium gravel). The students were required to sort out the "pollen" from the sediment, and then using actual pollen data from an old lake-bed in Washington State, they were supposed to construct the past climate history of the area surrounding the lake. The students really enjoyed getting their hands dirty with the sediment samples, and as I saw with the anemometer construction, the lower-achieving students seemed to commit to this the most. In fact, I only required that the students sort through two of the five layers, but many kids did not want to stop sorting. After finally calling a halt to the sorting process, the students shared their data with the class and then finished with a series of post-activity extension questions (Appendix D-XII). This was a very effective activity for connecting many of the things that the students had learned throughout the five-week unit, including the climate notes covered in lecture (Appendix B-VIII).

During the course of teaching this unit I planned a capstone activity before the unit test. In lieu of review games that I typically use at chapters' end, the students listened to a presentation by guest speaker Bill Steffen, who is the meteorologist at WoodTV 8 in Grand Rapids. I am always a little apprehensive about how the students will behave with a guest speaker, but I need not have been worried. Due to the fact that Mr. Steffen's presen

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presentation was packed with information that reiterated what they had just finished learning, the students were a rapt audience. In addition to this guest-lecture, I gave the students a study guide (Appendix D-XIII) and a take-home review crossword puzzle (Appendix D-XIV) for them to prepare for the unit test.

The final piece of this five-week plan was a comprehensive unit test (Appendix A-II) in which the twelve post-assessment questions were embedded. The questions on the unit test included multiple choice, completion, short answer, map questions and an essay. The students demonstrated seriousness as they took the test that I had not seen in many of them before, and I attribute that to the fact that they were more invested in this unit because of the hands-on activities in which they took part.

During the course of implementing this unit, data were collected from four assessment instruments: the pre-test, the post-test, the "Cloud Base Height" extension questions, and the weather travel brochures. A total of ninety-six students, out of a possible one hundred three, returned their consent forms (Appendix E-I) in order to be eligible for this study. Data were collected for all study participants on the pre- and post-assessments. The data from the remaining assessments were analyzed from six students who had been selected by their seventh grade teachers as being high-, middle- or low-achieving. In addition, a student opinion survey (Appendix D-XV), which served as a qualitative assessment of the unit, was completed by all participants.

III. Evaluation

A. Quantitative Analysis

Data for this unit were collected from four assessment instruments: the pre-test, the post-test, the Cloud Base Height Activity extension questions, and the weather brochure. The pre- and post-assessments were designed to objectively evaluate student understanding of this material before and after I taught the unit. The other two assessments were selected based on the length of the assignment, and the fact that they were hands-on activities of different nature. One activity involved outdoor data collection, and the other activity involved Internet research and computer design. A detailed analysis of these four unit assessments is provided below.

The pre-test (Appendix A-I) was designed to assess the prior knowledge of my students about each of the unit subtopics. There were a total of twelve questions on this assessment: two questions about the atmosphere and air pressure, two questions about heat, two questions about wind, two questions about moisture in the air, two questions about air masses and fronts, and two questions about climate. These same questions were embedded in the final unit test, which served as the post-assessment (Appendix A-II) for this project. Data were collected from a total of ninety-six students who participated in this study.

A student response analysis was completed for the twelve questions of interest on both assessments (Table 1 and Figures 2,3,4). Of all the students who took the pre-test, roughly one-third correctly identified the troposphere as the layer of the atmosphere in which Earth's weather takes place (Q.1, Figure 2). Since this was the only question

Table 1. Student Response Analysis of Pre- and Post-Assesments

Item # and Description	Pre-test (# correct)	Post-test (# correct)
1. Which layer of the atmosphere is the "weather" layer?	34	92
2. What happens to the density of air as it is heated?	29	78
3. What are the three methods of heat transfer? ...conduction	4	59
...convection	2	64
......radiation	0	46
4. Why is AZ warmer than MI?..............latitude (equator)	66	70
.......................direct rays	5	14
5. What causes wind?	16	52
6. In which global wind belt do we live?	0	45
7. What are clouds made out of? ....water	13	51
..................dust particles	3	52
8. Under what conditions does fog form?	14	45
9. Characteristics of an air mass that is............continental?	8	77
..............tropical?	59	85
10. What weather...as a cold front is passing over?	2	42
11. In which climate zone do we live?	4	63
12. What is the most abundant greenhouse gas?	19	74

*** Total number of students tested = 96**

on the pre-test that was written as a multiple-choice item, it would be expected that one-quarter of the respondents would answer this question correctly by default. Many of the students who answered this question incorrectly on the pre-test chose "thermosphere" as the correct answer. Since the students had learned about the atmosphere in seventh grade, I imagine that students simply confused the two terms that both started with the letter "t". I kept the format of the question the same on the post-test, and this time ninety-two students answered this question correctly. Since they heard the word "troposphere" repeatedly throughout this unit, it is not surprising that such a high number of them did well on this item. Question number two, which was from a related topic, asked the students about the density of air as it is heated (Q.2, Figure 2). Twenty-nine pre-test

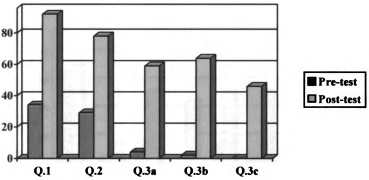
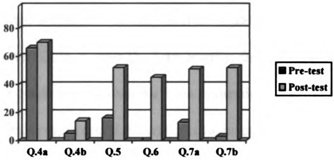


Figure 2

Students correctly stated that the density would decrease, and the number correct rose to seventy-eight students on the post-test. This can be attributed to the fact that we spent most of one class period performing the "Balloon Behavior Activity" (Appendix D-I), which directly relates to this question. Several students listed this activity as one that helped them learn the most during this unit.

The next two questions on the pre-test covered the topic of thermal energy and heat. Question number three asked the students to identify the three methods of heat transfer. On the pre-test, there were four students who correctly identified conduction (Q.3a, Figure 2), two students who mentioned convection (Q.3b, Figure 2), and zero students who included radiation (Q.3c, Figure 2). These numbers rose to fifty-nine, sixty-four and forty-six respectively, on the post-test. I attribute the higher post-test response for convection to the popularity of the "Aquarium Convection" demonstration (Appendix C-III). Nearly all post-unit survey respondents mentioned this as one of their favorite demonstrations of the unit. I expected better results on the post-test for this question, but this was the only essay question on the unit test, and twelve students did not even attempt an answer. The other assessment question related to heat (Q.4a-b, Figure 3), dealt with

Figure 3



insolation. The question specifically asked the students to give the reason that Arizona experiences warmer year-round temperatures than Michigan. Upon analysis, I also split student responses on this question into two parts. On the pre-test, sixty-six students correctly noted that Arizona is closer to the equator than Michigan. Five of these students also noted that locations closer to the equator receive more direct rays from the Sun. I was disappointed that these numbers only rose to seventy and fourteen respectively.

Questions number five and six concerned wind formation and global wind belts. Sixteen pre-test students could identify the factor that causes the formation of wind (Q.5, Figure 3). This number pleasantly surprised me, because this is not something that the students had learned in science class in recent years. The number of correct responses on this item rose to fifty-two on the post-test, which was similar to the results for the next question (Q.6, Figure 3), which asked the students to identify the global wind belt in which we live. Forty-five students correctly identified "the prevailing westerlies" as the answer on the post-test, where as none of them responded correctly to this item on the pre-test.

The next section of the pre-test dealt with moisture in the air. I anticipated that the students would not do well on these questions since most people hold misconceptions about this topic. Since many people tend to think that clouds are made out of water vapor, I was not surprised that on the pre-test only thirteen students knew that clouds were made out of liquid water (Q.7a, Figure 3). Additionally, three students correctly added that this liquid water condensed on dust particles in the air (Q.7b, Figure 3). On the same vein, question number eight asked the students to describe the conditions under which fog forms. Fourteen pre-test students correctly stated that humid air directly above the ground must be cooled to the dew point temperature (Q.8, Figure 4). These questions were then addressed in the "Cloud Base Height Activity" (Appendix D-VI), in which students used the dew point temperature and air temperature to calculate the altitude of the cloud bases. A significant amount of time was spent discussing the conditions under which clouds form, and the students were asked to extend this information to the subject of fog formation. After teaching the unit, approximately half the class answered these questions correctly.

Air masses and fronts were the topics of the following two questions on the pre-test: question number nine asked for the moisture (Q.9a, Figure 4) and temperature (Q.9b, Figure 4) characteristics of a continental tropical air mass, and question number ten solicited information on the expected weather as a cold front passed over. The student respons

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responses did not indicate that they had much prior knowledge in these areas, since only eight students knew that a continental air mass is dry, and only two students expected thunderstorms beneath a cold front. Interestingly enough, fifty-nine students correctly identified a tropical air mass as being warm, but I think that is because the students made an educated guess based on the word "tropical". On the post-test the number of correct answers rose to seventy-seven (Q.9a, Figure 4), eighty-five (Q.9b, Figure 4), and forty-two (Q.10, Figure 4). Most of the students who answered question number eight incorrectly were either too general with their answer (many students simple wrote that it would "rain"), or they made the mistake of describing the weather after the cold front had passed over. Perhaps, some of this confusion could have been avoided with better wording on the question. The activities that directly targeted this group of questions were the weather map bulletin board and the weather brochure activity. Most students reported

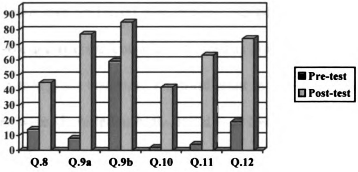

Figure 4

that they found these activities to be helpful, but due to time constraints they also felt rushed on the brochure assignment. Additional weather map forecasting time might also improve scores in this area.

The last section of the pre-and post-assessments included questions about climate zones and greenhouse gases. Sixty-three post-test students correctly identified the climate zone in which we live, compared with only four students on the pre-test (Q.11, Figure 4). This question was also targeted by the weather map bulletin board (Appendix D-VIII) and the weather brochure activity (Appendix D-IX). Post-test students also had a good understanding about the greenhouse effect, since seventy-four of them correctly identified carbon dioxide as the leading greenhouse gas (Q.12, Figure 4). This was an improvement over the nineteen who responded correctly to this question on the pre-test. This increase can be attributed to the hands-on activity in which the students investigated the greenhouse effect and albedo (Appendix D-IV).

In addition to the comparison of the pre- and post-assessments, there were two other assessments that indicated student acquisition of the material. These assessments were analyzed for a total of six students in my classes: two students who were identified as high-achieving (1-STH-A and 7-STH-B), two students identified as middle-achieving (6-STM-A and 1-STM-B), and two students characterized as low-achieving (1-STL-A and 3-STL-B) by their seventh grade teachers. The third letter in the identification code refers to whether they were identified as high-, middle- or low achieving. The first assessment that was analyzed was the page of extension questions that followed the "Cloud Base Height Activity" (Appendix D-VII). The first question on this assignment asked the students why the dew point temperature value was used on the graphing assignment instead of the value for relative humidity. I was hoping that the students would acknowledge that relative humidity changes throughout the day, while the dew point temperature remains the same (assuming a new air mass does not move in during the day). Unfortunately, none of the six students that were selected addressed this question correctly. Student 1-STH-A defined the term relative humidity, while most of the others simply stated that we were using the dew point temperature to find the height of the cloud bases. In other words, they did not seem to understand that the question was asking why the dew point temperature was the correct value to use. The student who came the closest to addressing the question correctly was 3-STL-B, who noted that a percentage (relative humidity) would not be easy to use for this activity. The second question on this assignment asked the students to predict which type of day (colder or warmer) would generate lower cloud base height. They were then asked to explain their prediction. Four of the six students correctly identified that the cloud bases would typically be lower on a colder day. Three of these four (1-STH-A, 6-STM-A, and 1-STL-A) accurately attributed this to the fact that colder air cannot hold as much water vapor, so clouds would form as condensation takes place. The fourth student (1-STM-B) incorrectly hypothesized that it usually rains on cold days, and rain clouds are lower. The two students (7-STH-B and 3-STL-B) who answered the first part of the question incorrectly, mistakenly associated warm days with higher humidity, and thus, they believed that the clouds would form due to the increase in humidity. When asked what effect an increase in water vapor (humidity) would have on the dew point temperature, all six students correctly noted that it would raise this value. Five of the six students also correctly answered that an increase in humidity would lower the altitude of the cloud bases. The only student to answer this part incorrectly was student 6-STM-A, who did not give an explanation for this prediction. Both high-achieving students correctly explained that when the humidity is high, the air is closer to being saturated, which favors cloud formation at lower altitudes. The last question on this assessment addressed the formation of fog. Four of the six students answered this question correctly. Student 1-STH-A noted "due to high humidity and the temperature reaching the dew point, a low cloud forms over the land." Student 3-STL-B explained "the formation of fog comes from air above the ground cooling rapidly that night", while students 6-STM-A and 1-STL-A both noted the cold temperatures and water vapor needed for the formation of fog. These students gave different responses that were equally correct. In terms of acquisition of the information, these six students did fairly well, and seemed to reflect the responses of the entire class.

The final assessment to be analyzed was the student-designed weather brochure (Appendix D-IX). This assignment was graded according to three criteria: content, appearance and promotional appeal (see rubric, Appendix D-X). Each of these grading areas was worth ten points, and then the individual scores were averaged. For the content portion of the grade, a score of ten indicated that the student described the temperature and precipitation of the location in detail, and also included the factors that influenced these climate characteristics. In terms of appearance, a score of ten acknowledged that the student liberally used color, graphics and/or pictures, their choice of font size and style enhanced the look of the brochure, and the text was complete and correctly placed. A score of ten points for promotional appeal was given to students who used creative wording and/or humor to catch the reader's attention, mentioned interesting trivia about the location, and used pictures, graphics and captions that enhanced the text. Scores below ten points indicate that the students neglected to do some or all of these things. Looking at individual results, student 1-STH-A, who made his brochure on Cairo, Egypt, scored a ten on content and promotional appeal. He scored an eight on appearance due to the fact that the text size and styles were inconsistent and did not enhance the look of the brochure. This brought his overall grade down to a nine and three-tenths. The other high-achieving student, 7-STH-B, scored tens on all components of her brochure on Godthab, Greenland for a perfect score. Another great brochure was made by student 6-STM-A about Quito, Ecuador. Scoring tens on appearance and promotional appeal, her overall score was lowered slightly by an eight on content for failing to provide the factors that influenced the climate of Ecuador. The other middle-achieving student, 1-STM-B, had an overall score of eight and seven-tenths on his brochure about Kabul, Afghanistan. This was the same overall score that the two low-achieving students received on their brochures. Student 1-STL-A scored eights on content and appearance, and a ten on promotional appeal for his brochure on the Falkland Islands, while student 3-STL-B scored a ten on content and eights on appearance and promotional appeal for her brochure on Madagascar. The quality of the students' work, especially the low-achieving students in my classes, was beyond what I expected on this assignment. It is especially remarkable considering that many of the students felt that they needed more time on this assignment, and that I gave minimal instruction on how to use the Microsoft Publisher program.

The four assessments for this unit: the pre-test, the post-test, the "Cloud Base Height Activity" extension questions, and the weather brochure, proved to be very effective in gauging the students' acquisition of the material. Students who were middle- and low-achieving, as well as those who typically excel in school, demonstrated that they considered the assignments enjoyable and relevant enough to turn in quality work.

B. Qualitative Analysis

In terms of assessing this unit in a qualitative manner, the new demonstrations and hands-on activities proved to be highly effective. Student response was overwhelmingly positive. The demonstrations that I had planned were met with enthusiasm and curiosity. The students would routinely enter my classroom each day and inquire about the agenda for the hour. Perhaps most rewarding, students in my afternoon classes would often come in to my room already aware of the planned activities because they had been discussing them with their peers outside of class.

The interest and excitement that the students felt can best be represented by some of the student quotes from the post-unit survey (Appendix D-XIV). In response to the demonstration "Aquarium Convection" (Appendix C-III) that showed the distinct temperature layers that form in a tank of water, a student in my sixth hour class remarked, "that was tight, Mrs. Tate!" (Tight being new slang for awesome.) In a post-unit survey, nearly all of my students mentioned this as their favorite demonstration, because it gave them a "visual understanding" of the process of convection. Students also acknowledged that the demonstrations with the bell jar (Appendix C-I and II) and the "Candle Extinguisher" (Appendix C-VI) were "cool", and they had "no idea what was going to happen." One of my students in first hour picked the candle demonstration as his favorite because it was "like something out of a magic show", and another student in that class told me that she liked that demo so much she went home and showed it to her younger brother. One student also mentioned that she learned a lot from the demonstration of the seasons because she "learned how the seasons changed and [she] never really understood before."

In terms of hands-on activities, the students preferred projects during which they got to go outside. The "Cloud Base Height Activity" (Appendix D-VI) for example proved to be quite popular for this reason. Interestingly enough, many students found the indoor portion of this activity (especially the extension questions) to be too difficult, but as a teacher I was pleased when a girl in my seventh hour echoed what her classmates were saying when she observed that she "didn't like it. It was challenging; it made me think." I informed her that that was what I was hoping to do. In addition to going outside, I found that my students loved getting their hands dirty. When they were working on the "Paleoclimates and Pollen Activity" (Appendix D-XII), their favorite part was sifting through the dirt to pick out the confetti. Because they had so much fun looking for the "pollen" and sorting it into types, they took more ownership for their data when it was time to share their results and analyze them. A student in my sixth hour class admitted that she like this activity the best because "it was just something different."

Students also responded favorably to the classroom weather map (Appendix D-VIII). Upon entering my classroom the first day of the unit, typically five or six kids per class hour would remark upon how "cool" or "pretty" it looked. One student noted that "it looks just like the one the weather man uses!" There were a handful of students each hour that volunteered to update the map with the current day's placement of the cyclones, anticyclones and fronts, and make a prediction of the next day's weather.

Other activities that the students reported that they learned from were "Building an Anemometer" (Appendix D-V) and making the weather brochure (Appendix D-IX). Referring to the former, a student in seventh hour was excited that "it actually worked and it was neat to know I actually made it." Another student echoed her thoughts, and added that it

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added that it was also cool to "get a free pencil," although there were some students who reported that this was their least favorite activity because "it was hard to make." The students also had some mixed reactions about making the weather brochure. Many students agreed with a girl in sixth hour that it was nice "being creative with science, and it was a fun learning activity." Most negative reactions had to do with the fact that many students felt that they were "pressed for time", and that they "could have done a better job" if they had more time. Since this seemed to be a very effective activity, I would plan on giving the students the time that they asked for in the future. It was rewarding to hear from some students that this was the activity that they learned the most from in this unit. Not only did they learn about the weather, but also as one boy in my seventh hour class shared, they got to "learn about a place they never heard of."

The students also enjoyed the times in class that they considered to be academic down time. The movie "Twister" was shown the half-day before spring break specifically for that reason, but it was encouraging to see that many of the kids noted the movie's relevance, and as one student remarked "we could see the action that we talked about in class." Likewise with our guest speaker, meteorologist Bill Steffen from WoodTV 8 in Grand Rapids, many of the kids felt that this was time spent "out of class." One observant girl, however, noted, "I thought it was pretty neat that I could understand what he was talking about when he said words like anemometer, or barometer, or if he was talking about how location affects precipitation." The majority of the students agreed that listening to Mr. Steffen was one of the activities that they learned from and enjoyed the most.

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In summary, the students overwhelmingly liked the hands-on activities and demonstrations that were part of this unit plan. As a student in sixth hour class observed, "hands-on stuff helped me understand what they were talking about in the book." This was echoed by a girl in seventh hour when she said, "hands on helps you learn more because your [sic] doing it yourself and you observe more." These student quotes qualitatively reinforce the efficacy of these activities.

IV. Discussion

This unit was designed to target the academic, social and emotional needs of middle school science students, by implementing lessons that were learner-focused, eliminating reliance on the textbook, developing hands-on activities and engaging demonstrations, and by allowing students more opportunities to work in cooperative groups. Data collected during the implementation of this unit indicate that the goals of this project were met. Academically, the students demonstrated their acquisition of the material on the post-test and supplemental assessments. The students met social goals by working well in cooperative learning groups and by taking part in class discussions and data sharing. Finally, the students indicated that their emotional needs were met by coming to class each day full of excitement and inquiry, and by demonstrating that when presented with material in a hands-on format, students previously defined as low- and middle-achieving are capable of producing top-quality work.

The teaching of this unit was successful for many reasons. First of all, the textbook as a primary source was eliminated. I only assigned textbook excerpts as supplemental reading for those students who like seeing the material in an additional format. Another reason this unit was successful is because I came to class each day well prepared and full of excitement for the activity at hand. I made it a point to be well organized and enthused, and I think that because of this, the students were very involved in the discussions and willing to give me the benefit of the doubt if a demonstration or activity was not going as well as planned. The most important reason that this unit was effective is because students of this age seem to have an innate interest in science as long as it is presented in a fun, entertaining way, and they get to be actively involved during the lesson. T

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the lesson. Even lecture notes, which most of my students found dull before, became exciting with the addition of numerous engaging demonstrations. Designing this unit provided a great opportunity for me to assess my teaching and the manner in which middle school students learn best, which is through a variety of teaching methods and hands-on activities.

In hopes of engaging my students, and catching their attention, I implemented several demonstrations during the teaching of this unit. The four that were the most popular were "Aquarium Convection", "Candle Extinguisher", and the two bell jar demonstrations, one with the marshmallow peep® candy and the other with boiling water; I think my students thought I was a magician when these were presented. All of these demonstrations elicited interesting and thoughtful comments during discussion. A different demonstrations that I plan on modifying for next year is the explanation for the seasons. This demo seemed to take too long, and without active student involvement, many students lost their focus and missed the point of the exercise. For the same reason, I would also either modify or eliminate the demonstration involving the heat capacity of land vs. water. This was not very effective as a demonstration in front of the class, and I may adapt it so that it becomes part of a hands-on activity, in order for the students to take more ownership for the data and the explanation.

While there were not any hands-on activities that I would eliminate in the future, some of them could be modified slightly to make them more effective, and to reduce student confusion or frustration. The "Flashlight Insolation" activity seemed to be a good precursor to the "Insolation Investigation". However, there was some confusion about the angle of insolation and the application of that to the Earth. In the future, I would probably have the students hold the graph paper up to the wall and then shine the flashlight on it, so that the orientation of the light for both activities is the same. I would also spend more time in class discussing the topic of sun angle and direct rays. There were other activities that could have been more effective if the students had additional time. I think that more of the students would have enjoyed building their anemometers if they had not felt rushed. Since I did not think this activity would take the entire class period, I used the first fifteen minutes of class for the presentation of lecture notes. Unfortunately, this was time that the students really needed for the project, since many of them did not finish in time to test their anemometer outside. Next time, I would start this activity at the beginning of the hour to ensure that everyone had time to go outside to collect data. Additional time also would have helped for the weather brochure activity. Even though I was very impressed by the quality of work shown on the brochures, many students felt like they could have done a better job if they could have worked on it longer. In fact, there were a couple of students who did not turn in their brochure because they did not have time to finish it. This was definitely not the objective of the project. In the future, I would have the students practice using the Microsoft Publisher program throughout the year, so that they would be more comfortable, and work faster when making their brochures.

In addition to modifying a lesson to allow for more time, one of the activities in this unit would have been more effective if it had been taught on consecutive days. The students spent one and a half class periods working on the Cloud Base Height activity collecting data and graphing, and then we did not return to class to work on the extension questions until five days later. By this time, many of the students had forgotten the key ideas of the activity, which led to confusion and frustration. Many students reported in the post-unit survey that they felt rushed on this activity. I would probably lengthen this activity to include days of different cloud types and heights, and include more cloud identification and calculations. Now that I am aware of the length of time needed for this activity, I can use better planning when implementing this in the future.

More time and consideration during implementation would have also strengthened the effectiveness of the weather map bulletin board. Quite a bit of thought and planning went into the construction of this weather map during summer research. I started by making an overhead transparency of a map of the United States, with state borders shown. This image was then projected onto the wall, where I traced the map on a large piece of green felt. Weather symbols and fronts were also cut out of felt. The central idea was that these symbols could be easily moved to represent the current day's weather map. Due to time constraints, movement of these weather symbols became the job of a handful of volunteers in each class. These volunteers also made some predictions about the weather. In the future, I would like to have more activities revolve around this bulletin board that get all of the students involved. Some ideas that come to mind include formal daily forecasts for the student announcements, and a forecasting contest in which all of the students make predictions about the next day's weather based on the current weather map. I would also like to include some type of formal student worksheet or weather log on which the students are responsible for keeping track of daily weather formation and movement.

Because of the success of this unit, I plan on integrating more demonstrations and hands-on activities into the rest of my curriculum. The time spent developing and planning these activities is well worth it when their efficacy is considered. This unit met the goal of increasing student interest and performance through learner-centered instruction and lessons. The students were more focused, inquisitive learners, and as a teacher I was filled with more enthusiasm and pride in the lessons that I teach.

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APPENDICES

Appendix A-I

Weather and Climate **Name:**
Pre-Assessment **Hour:**
8th Grade Science
Mrs. Tate

1. What layer of the atmosphere does Earth's weather take place in? (circle)
   A. Mesosphere
   B. Troposphere
   C. Thermosphere
   D. Stratosphere

2. What happens to the density of air as it is heated?

3. What are the 3 methods of heat transfer?

4. What is the reason why year-round temperatures are warmer in Arizona than in Michigan?

5. What causes wind?

6. What global wind belt do we live in?

7. What are clouds made out of?

8. Under what conditions does fog form?

9. In terms of temperature (cool/warm) and moisture content (moist/dry), what would be the characteristics of a Continental Tropical air mass?

10. What weather would you expect as a cold front is passing over?

11. What climate zone do we live in?

12. What is the leading greenhouse gas?

Appendix A-II

Weather and Climate **Test #**
Unit Test
8th Grade Science
Mrs. Tate

Part I-- Multiple Choice (1 pt. each)

1. In which layer of the atmosphere does Earth's weather take place?
    A. Mesosphere
    B. Troposphere
    C. Thermosphere
    D. Stratosphere

2. As elevation increases, the density of air:
    A. increases
    B. decreases
    C. stays the same
    D. doubles

3. Air pressure is measured with a:
    A. thermometer
    B. anemometer
    C. barometer
    D. psychrometer

4. Which of the following dates is known as an equinox?
    A. June 21st
    B. September 21st
    C. March 21st
    D. both B and C

5. On an equinox date, the sun's direct rays fall on:
    A. the equator
    B. the tropic of cancer
    C. the poles
    D. Michigan

6. Warm air that rises over land and is replaced by cooler air from over water is:
    A. a doldrum
    B. a sea breeze
    C. a land breeze
    D. a prevailing wind

7. Global wind belts are curved due to:
    A. the Coriolis effect
    B. the greenhouse effect
    C. hurricanes
    D. tall buildings

8. Large, "puffy" fair weather clouds are:
    A. cirrus
    B. stratus
    C. cumulus
    D. cumulonimbus

9. Thunderstorms and hail are usually associated with:
    A. a warm front
    B. a cold front
    C. an occluded front
    D. a stationary front

10. Lines on a weather map that connect places with equal temperature are:
    A. jet streams
    B. isobars
    C. isotherms
    D. rivers

Part II– Completion (1 pt. each) Give the term or phrase that answers each question.

11. As air is heated, its density _____?_____.

12. Which hemisphere has more surface area covered with water?

13. What is the leading greenhouse gas?

14. A southwest wind blows <u>from</u> which direction?

15. Which global wind belt do we live in?

16. Wind speed is measured with a(n) ______?_______.

17. The scientific name for a low pressure system is a(n) ______?_______.

18. The heat stress index, which estimates your body's comfort level on a summer day, takes into account the day's temperature and _______?_______.

19. The temperature at which condensation will form on outdoor surfaces (grass, trees, etc.) is called the ________?________ temperature.

20. The temperature of a tropical air mass is (high/low).

21. The moisture content of a continental air mass is (high/low).

22. Which climate zone do we live in?

23. El Nino occurs when currents shift in which ocean?

24. Which climate zone rarely has temperatures above freezing?

25. What is one method that scientists can use to investigate past climate?

Part III-- Short Answer (2 pts. each)

26. What is the reason that year-round temperatures are warmer in Arizona than in Michigan?

27. What causes wind?

28. What are clouds made out of?

29. Under what conditions does fog form?

30. What weather would you expect as a cold front is passing over?

Part IV-- Weather Map: use the information given on the class weather map to give a daily forecast for 2 of the 3 locations. (3 pts. each) Consider the following when giving your forecast:

- temperature (cool/warm/hot)
- relative humidity or dew point
- precipitation (none, rain, thunderstorms)
- clouds (clear/cloudy)
- wind direction
- barometer (rising/falling)

Hint: Choose the details that you're most confident about. I will be looking for three correct statements for each forecast. Incorrect statements will count against you.

Part V—Climate Map (1 pt. each)

27. Nome, Alaska is in which climate zone?

28. Which city, Saskatoon or Topeka, has colder yearly temperatures?

29. Atlantic City is warmed by which ocean current?

30. What is the only U.S. city shown in the tropic zone?

31. Which gets more precipitation San Fransisco or Las Vegas?

32. Which city, Denver or Omaha, has warmer yearly temperatures?

Part VI—Essay (5 pts.)

Name the three methods of heat transfer and give an example of each that is related to this unit.

Weather and Climate
Unit Test—Answer Sheet
8th Grade Science
Mrs. Tate

Name:

Test #

Part I—Multiple Choice

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______
9. ______
10. ______

Part II—Completion

11. ______________________________
12. ______________________________
13. ______________________________
14. ______________________________
15. ______________________________
16. ______________________________
17. ______________________________
18. ______________________________
19. ______________________________
20. ______________________________
21. ______________________________
22. ______________________________
23. ______________________________
24. ______________________________
25. ______________________________

Part III—Short answer

26. ____
27. ____
28. ____

29. ____

30. ____

Part IV—Weather Map

Location _______ Forecast: ______________________________
____
____

Location _______ Forecast: ______________________________
____
____

Part V—Climate Map

31. ____________________ 34. ____________________

32. ____________________ 35. ____________________

33. ____________________ 36. ____________________

Part VI—Essay

____
____
____
____
____
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____
____

Appendix B-I

Weather and Climate Unit

Topic 1: Understanding Earth's Atmosphere

Key Idea: The atmosphere is a thin layer of gases that surrounds the Earth.

1. **Composition of the atmosphere**:
    - A. Nitrogen (~78%)
    - B. Oxygen (~21%)
    - C. CO_2, Water Vapor, trace gases (~1%)
    - D. Solid particles

2. **Layers of the atmosphere**—divided according to temperature.
    - A. Troposphere—"weather layer"; temperature ↓ as altitude ↑.

    - B. Stratosphere—location of the jet stream. Ozone layer causes temperature to ↑ as altitude ↑.

    - C. Mesosphere—meteoroids burn up here; temperature starts to drop again.

    - D. Thermosphere—Air extremely thin; particles extremely hot.

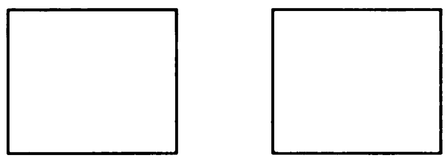
Appendix B-II

Topic 2: Air Pressure and Density

Key Idea: Air pressure is the force of air pushing down on the Earth's surface.

1. At sea level, air pressure is ~14.7 lbs/in^2. (Newspaper demo)

2. Air pressure is related to the density of air. (more dense = more air pressure)



more dense less dense

3. The **density** of air depends on three factors:

    A. Temperature—in an open "container" like our atmosphere, an ↑ in heat causes density to ↓, because of particle movement.

    B. Elevation—as altitude ↑, the density of air ↓.

    C. Water vapor—moist air is **less** dense than dry air, because H_2O is lighter than N_2 or O_2.

4. Air pressure is measured with a barometer.

Appendix B-III

Topic 3: Heat Transfer in the Atmosphere

Key Idea: Heat is a form of energy. The Earth receives heat energy from the Sun.

1. **Heat transfer** is the movement of heat from one place to another.

2. There are three methods of heat transfer:

   A. **Conduction** is the direct transfer of heat from one substance to another. *Example*: the warm ground heats the air directly above it.

   B. **Convection** is the transfer of heat within a fluid (gas or liquid). Most of the heat energy in the atmosphere is transferred by convection currents.
   Warm air ↑; cold air ↓.

   C. **Radiation** is the transfer of heat energy through a vacuum. This is how the heat (and light) from the Sun reaches the Earth.

Appendix B-IV

Topic 4: Temperature Controls

Key Idea: There are many factors that cause variation in temperature from place to place. They include:

1. **Insolation**—(incoming solar radiation). Affected most by latitude and Earth's tilt (23.5°) on its axis. Locations in the tropics receive the most direct rays of the Sun, so they are usually the warmest.

   - It is because of Earth's tilt that we experience seasons.
     --**Summer Solstice** (~June 21st)—direct rays hit the Tropic of Cancer (23.5° N)
     --**Fall Equinox**(~Sept. 21st)—direct rays hit the Equator.
     --**Winter Solstice**(~Dec. 21st)—direct rays hit the Tropic of Capricorn (23.5° S)
     --**Spring Equinox**(~March 21st)—direct rays hit the Equator.

2. **Heating of land vs. water**—Differences in heat capacity cause land to warm up faster than water. However, for the same reason, land will cool down faster than water. Therefore locations away from water experience greater temperature extremes. (Temps. are **moderated** or buffered by proximity to water.)

3. **Ocean currents**—warm ocean currents like the Gulf Stream in the Atlantic keep coastal locations warmer.

4. **Altitude**, or elevation—temperature ↓ as altitude ↑.

5. **Cloud cover and albedo**—light colored surfaces and clouds reflect a great deal of light, causing a decrease in daytime temperatures. However, clouds will also trap in heat at night causing it to be warmer than on a clear night.

6. **Greenhouse Effect**—A "blanket" of carbon dioxide and other gases traps heat in our atmosphere. This is a good thing, unless the level of CO_2 gets too high, which could cause global warming.

Appendix B-V

Topic 5: Wind Formation and Types

Key Idea: Wind is caused by differences in air pressure due to unequal heating of the Earth.

1. **Local winds**—are those experienced by a specific location.

    A. Winds are named according to the direction from which they blow.

    B. A **sea breeze** happens during the day when warm air over land rises and a cool breeze off the water rushes in to take its place.

    C. A **land breeze** happens at night when warm air over water rises and cooler air over the land takes its place.

    D. A **cyclone** is a low-pressure system. Winds move in a counterclockwise direction.

    E. A high-pressure system called an **anticyclone** has clockwise winds.

    F. Special types of local winds: monsoon, chinook.

2. The **Coriolis effect** is a shift in global wind patterns due to the rotation of the Earth.

3. **Global wind belts**—

    A. Calm winds at the Equator (0° latitude) are called the **doldrums**.

B. The **trade winds** are felt between the Equator and the horse latitudes (30° N and S.)

C. The **prevailing westerlies** are strong winds experienced between 40° and 60° latitude N and S. This is the global wind belt in which we live.

D. The **polar easterlies** are very cold, weak winds between 60° and 90° N and S.

4. Wind **speed** is measured with an **anemometer**.

5. Wind **direction** is measured with a **wind vane**.

Appendix B-VI

Topic 6: Moisture in the Air

Key Idea: Water can be present in our atmosphere as a gas, liquid or solid.

1. **Water vapor** is the gas form of water. The amount of water vapor in the air can be expressed as:

   A. **Relative humidity** (%)—the amount of water vapor in the air compared to the amount that can be held at that temperature.

   B. **Dew point** (°)—the temperature that the air would have to drop to become saturated.

   C. These are both measured with a **psychrometer**.

2. The **heat index** is a measure of how warm the air feels due to the humidity.

3. **Clouds** are **not** made of water vapor! They are made of **liquid** water that has condensed on particles of dust in the air (condensation nuclei).

   A. **Cumulus**—big, puffy fair weather clouds. Cumulonimbus clouds are large clouds associated with thunderstorms.

   B. **Stratus**—a smooth blanket of clouds. Usually bring light rain.

C. **Cirrus**—wispy, high-altitude clouds. Usually found in fair weather, but can indicate potential snowfall.

4. **Fog**—basically a cloud that forms at ground level. Fog happens when the cold ground cools the air above it to the dew point temperature.

5. **Precipitation**—the falling products of condensation in the atmosphere.

   A. Includes rain, sleet, hail and snow.

   B. Climate factors that affect precipitation:

   - **Mountains**—windward side gets heavy precipitation. Leeward side forms a rain-shadow desert.

   - **Bodies of water**—coastal cities with prevailing wind that blows from water to land get heavy precipitation.

Appendix B-VII

Topic 7: Air Masses and Fronts

Key Idea: An **air mass** is a large body of air that has a uniform temperature and moisture content.

1. The name given to an air mass describes its properties by indicating where it formed.

   A. In terms of **moisture content**, the air mass is either **maritime** (formed over water; moist) or **continental** (formed over land; dry).

   B. In terms of **temperature**, the air mass is either **tropical** (formed at low-latitudes; warm) or **polar** (formed at high-latitudes; cold).

2. A **front** forms at the boundary between two air masses.

   A. **Cold front**—a cold air masses violently pushes under a warm air mass. *Weather*: thunderstorms, drop in temperature.

   B. **Warm front**—a warm air mass slides over a cold air mass. *Weather*: rain showers, increase in temperature.

   C. **Stationary front**—two air masses meet, but there is no movement. *Weather*: **extended** rain showers.

   D. **Occluded front**—a cold front will sometimes overtake a warm front. *Weather*: intermediate.

Appendix B-VIII

Topic 8: Climate

Key Idea: **Climate** is defined as the general conditions of temperature and precipitation for an area over a long period of time.

1. The Earth is divided into three climate zones:

   A. **Tropical Zone**—includes area approximately between the tropic lines.

   B. **Temperate Zone**—includes areas in the mid-latitudes.

   C. **Polar Zone**—includes areas in the high-latitudes to the poles.

2. Since we only have reliable climate data for the last hundred years (or so), scientists must rely on other methods for determining the past climate (**paleoclimate**) of an area. Examples include:

   A. Sediment cores and palynology

   B. Ice cores

   C. Dendrochronology

Appendix C-I

Weather and Climate Unit
Demo--"Attack of the Killer Peep®"

Key Idea: This demonstration allows students to see what happens when an object is no longer subjected to the force of air pressure around it.

1. Place a marshmallow Peep candy inside a bell jar that is hooked up to a vacuum pump.

2. Ask the students to record their "before" observations.

3. Turn the pump on to remove the air from the bell jar.

4. Release the pump valve to allow the air back inside the jar.

5. Ask the students to record their observations and explain what happened with the candy in both situations.

6. Students should report that the Peep expanded when the air was removed from the jar due to the fact that air was no longer pushing on the candy. The candy shrank in size when the air was allowed back into the jar because the air pressure on the outside of the candy increased.

Appendix C-II

Weather and Climate Unit
Demo--"Bell Jar Boil"

Key Idea: This demonstration allows students to see what happens when an object is no longer subjected to the force of air pressure.

1. Place a 250-mL beaker of water (approx. 2/3 full) inside of a bell jar that is hooked up to a vacuum pump.

2. Turn the pump on to remove the air from the bell jar.

3. Within seconds, the water in the beaker should start to boil.

4. Turn the pump off and release the valve to allow the air back inside the bell jar.

5. Ask the students to explain what happened to the water.

6. After discussion, the students should understand that when an object boils, the dissolved gases in the liquid form bubbles and rise to the surface. This can be accomplished by heating the liquid, and/or decreasing the air pressure on the surface. This is why liquids boil at lower temperatures when they are at higher elevations (less air pressure). *Note*—the physics of boiling may be too complex for middle school students—keep it relatively simple.

7. If you feel like giving your students a surprise, remove the beaker from the bell jar and scream dramatically as you dip your fingers in the water. (Some students will think the water is hot because it was just boiling.)

Appendix C-III

Weather and Climate Unit **Name:**
"Aquarium Convection"
8th Grade Science **Hour:**
Mrs. Tate

During this demonstration, water from four Styrofoam cups will be released into an aquarium full of room temperature water. The cups will contain boiling water (red), warm water (purple), cool water (blue) and ice water (green). In the rectangle below (which represents the aquarium), use colored pencils to shade in the water, as you would expect to see it after the colored water has been released.

(side view of aquarium)

1. Why did you choose the color pattern that you drew?

2. How is air movement in our atmosphere related to the movement of water in this demonstration?

Adapted from www.ucar.edu/ucar/

Appendix C-IV

Weather and Climate Unit
Demo—"Reason for the Seasons"

Key Idea: Seasons are caused by the tilt of Earth on its axis, and the planets progression in its orbit around the Sun.

1. Ask for a student volunteer to be the Sun. (I usually pick someone dressed in bright yellow or orange.) This student stands in the middle of the room holding a flashlight or spotlight.

2. Using a globe or ball to represent the Earth, engage the students in a discussion (What is the axis? Where is it? How many degrees is it tilted? What is it called when Earth spins on its axis? How long does this take? What does this cause? Etc.,)

3. Making sure that you keep the axis oriented in the same direction, "orbit" around the room stopping at solstice and equinox points. Ask the students to identify which season we are having in the Northern hemisphere at each point. Ask them to estimate the number of hours of daylight and darkness that corresponds to each.

Appendix C-V

Weather and Climate Unit
Demo—Heat Capacity of Land vs. Water

Key Idea: Water heats up and cools down slower than land due to the higher heat capacity of water.

1. Take two 1000-mL beakers and fill one of them with water, and one with dirt (approx. half full.)

2. Place a thermometer inside the beaker of water so that the bulb of the thermometer is one or two centimeters below the surface of the water. Tape the thermometer to a ring stand or box so that it remains suspended in the water.

3. Repeat step 2 with the beaker of dirt.

4. Take an initial temperature reading.

5. Place a heat lamp directly over the beakers and record the temperatures at regular intervals.

6. If time permits, turn off the lamp and monitor the temperature as it decreases for the two beakers.

7. Discuss the results with the students.

Appendix C-VI

Weather and Climate Unit
Demo—"Candle Extinguisher"

Key Idea: Air is a fluid. As such, it will flow from an area of high density to an area of low density.

Materials:
1 Tbsp. baking soda
¼ cup vinegar
500-mL beaker
votive candle
matches
Strip of poster board (≈ 12" by 3")

1. Fold the strip of poster board "hot dog style" to form a narrow trough.

2. Light the votive.

3. Place baking soda in the beaker and add vinegar. This reaction will produce carbon dioxide gas.

4. Quickly, "pour" the carbon dioxide gas from the beaker down the trough to the candle. *Note*: Be careful not to pour actual liquid down the trough (too much vinegar)—this will extinguish the candle also, but it's not the point of the demonstration!

5. Help the students make the connection that the carbon dioxide was more dense, so it moved to replace the room air, which was less dense, above the candle. In the demo, this movement extinguished the candle. In the atmosphere the movement of dense air (cold) to an area that is less dense (warm) creates wind.

Appendix C-VII

Weather and Climate Unit
Demo—Ping-Pong Ball Anemometer

Key Idea: A simple anemometer can be made that relates the angular displacement of a ping-pong ball on a string to the wind speed.

1. Create some sort of stand for your anemometer. If you have access to the woodshop, pieces of 2x4 work well. In a pinch, PVC pipe or a ring stand would do.

2. Hand a protractor upside down from the stand so that the flat edge of the protractor is on top.

3. Attach a ping-pong ball to a long piece of thread (use a needle to thread this if possible) and hang it from the top, center of the protractor so that the string hangs down past the 90° mark.

4. Use a fan to create wind that will displace the ping-pong ball. Have a student take a reading from the protractor. I like to have students make estimates of the wind speed before we use the chart to find the correct answer.

Wind Speed Chart

Angle (°)	Km/h	mph
90	0.0	0.0
85	5.8	3.6
80	8.2	5.1
75	10.1	6.3
70	11.8	7.4
65	13.4	8.4
60	14.9	9.3
55	16.4	10.2
50	18.0	11.2
45	19.6	12.3
40	21.4	13.4
35	23.4	14.6
30	25.8	16.1
25	28.7	17.0
20	32.5	20.3

Adapted from <u>Exploring Earth's Weather</u>

Appendix D-I

Weather and Climate **Name:**
Air Pressure/Density Activity **Hour:**
"Balloon Behavior"
8th Grade Science
Mrs. Tate

Answer the following questions before viewing the "balloon behavior" demonstration.

1. Draw a balloon on each bottle that represents what you expect to see. If you could see the individual air molecules inside the apparatus, what would they look like? Add air molecules to your drawings.

Room Temperature Boiling Water Ice Bath

2. Describe the activity that think will be happening inside each bottle apparatus:

____

____

____

____

3. **After demo:** What happens to air molecules when they are heated? Cooled?

____

____

4. What would happen to the air molecules in this demo if it were not a "closed" system? (Explain for both hot/cold situations)

Extension Questions:

1. Why is it difficult to breath at high altitudes?

2. Why would a southern coastal city tend to have lower air pressure than an inland city farther north?

3. Why does the reading on a barometer rise when the air gets cooler?

Appendix D-II

Weather and Climate
Investigating Sun Angle
8th Grade Science
Mrs. Tate

Name:
Hour:

Directions: Working with a partner, you will use a pencil and graph paper to trace the circle of illumination produced by a flashlight. The flashlight will be held at various angles to represent the sun angles experienced at different latitudes on Earth.

Procedure:

1. **Hold** the flashlight at a 90° angle approximately 20 cm above the sheet of graph paper.
2. With one group member holding the flashlight to keep it steady, the other group member should carefully **trace** the inner-most (brightest) circle of light produced by the beam.
3. **Count** the number of squares within the traced circle. (If >1/2 of the square is inside, count it.)
4. **Record** your results below.
5. **Repeat** steps #1-4 for both 60° and 30° angles.
6. **Label** the circles on the sheet of graph paper and **attach** it to this cover page.

Results:

Flashlight Angle	# of Squares Illuminated

Questions:

1. What conclusion can you draw about the relationship between the flashlight angle and the intensity (strength) of the circle of illumination?

2. How does this activity relate to what occurs with the Sun and Earth?

Appendix D-III

Weather and Climate **Names:**
Investigation of Insolation
8th Grade Science
Mrs. Tate **Hour:**

Background Information: Insolation is defined as the amount of incoming solar radiation received by an exposed surface. Insolation depends on the angle of the Sun above the horizon. Not only is there a **daily** variation in the amount of solar radiation that a location receives, but more importantly, there is variation due to **latitude** and the **tilt** of the Earth on its axis. In this investigation you will discover how sun angle affects temperature on the Earth.

Problem: How does the angle of insolation affect the rate of temperature change on a surface?

Materials: (per group of 3)
- watch
- 3 Celsius thermometers
- incandescent lamp
- 3 wooden blocks (30°-60°-90° triangles)
- masking tape

Procedure:
1. Using masking tape, attach one thermometer to the 30° angle of one block. Attach the second thermometer to the 60° angle of another block, and the third thermometer to the 90° angle of the last block.

2. Place the blocks in front of the lamp as shown in Figure 1. Position the lamp so that it is approximately 20 cm away from the blocks.

3. Turn on the lamp. Record in the data table the temperature of each thermometer every minute for fifteen minutes.

4. When finished recording your data, turn off the lamp.

5. Construct a line graph of your data. The data collected for each block will be a different color line on your graph. Be sure to include a key.

Figure 1.

Observations:

Graph:

Title:______________________________

Analysis and Conclusion Questions:

1. Which angle caused the temperature to increase the **most** during the 15 minutes? What region of the Earth receives sunlight at this angle?

2. Which angle caused the temperature to increase the **least** during the 15 minutes? What region of the Earth receives sunlight at this angle?

3. What is the relationship between the size of the angle of insolation and the surface temperature?

Appendix D-IV

Weather and Climate **Names:**
Greenhouse Investigation
8th Grade Science **Hour:**
Mrs. Tate

Background: The greenhouse effect is caused by a "blanket" of carbon dioxide and other gases in our atmosphere that traps in heat. This can have a big impact on the amount of warming that a location experiences. However, it is not the only factor that controls the temperature of an area. Other factors include insolation, heat capacity of land vs. water, altitude, ocean currents, cloud cover and surface albedo (reflection). In this investigation we will look at a few of these factors and their impact on temperature.

Problem: What factors are important in determining temperature in a model atmosphere?

Materials: (per group of 2)
2-L pop bottle (clean, dry, with bottom cut off)
deli container
thermometer
white paint
250 mL of surface material (dark soil, white sand or water)
reflector lamp with 100 watt bulb
ring stand

Procedure:

1. You and your lab partner will be assigned one of the following experimental set-ups:
   A—Dark soil
   B—Dark soil with cloud cover
   C—White sand
   D—White sand with cloud cover
   E—Water
   F—Water with cloud cover

   - The upper 1/3 of bottles B,D and F will be painted white to simulate cloud cover.

2. Fill the deli container with the assigned surface material.

3. Place the bottle top on the deli container base. Make sure the bottle is capped.

4. Insert the bulb-end of the thermometer into the bottle so that the bulb is located in the center of the chamber, above the surface material.

5. Place the model atmosphere approximately 20 cm beneath the reflector lamp.

6. Record the temperature of the chamber at time zero.

7. Answer the prediction questions.

8. Turn on the lamp and record the temperature in degrees Celcius every two minutes. Continue for 20 minutes. Turn off the lamp and clean up.

9. Collect remaining temperature data from other groups.

10. Construct a line graph of the results.

Prediction Questions:

1. Which experimental atmosphere will generate the highest temperature? Why?

   ____

2. Which experimental atmosphere will generate the lowest temperature? Why?

   ____

3. How will the models with cloud cover compare to the models without?

   ____

Data Table:

Temperature (°C)

Model Atmosphere	Time 0 (min.)	2	4	6	8	10	12	14	16	18	20
A											
B											
C											
D											
E											
F											

Graph: Construct a line graph of your results. Include a title, labels for the x-axis and y-axis, an appropriate scale, and a color key.

Title: ____

Conclusion Questions:

1. How did the actual results compare to your predictions?

____

____

2. How do these model atmospheres relate to the "global greenhouse" that is our atmosphere?

____

____

Appendix D-V

Weather and Climate **Name:**
Building an Anemometer
8th Grade Science **Hour:**
Mrs. Tate

Directions: In this activity you will build your own anemometer and use it to calculate wind speed.

Materials:
5 Dixie cups (three ounce)
2 plastic drinking straws
straight pin
pencil
scissors
paper punch
small stapler or tape

Procedure:

1. Take **four** of the Dixie cups. Using the paper punch, punch one hole in each cup, approximately one centimeter below the rim.

2. Use a red marker to color the rim of **one** of these four cups. (This will be the "focus" cup as your anemometer spins.)

3. Take the fifth cup. Punch four **equally spaced** holes about ½ a centimeter below the rim. Then punch a hole in the bottom of the cup. This will be the center cup on your anemometer.

4. Take one of the four cups and push a straw through the hole. Fold the end of the straw and staple or tape it to the side of the cup across from the hole. Repeat this step with one other one-hole cup and straw.

5. Slide one cup-straw assembly through two of the holes in the center cup. Put a one-hole cup on the other end of this straw. Bend the end and secure it like you did in step #3. **Make sure that the cups are facing in opposite directions!**

6. Repeat step #4 with the remaining cup-straw assembly and one-hole cup.

7. Align the cups so that their open ends are all pointing in the same direction (clockwise or counterclockwise) around the center cup. Push the straight pin through the two straws where they intersect.

8. Put the eraser end of the pencil through the hole in the bottom of the center cup. Push the pin into the eraser as far as it will go. Your anemometer is ready to go!

Calculating wind speed: Your homemade anemometer can be used to quantify wind speed mathematically.

Step 1: Calculate the *circumference* of the anemometer, or the distance that the cups are spinning. This can be found by measuring the diameter and multiplying by π.

Diameter = _______cm

Circumference (C) = _______cm

Step 2: The next step is to count the *revolutions per minute* of the focus cup.

RPM = _______

Step 3: Use the following formula to calculate wind speed in km/hr:

RPM x C(cm) x 60 min/hr x 0.00001 km/cm

Wind speed = ___________km/hr

Appendix D-VI

Weather and Climate Unit **Name(s):**
Cloud Base Height Activity
8th Grade Science
Mrs. Tate **Hour:**

Background information: Clouds form when temperature and moisture conditions in our atmosphere allow water vapor to condense on dust particles. This is more likely to happen when the air has high humidity and/or cools down. Since the temperature of the troposphere decreases at a constant rate with height, a rising parcel of air will eventually reach an altitude cool enough for clouds to form. The base (bottom) of the cloud indicates this altitude.

In this activity, you will use your psychrometer to measure temperature and dew point. You will then use this information to construct a graph with which you can interpret cloud base height.

Pre-Activity Vocabulary:

1. Condensation—

2. Troposphere—

3. Dew point (temperature)—

4. Wet-bulb thermometer—

Materials needed: Psychrometer, water bottle filled with room temperature water, cloud base activity and data sheets, graph paper, pencil.

Procedure:

1. Find an outdoor location to collect your data.
2. Make some observations about the weather and record on the data sheet.
3. Use the water bottle to saturate the cotton gauze on the wet-bulb thermometer.
4. Swing the psychrometer through the air for a couple of minutes, or until the wet-bulb temperature reading stops decreasing.
5. Record the dry- and wet-bulb temperatures on your data sheet.
6. Return to the classroom to construct and interpret your graph.

Cloud Base Height Activity
Data Sheet

Date: ____________ Time: ____________

Air Pressure: ________

Wind Speed and Direction: _________ out of the _______

Cloud types seen (circle all that apply):

Cumulus Stratus Cirrus

Percent cloud cover (circle):

100 75 50 25 <25

Dry-bulb temperature: _______ °C

Wet-bulb temperature: _______ °C

Dew Point temperature (use chart): _______ °C

Graphing instructions:
You will be constructing a line graph of temperature vs. altitude. There will be two lines on this graph—one for air temperature and one for dew point temperature.

1. The y-axis (vertical) should be labeled altitude and range from 0 to 5 km.
2. The x-axis (horizontal) should be labeled temperature and range from −10 °C to 40 °C. (Keep all values to the right of the y-axis.)
3. Plot the air temperature (dry bulb) recorded at the ground (0 km).
4. Continue plotting this line based on the information that air temperature decreases at a rate of 10°C/km.
5. Plot the dew point temperature recorded at the ground (0 km).
6. Continue plotting this line based on the information that dew point temperature decreases at a rate of 2°C/km.
7. Find the intersection of these two lines and record the altitude. This is the height of the cloud base.

Cloud base height: __________ km

Activity adapted from www.pbs.org
"Living Edens—Borneo"

Appendix D-VII

Cloud Base Height Activity
Follow-up Questions

1. Using the wet- and dry-bulb values that you found at your data collection site, look up the relative humidity in the table in your book. Relative humidity = __________. Considering the fact that both relative humidity and dew point indicate the amount of water vapor in the air, why do you think dew point was used in this graphing activity?

2. Which type of day (warm or cold) would be expected to have lower cloud base formation? _____________ Why?

3. What effect would an increase in water vapor (humidity) have on the dew point? Raise or Lower (circle one). What effect would it have on cloud base height? Higher or Lower (circle one). Explain.

4. Based on what you learned in this activity, explain the formation of fog.

Activity adapted from www.pbs.org
"Living Edens—Borneo"

Appendix D-VIII

Weather and Climate Unit
Weather Map Bulletin Board Photos

Appendix D-IX

Weather and Climate Unit **Name:**
Weather Brochure
8th Grade Science **Hour:**
Mrs. Tate

Name of location: ___________________________________

Latitude: ___________

Longitude: ___________

Description of location:
*

*

*

*

*

Climate

1. Temperature
   Minimum?
   Maximum?

   Factors that affect the temperature of your location:
   *

   *

   *

2. Precipitation
   Yearly rainfall?
   Greatest monthly rainfall?
   Snowfall?

Factors that affect the amount of precipitation at your location:

*

*

*

Weather

Typical day's weather in summer: ______________________________________

____

Typical day's weather in the winter: ____________________________________

____

How do the weather and climate affect the activities and attractions at your location?

____

____

____

How do weather and climate affect the way people live and work at your location?

____

____

____

What interesting scenery and agriculture are present due to the weather and climate?

____

____

____

Appendix D-X

Grading Rubric for Weather Brochure Activity
8th Grade Science
Mrs. Tate

	Content	**Appearance**	**Promotional Appeal**
10 points—Wow! I'll take two tickets.	Describes temperature and precipitation in detail, including factors that influence the climate.	Liberal use of color, graphics and/or pictures. Font size and style enhance the look of the brochure. Text is complete and correctly placed.	Uses creative wording and/or humor to catch the reader's attention. Mentions interesting trivia about the location. Pictures, graphics and captions enhance the text.
8 points—Sounds like a nice place.	Describes climate characteristics in detail. Does not mention influencing factors.	Moderate use of color, graphics and/or pictures. Font size and style inconsistent. Text is occasionally broken and/or misplaced.	Occasionally uses creative wording or humor to catch the reader's attention. Some trivia about the location is mentioned. Pictures, graphics and captions occasionally enhance the text.
6 points—Hmmm…I'm not so sure.	Mentions climate characteristics. Does not give detail or mention influencing factors.	Occasional use of color, graphics and/or pictures. Font size and style inconsistent. Text is often broken and/or misplaced.	Rarely uses creative wording or humor to catch the reader's attention. Very little trivia about the location is mentioned. Pictures, graphics and captions are used without purpose.
4 points—No thanks; I'd rather stay home.	Fails to mention one or both climate characteristics.	Lacks color, graphics and/or pictures. Font size and style is distracting. Text is mostly broken and/or misplaced.	Wording lacks creativity and humor. No trivia about the location is mentioned. Pictures, graphics and captions detract from the text.

Appendix D-XI

Weather and Climate Unit
Weather Travel Brochure—Location Lottery!
8th Grade Science
Mrs. Tate

Sydney, Australia	Queensland, Tasmania
Auckland, New Zealand	Manila, Philippines
Calcutta, India	Kabul, Afghanistan
Beijing, China	Tokyo, Japan
Kondakova, Russia	Point Barrow, Alaska
Prince Rupert, B.C.	Edmonton, Alberta
Halifax, Nova Scotia	Reykjavik, Iceland
Godthab, Greenland	Cozumel, Mexico
Havana, Cuba	Panama City, Panama
Quito, Ecuador	Rio de Janeiro, Brazil
La Paz, Bolivia	Santiago, Chile
Lillehammer, Norway	Helsinki, Finland
Warsaw, Poland	Madrid, Spain
Lisbon, Portugal	Cairo, Egypt
Casablanca, Morocco	Freetown, Sierra Leone
Kampala, Uganda	New Delhi, India
Johannesburg, South Africa	Cape Town, South Africa
Madagascar	Canary Islands
Falkland Islands	Bikini Island

Appendix D-XII

Weather and Climate Unit **Name(s):**
Paleoclimates and Pollen Activity
8th Grade Science
Mrs. Tate **Hour:**

Background information: Since human-recorded weather data exists only for the last hundred years or so, scientists who wish to study past climate have to utilize other means. One method involves collecting sediment cores from old lake beds, and examining the pollen grains that became trapped in the sediment hundreds or thousands of years ago when they floated into the lake. Sediment in the bottom of lakes is ideal for determining pollen changes over time because it tends to be deposited in annual layers (much like tree rings). Therefore, the sediment layers create a pollen history of the area around the lake.

Once scientists have used the pollen to identify the plant species that grew around the lake, they can infer the climate of the layer being studied by relating it to the current climate preferences of the same plants. In other words, if the sediment layer has a lot of western red cedar pollen, the climate during that time was probably cool and wet, because those are the current conditions in which that kind of tree grows best.

In this activity, you will become "paleoclimatologists" by analyzing simulated sediment layers taken from Battleground Lake in Washington state. You will collect and identify the pollen in each layer, and then use that information to draw some conclusions about the paleoclimate of the region.

Pre-Activity Vocabulary:
1. paleoclimate—

2. pollen—

3. infer—

Materials needed: baggie of sediment, forceps or tweezers, pie pan, pollen key, paleoclimate activity data table, pencil.

Procedure:
1. Empty the contents of your sediment baggie into the pie pan.
2. Sort through the sample to separate out the pollen grains from the sediment.
3. Determine from the key what species of plants are represented.

4. Record the number of each type of pollen per layer on the data sheet.
5. Carefully return the sediment and pollen to the baggie.
6. Return the baggie and pan to the front of the room and obtain another sample.
7. Repeat steps 1-5 for the new sediment layer.
8. When all groups have finished two sediment layers, you will be asked to report your data to the class.

Data:

Plant Species for Battleground Lake, Washington
Student Data Table

	Sediment Layer				
Plant Species	1	2	3	4	5
Western Hemlock					
Douglas fir					
Grasses and Sedges					
Alder					
Grand fir					
Engelmann spruce					
Western cedar					
Lodgepole pine					
Mixed meadow species					
Oak					
Alpine sagebrush					

Analysis:
1. For each of the sediment layers, identify the dominant species present and what clues it gives about the climate during that time.

   Layer 1--- Dominant species:______________________________

   Climate: _______________________________________

Layer 2--- Dominant species:___________________________

Climate: ___________________________________

Layer 3--- Dominant species:___________________________

Climate: ___________________________________

Layer 4--- Dominant species:___________________________

Climate: ___________________________________

Layer 5--- Dominant species:___________________________

Climate: ___________________________________

2. Why do you think that the sediment layers contained pollen from grasses and trees, but not flowering plants?

3. What influences besides the climate could have impacted the types or quantity of pollen found in the sediment layers?

4. Why do you think it's important for scientists to do this type of research?

Activity adapted from "Paleoclimates and Pollen"
www.ucar.edu/learn

Appendix D-XII

Paleoclimates and Pollen
Teacher Notes

Background: A fair amount of background is given on the student activity sheet, but depending on the amount of time allotted you may want to go into detail on the following—

- Reliable human-recorded weather data only goes back about 130 yrs.
- Other methods of researching paleoclimate include dendrochronology, ice cores, and the fossil record. If you're interested in more information on dendrochronology, check out the University of Arizona on the web. Speaking of U of A, Owen Davis is a pollen outreach educator. Good pictures of pollen grains maintained on his site. (Search under "palynology")
- Actual sediment cores are approximately 5 cm in diameter and >10 m long. The core is sampled every 10-20 cm and washed with corrosive chemicals (potassium hydroxide, hydrochloric acid and hydrogen fluoride) to remove organic and mineral particles. The pollen remains intact because it made of some of the most chemically resistant organic compounds in nature.

Activity Set-up:

- This activity is a simulation of actual pollen data from a lake in Washington just south of the glacial limit of the last ice age.
- Construct a sediment column using a graduated cylinder or 2-liter pop bottle as a model for the class. Use five different "sediments" for the column, and make sure you have enough for the student samples. Good sediment materials include: sand, dirt, aquarium gravel, etc.
- Choose colored paper dots or confetti to represent the pollen types. Print copy a copy of the pollen key for each pair of students and replace letters with confetti or dots. It may help to laminate these, so they can be reused.
- Prepare a sample of each layer. Use a re-sealable sandwich bag—put in one cup of sediment material and pollen grains according to the teacher key. You may want to make two or three bags of each layer. Label the bags with stickers or permanent marker as to which layer they represent.
- You are now ready to begin the activity. You may want to obtain pollen pictures off the internet or from print sources. Discuss with your students the structural differences between the different species of pollen, and how scientists can use these differences to identify the plants from which they came.
- Display the sediment column and discuss the process of sedimentation and coring. Have the students begin the activity.
- After the students have collected and analyzed their data, the actual paleoclimate of Battleground Lake should be presented. The students can see how close they were to the actual climate.

Activity adapted from "Paleoclimates and Pollen" at www.ucar.edu/learn/1_2_2_10.htm

Appendix D-XII

Pollen Key for Battleground Lake, Washington

"Pollen"	Plant Species	Climatic Characteristics
	Western Hemlock	Principle dominant tree of many lowland, temperate sites. Requires very moist, temperate conditions for growth.
	Douglas Fir	Broadly distributed throughout the Pacific Northwest from moderately cool to warm sites. Grows best under temperate, somewhat moist conditions.
	Grasses and Sedges	These grasses and sedges are typically found in very cool alpine/sub-alpine meadow sites characterized by very cool summers, harsh winters and short growing seasons.
	Alder	Widespread throughout the Pacific Northwest, often colonizing gravel bars or other poor soils; prefers abundant water and can grow in cool climates.
	Grand Fir	Found at mid-elevations in the Cascade mountains. Grows in cool climates, but not as cold tolerant as trees found at high altitudes.
	Engelmann Spruce	Found in cold, usually sub-alpine sites.
	Western Cedar	Found only in temperate, very moist climates.
	Lodgepole Pine	Found in areas of very cool climates typically growing in poor soils, often at high altitudes (above 3,500 feet) under the present climate.
	Mixed meadow species	This pollen is typical of a mixture of herbaceous plants common to warm-temperate meadowlands. Typically, these species grow in areas of warm summer temperatures and summer drought.
	Oak	Found in warm-temperate sites characterized by dry, warm summers such as can be found from Oregon's Willamette Valley south into California.
	Alpine Sagebrush	Woody, low-growing shrub related to the sagebrush of eastern Washington and Oregon. Found only at high-altitude, cold sites.

Appendix D-XII

Sediment Composition for Battleground Lake, Washington
Teacher Key

Sediment Layer	Plant Species	Color or Shape Code	Number of dots or confetti needed
1 (present-- 4,500 ybp)	Western cedar Western hemlock Douglas fir alder	G A B D	6 5 10 4
2 (4,500 ybp-- 9,500 ybp)	Douglas fir Oak Mixed meadow sp.	B J I	3 3 19
3 (9,500 ybp-- 11,200 ybp)	Douglas fir Grand fir alder	B E D	7 5 13
4 (11,200 ybp-- 15,000 ybp)	Lodgepole pine Engelmann spruce Grand fir Grasses & sedges Alpine sagebrush	H F E C K	7 3 3 9 3
5 (15,000 ybp-- 20,000 ybp)	Grasses & sedges Alpine sagebrush Lodgepole pine Engelmann spruce	C K H F	15 4 4 2

Appendix D-XII

Paleoclimate of Battleground Lake, Washington
Actual Paleoclimate—Overhead Transparency

Layer	Time Period	Description
1	Present—4,500 ybp	A cooler and moister period than the previous one. The dry-land vegetation has been replaced by the coniferous forests seen today. Hemlock and Western red cedar dominate the areas undisturbed by logging.
2	4,500—9,500 ybp	The climate continues to be warm with mild, moist winters and warm, dry summers. The forests of the previous period disappear, and are replaced by more drought-adapted species: mixed oak, Douglas fir and dry meadowland.
3	9,500—11,200 ybp	The warming continues and the first occurrence of "modern" temperate coniferous forest is found in this period. Douglas fir, alder and Grand fir dominate. The climate is similar to today's climate.
4	11,200—15,000 ybp	Glaciers have begun to recede as the climate starts a warming trend. Although still cold compared to the present climate, warming has allowed more extensive forests of Lodgepole pine, Engelmann spruce and Grand fir to replace the tundra vegetation previously seen.
5	15,000—20,000 ybp	Glacial maximum, with nearly a vertical mile of ice over Seattle, and the continental glaciers extending south of present-day Olympia. An alpine glacier from Mt. St. Helens reaches to within 30 km of the lake site. The climate was cold, with a short growing season. The landscape resembled arctic tundra, with alpine grasses and sedges, low woody shrubs, and occasional tree islands of cold- tolerant Engelmann spruce and Lodgepole pine.

Activity adapted from "Paleoclimates and Pollen" at www.ucar.edu/learn/1_2_2_10.htm

Appendix D-XIII

Weather and Climate Unit
Study Guide
8th Grade Science
Mrs. Tate

Topic 1: Understanding Earth's Atmosphere

- The layers of the atmosphere include the troposphere, stratosphere, mesosphere and thermosphere.
- Earth's weather takes place in the troposphere.

Topic 2: Air Pressure and Density

- When air is heated, its density decreases because the molecules spread out.
- When air is cooled, its density increases because the molecules come together.
- As elevation (altitude) increases, the density of air decreases (air gets thinner).
- Moist air is less dense than dry air.
- Air pressure is measured with a barometer.

Topic 3: Heat Transfer in the Atmosphere

- Conduction is the direct transfer of heat from one substance to another.
- Convection is the transfer of heat through a fluid (air or water). Warm air rises; cool air sinks.
- Radiation is the transfer of heat through a vacuum.

Topic 4: Temperature Controls

Climate factors that affect temperature:

- Latitude—locations closer to the equator receive more direct rays of the Sun.
- Elevation—as you go up higher in the mountains, the temperature decreases.
- Nearness to a body of water—moderates temperature. (Southern Hemisphere has more surface area covered by water, so temperatures are not as extreme as in the Northern Hemisphere.)
- Ocean currents—the Gulf Stream is a warm water current in the Atlantic.

Other info:

- Seasons are caused by Earth's tilt on its axis (23.5°).
- Solstices (summer and winter) occur when the Sun's direct rays hit one of the Tropic lines.
- Equinoxes (spring and fall) occur when the Sun's direct rays hit the Equator.
- The Greenhouse effect is caused by carbon dioxide in the atmosphere.

Topic 5: Wind Formation and Types

- Wind is caused by differences in air pressure due to unequal heating of the Earth. Air moves from high pressure to low pressure.

- A sea breeze happens when warm air over land rises and a cool breeze from the water moves in to take its place.
- A cyclone is a low pressure system.
- An anticyclone is a high pressure system.
- The Coriolis Effect is caused by the rotation of the Earth.
- The global winds that we experience are the prevailing westerlies. The other belts are the trade winds and the polar easterlies.
- Wind speed is measured with an anemometer.

Topic 6: Moisture in the Air

Climate factors that affect precipitation (increase):

- Location on the windward side of a mountain
- Location near a body of water where the prevailing wind blows from water to land. Example: West Michigan

Other info:

- Water vapor is the gas form of water.
- The amount of water vapor can be expressed in terms of relative humidity or the dew point temperature. Both are measured with a psychrometer.
- The heat stress index takes into account heat and humidity.
- Clouds are made of liquid water that has condensed on dust particles in the air.
- The three main cloud types are cumulus (big puffy), stratus (smooth gray) and cirrus (high wispy).
- Fog is basically a cloud that forms at ground level. The air must cool to the dew point temperature.

Topic 7: Air Masses and Fronts

- An air mass is a large body of air that has a uniform temperature and moisture content.
- A maritime air mass forms over water and is moist.
- A continental air mass forms over land and is dry.
- A tropical air mass forms near the equator and is warm.
- A polar air mass forms at high-latitudes and is cold.
- A front is the boundary between air masses.
- Cold front: thunderstorms; behind it are cooler temperatures.
- Warm front: rain showers; behind it are warmer temperatures.

Topic 8: Climate

The three climate zones are:

- Tropical zone--30° N to 30° S
- Temperate zones--30° to 60° N and S
- Polar zones--60° to 90° N and S
- El Nino is a shift in a current in the Pacific Ocean that causes worldwide climate change.
- Scientist can study past climate by looking at sediment cores or tree rings.

Appendix D-XIV

Weather and Climate Unit **Name:**
Review Crossword Puzzle
8th Grade Science **Hour:**
Mrs. Tate

Across

1. A(n) ____________ front will bring rain showers, and behind it will be an increase in temperature.
2. Global wind belt experienced by Whitehall, Michigan. (Abbreviation)
3. One way of measuring the amount of humidity in the air is by calculating the _____________ temperature.
4. This is the layer of the atmosphere in which weather takes place.
6. An anticyclone is another name for a _______ pressure system.
11. The amount of incoming solar radiation that a location receives is known as _______________.
13. A _________ is the boundary between two air masses.
15. This is caused by differences in air pressure due to unequal heating of the Earth.
16. Precipitation known as hail is really just little pellets of ________.
19. Wind speed is measured with a(n) _______________.
20. Big, puffy fair weather clouds are known as ____________.
21. The ___________ effect is caused by rotation of the Earth on its axis.
22. The equator is located at 0° ____________.
23. The climate zone that we live in is the ______________ zone.
25. Lines on a weather map that connect places with equal temperature are known as _______________.
26. _____________ is a climate change brought on by a shifting current in the Pacific Ocean.

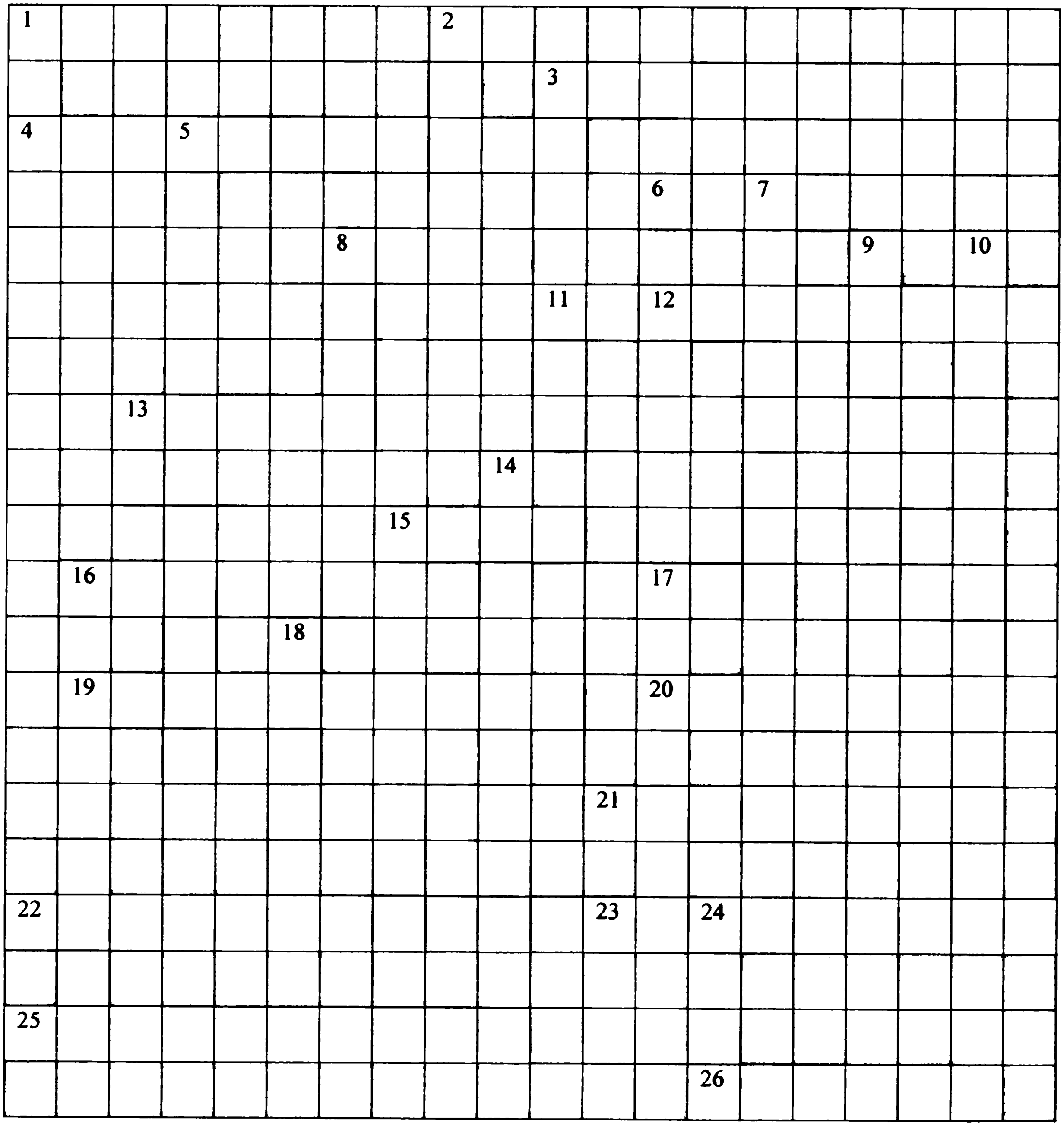
Down

1. The gas form of water is called ________________.
2. This characteristic of air is measured with a barometer.
3. As air is heated, its ____________ decreases.
5. This instrument is made up of wet-bulb and dry-bulb thermometers.
7. The __________________ is a warm-water current off the east coast of the United States.
8. The seasons are caused by the ________ of Earth on its axis.
9. The heat __________ index indicates what temperature it feels like due to the humidity in the air on a hot, summer day.
10. The first day of summer and winter are known scientifically as _____________.
12. When warm air over land rises, and cool air from over the water moves in to take its place, it is known as a ______ breeze.
14. As elevation (altitude) ______________, temperature decreases.

17. A low pressure system is known scientifically as a _______________.
18. The moisture content of a continental air mass would be _______.
19. A large body of air with a uniform temperature and moisture content is called a(n) _____________.
24. Cold air is ________ dense than warm air.

Weather and Climate Unit
Review Crossword Puzzle
8th Grade Science
Mrs. Tate

Name:



Appendix D-XV

Weather and Climate Unit
Post-Unit Survey

Name (optional):

1. Which activities in this unit did you enjoy the most? Why?

2. Which activities in this unit did you enjoy the least? Why?

3. During this unit specifically, what helped you learn the most?

Appendix E-I

February 21, 2003

Dear Students/Parents/Guardians,

For the past three years I have been working on a Masters of Science degree through the Division of Science and Mathematics Education at Michigan State University. This past summer I redesigned a unit that I teach on weather and climate. The new unit plan includes more inquiry based laboratory exercises, data collection and analysis, and more direct application of the material to current climate issues. The unit will last approximately five weeks.

In order to evaluate the effectiveness of this unit, I will be collecting data through pre- and post-tests, inquiry and reflection questions from the laboratory, field experiences and homework. This work is required of all students independently of my thesis. With your permission, I would like to use your student's scores from the aforementioned items for my master's thesis. **At no time will any student's name be used in, or connected to the thesis.**

In addition to the above data collection, I also plan to take photographs of the students when we are doing various laboratory and field research activities. These photos may be used to enhance my thesis defense and a possible presentation to other science teachers at a state science conference. As above, no student's name or individual data will be attached to these photographs.

Please complete the attached permission form and return it to me by February 28, 2003. I am asking to use your student's data from the weather and climate unit for my thesis. There is no penalty for denying permission to use this data. Your decision will not affect your student's grade in any way. Declining permission will not exempt your student from doing the same assignments as everyone else, it just means that I will be unable to use his/her data in my thesis. Should you choose to withdraw your student from the study after signing the permission form, you may do so at any time. Your student's privacy will be protected to the maximum extent allowable by law.

Thank you for your time. If you have any questions regarding participant's rights as human subjects for research please contact the Internal Review Board Chairperson, Ashir Kumar, 202 Olds Hall, Michigan State University, East Lansing, MI 48824; the telephone number is (517) 355-2180 and the email is ucrihs@msu.edu. Please contact me at 893-1030 ext. 4119 with any questions or concerns about your child or this study.

Sincerely,

Mrs. Susan Tate
8th Grade Science Teacher
Whitehall Junior High School

Please read the following permission statements carefully and **check all that apply**:

Data Use:

_______ I give Mrs. Tate permission to use my son/daughter's data collected from the weather and climate unit for her thesis. I understand that Mrs. Tate will not use my son/daughter's name and that all student data will remain confidential to the maximum extent allowable by law.

_______ I do not wish Mrs. Tate to use my son/daughter's data collected from the weather and climate unit for her thesis. I understand that there is no penalty for declining permission to use the data.

Photograph Use:

_______ I give Mrs. Tate permission to use my son/daughter's photograph, taken during laboratory and field research activities, in the presentation of her thesis defense. I understand that my son/daughter's name will in no way be attached to these photographs.

_______ I do not wish Mrs. Tate to use my son/daughter's photograph in the presentation of her thesis defense.

Signatures:

Student Name (Printed) ____

Student Signature ____________________________________ Date _________

Parent/Guardian Signature ______________________________ Date_________