Evaluation of Real-Time Weather Map Discussions in the Middle School Classroom

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CHAPTER ONE: INTRODUCTION

In 1996 the Council of the American Meteorological Society (AMS) commissioned a study to plan for the future of the Society and in 1998 the report was presented. The report mentioned that change was occurring in the field of meteorology and identified five changes that have affected and would continue to affect the Society. One of the changes mentioned was that “the expanding public interest in our field and its products means enhancing our outreach” (“BAMS Annual Report”, 2003, p. 8). Because of the growing importance of weather in education and society, the meteorological community is placing more emphasis on weather outreach. This outreach currently includes individual programs focused on specific meteorological concepts or geographical areas, such as the Community Collaborative Rain, Hail, and Snow network, national programs directed at the general public, such as the National Weather Service’s Weather Safety Campaigns, and professional development opportunities for teachers such as the AMS’s DataStreme course (Pandya et al., 2004). The effectiveness of this outreach has yet to be fully evaluated, as most measures presently only evaluate the numbers of outreach programs created and presented, or evaluate the effectiveness of specific individual outreach programs. Few published studies have examined whether students actually understand and retain information from the different outreach programs. As outreach activities continue to expand, it is important to assess how students understand and learn weather, so that more effective outreach programs can be created.
Inquiry-based teaching and learning have become a “hot topic” in science classrooms since the National Science Education Standards (developed in 1996) included inquiry as “both a learning goal and as a teaching method” (Center for Science, Mathematics, and Engineering Education [CSMEE], 2000, p. 18). Inquiry as defined by the Standards “involves making observations, posing questions, …using tools to gather, analyze, and interpret data…” (National Research Council, 1996, p. 23). These processes are also a main part of learning meteorology, especially when dealing with real-time data. Real-time data weather maps allow for students to make observations about what the weather is doing, ask questions about something on the map that is not familiar, and analyze and interpret the data to make a forecast.

With schools emphasizing inquiry learning, it makes sense to evaluate inquiry learning as a possible learning method for outreach programs to use. Towards this end, the goal of this thesis is to evaluate how current surface weather maps help middle school students learn weather fundamentals, by assessing which methods allow students to retain the most correct information, so that meteorological outreach can be improved. This research will focus solely upon middle school students, as within Ohio’s school curriculum, “weather” is referred to most often in the middle school Earth and Space Science Standards, Benchmarks, and Indicators (Ohio Department of Education, 2005).

A total of 531 students across 2 schools in Stark County, Ohio were divided into two different groups, reflecting two different teaching methods. One group only received the standard curriculum, mainly using textbook learning, while the second group received both the standard curriculum and a daily weather map discussion using current weather
maps. The weather map is chosen as the methods variable, as it is one of the most fundamental tools used to convey meteorological information; further, several of the Earth and Space Indicators for seventh grade refer to creating and interpreting weather maps (Ohio Department of Education, 2005). Through the implementation of background surveys, as well as pre- and post-assessments, and comparisons across the two groups, the utility of incorporating daily weather map discussions into the middle school classroom is evaluated.
CHAPTER 2: LITERATURE REVIEW

While there is no other research currently out specifically looking at how middle school students understand weather maps, there is much research relevant to this thesis. Since the research takes place in the classroom, it is very important to understand educational learning theory and educational learning standards. The history of weather maps provides insight into the purpose and uses of weather maps, as well as how weather maps have changed. Looking at students’ spatial abilities from the geographic standpoint should provide insight into how students read maps.

2.1 Educational Learning Theory

Weather maps are typically taught during the subject of science in the K-12 classroom, therefore it is also important to look at learning theories, both general and scientific, to understand how teaching methods and students’ learning abilities might influence the understanding of weather concepts. According to Jack Hassard (2005), author of *The Art of Teaching Science*, “Research on learning has moved from an emphasis on behaviorism…to constructivist views” (p.167). Modern science teaching methods, arguments, and standards have evolved from these constructivist perspectives, making them important background to understanding current approaches to teaching weather in the science classroom.
The idea behind the constructivist perspective comes from Piaget, who believed that “knowledge is constructed and ... students are builders of knowledge structures” (p. 171). Piaget’s Cognitive Theory states that “individuals actively construct their understanding of the world and go through four stages of cognitive development” (Santrock, 2003, p. 46). Organization and adaptation form the foundation of people’s cognitive construction of the world. People organize observations and experiences, connecting one idea to another to make sense of the world. As new ideas are added, individuals adapt their thinking to include the new ideas and increase understanding of the world.

Piaget believed that people go through four stages in understanding the world, with each stage being age-related and including distinct ways of thinking (Santrock, 2003). He felt that children advance from stage to stage by gaining a different way of understanding, not by knowing more information. The first stage lasts from birth to about 2 years of age and is known as the sensorimotor stage. In this stage, an understanding of the world is constructed by connecting “sensory experiences (such as seeing and hearing) with physical, motoric actions” (p. 47). By the end of this stage, two-year-olds have complex sensorimotor patterns and are starting to operate with primitive symbols (recognizing that a baby bottle represents milk).

The second stage is the preoperational stage, which lasts approximately from 2 to 7 years of age (Santrock, 2003, p. 47). At this stage, children begin to represent the world with words, images, and drawings. Thought is still symbolic, however it goes beyond connecting sensory information and physical action. It is important to note
however that Piaget believed preschool children still lack the ability to perform operational thinking – the Piagetian term for internalized, mental actions that allow children to do mentally what they have previously done physically (p. 47). Therefore it is important to have very hands-on physical activities for pre-school children, because they are still doing a lot of learning through their senses and motor activities. Activities that require children in pre-school and kindergarten to sit at desks and do a lot of paperwork would be developmentally inappropriate for the classroom and only allow the most advanced students to learn.

The third stage is the *concrete operational stage*, which lasts from approximately 7 to 11 years of age (Santrock, 2003). “Children can perform operations, and logical reasoning replaces intuitive thought, as long as reasoning can be applied to specific or concrete examples” (p. 47). Seventh graders are typically at the transition from this stage to the next stage, which involves abstract thinking. A 7th grade classroom would most likely include both students who are firmly at the concrete operational stage and students who have moved into more abstract thinking. This is especially likely if there are students with disabilities in the classroom. At this stage math and science need to be taught using manipulatives and hands-on experiments, because concrete operational thinkers may still struggle with tasks that require abstract thinking. Students may only grasp the logical reasoning behind math and science concepts if they can see it acted out in a concrete way. Weather maps are therefore important to learning weather concepts at this stage because they provide a visual support and concrete example for abstract concepts.
The fourth and final stage is the \textit{formal operational stage} (Santrock, 2003). In this stage, “individuals move beyond concrete experiences and think in abstract and more logical terms” (p. 47). Formal operational thinkers solve problems systematically – developing hypotheses about why something is happening and then testing those hypotheses in a deductive fashion. Students at this stage are also developing \textit{hypothetical-deductive reasoning} – the ability to develop hypotheses, or best guesses, about the ways to solve problems. They can deduce a best path to follow in solving the problem. Formal operational thinkers can test hypotheses with “judiciously chosen questions and tests, while concrete operational thinkers often fail to understand the relationship between a hypothesis and a well-chosen test of it…” (p. 110).

Piaget originally stated that the fourth and final stage occurs between the ages of 11 and 15, but then later revised that view and concluded that it wasn’t completely achieved until between approximately 15 and 20 years of age (Santrock, 2003, p.110). Santrock also quoted other researchers who support this idea, including the following:

Some individuals in early adolescence are formal thinkers; others are not. A review of formal operational thought investigations revealed that only about one in every three eighth-grade students is a formal operational thinker (Strahan, 1983).

If only one in every three eighth-grade students is a formal thinker, then it can be assumed that an equal or less percent of seventh-grade students are formal thinkers. Therefore it is critical to present science concepts to students in as concrete an approach as possible, providing activities that are hands-on, visual, and tactile-kinesthetic.

Santrock (2003) noted that:

One main argument that has emerged from the application of Piaget’s theory to
education is that instruction may too often be at the formal operational level, even though the majority of adolescents are not actually formal operational thinkers. That is, the instruction might be too formal and too abstract. Possibly it should be less formal and more concrete. Researchers have found that adolescents construct a view of the world on the basis of observations and experiences and that educators should take this into account when developing a curriculum for adolescents.

Lev Vygotsky, like Piaget, also believed that children construct their own knowledge, however his theory is a sociocultural cognitive theory (Santrock, 2003). The theory has three claims, each of which emphasizes the impact of society on cognitive abilities. Vygotsky’s first claim was that the cognitive skills of children and adolescents can only be understood when they are developmentally analyzed and interpreted. To developmentally analyze an aspect of cognitive functioning, “one must examine its origins and transformations from earlier to later forms” (p. 47). A mental function should be evaluated as “a step in a gradual development process” (p. 47). Vygotsky’s second claim was that “to understand cognitive functioning it is necessary to examine the tools that mediate and shape it”, which led him to believe that language is the most important of these tools (p. 47). The tool of language is what helps children and adolescents plan activities and solve problems. Vygotsky’s third claim was that cognitive skills originate in social relations and culture, and that development is inseparable from social and cultural activities (Santrock, 2003). He believed that by learning to use the inventions of society – language, mathematical systems, and memory strategies – children and adolescents develop memory, attention, and reasoning skills.

Vygotsky’s theory supports the idea that knowledge is “situated and collaborative” (Santrock, 2003). In other words, “knowledge is distributed among
people and environments, which include objects, artifacts, tools, books and communities in which people live” (p. 48). This suggests that interacting and cooperating with others on activities could be the best way to advance knowledge. Slavin (1995) supports this concept by noting that researchers have found cooperative learning to be an effective strategy to improve student achievement.

Along with the three claims, Vygotsky’s theory includes the concept of the zone of proximal development (ZPD), which refers to “the range of tasks that are too difficult for an individual to master alone, but can be mastered with the guidance and assistance of adults or more skilled peers” (Santrock, 2003, p.115). The level of problem solving adolescents can achieve on their own falls on the lower level of the ZPD. The upper limit of the ZPD is the amount of problem solving an adolescent can achieve with the help of an able instructor. Vygotsky’s creation of the concept of the ZPD supports his belief “in the importance of social influence on cognitive development” (p. 115).

Several contemporary teaching concepts are compatible with Vygotsky’s theory, including scaffolding and cognitive apprenticeship (Santrock, 2003). Scaffolding refers to the amount of support a student receives over the course of a teaching session, with the teacher adjusting the amount of guidance the student is given as the student’s level of performance changes. At the beginning, when the student is learning a new concept, direct instruction might be used. As the student begins to understand the concept, less guidance from the teacher is needed. Cognitive apprenticeship works somewhat the same way in that an expert stretches and supports the novice’s understanding (Rogoff, 1990, 1998). Teachers model strategies and concepts for students and then support the
students’ efforts at completing the task. Finally the teacher encourages the students to work independently. With both of these concepts the expert’s evaluation of when the learner is ready to take the next step is key to how much support is given by the expert (Santrock, 2003). A good teacher should always be observing for signs of understanding from the student to determine whether or not support is needed.

Besides Piaget’s and Vygotsky’s models of constructivist theory, there are several other cognitive models that fall under the constructivist perspective. They all share the following four characteristics: the importance of content knowledge, integration of skills and content, the intrinsic nature of motivation, and the role of learning groups (Hassard, 2005, p. 171 – 173).

The importance of content knowledge refers to the idea that teachers need to be able to determine “what students know and then find ways to link this knowledge…to new learning structures (p. 171). Integration of skills and content emphasizes “the development of thinking skills” at the same time students are learning content (p. 171). The intrinsic nature of motivation comes from the realization that it is important to develop “a learning environment in which students will want to learn” and the need to use the content itself as motivation (p. 172). Lastly, learning groups are a crucial part of learning when the groups are “small, mixed ability cooperative groups” (p. 173).

2.1.1. Inquiry-based Learning

The constructivist perspective supports the need for a teaching environment where there is activity-based instruction and interaction with the physical world (Hassard, 2005,
p. 172), also known as an inquiry-based learning environment. According to the *National Science Education Standards* (1996), the definition of inquiry is

…a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Students will engage in selected aspects of inquiry as they learn the scientific way of knowing the natural world, but they also should develop the capacity to conduct complete inquiries. (p. 23)

In other words, inquiry is about students asking questions, collecting the data themselves, forming their own theories based on the data and other content knowledge, then presenting and discussing their findings with others. The student becomes “a seeker of information and a problem solver” (Hassard, 2005, p. 237) at the same time. Science learning means students should be both learning about science and about how to do science (Hassard, p. 169). Inquiry allows students to be using and learning scientific processes at the same time they are learning various science concepts.

When the National Research Council developed the *National Science Education Standards* in 1996, the developers observed “that many students were mastering disconnected facts in lieu of broader understandings, critical reasoning, and problem-solving skills” (Center for Science, Mathematics, and Engineering Education, National Research Council [CSMEE], 2005, p. 17). Inquiry learning, on the other hand, promotes students creating broader understandings and critical thinking skills. The writers of the *Standards* decided that inquiry needed to appear in several places within the standards and be addressed as both a learning goal and teaching method (p. 18). To promote this
they developed five essential features that apply to teaching and learning at all grade levels (p. 24). These features help to better show the concept and process of inquiry.

The first feature is that “learners are engaged by scientifically oriented questions” (CSMEE, 2005, p. 24). Teacher questions generate “how” questions and from there students develop a “need to know” drive, which leads to more questions (p. 24). The second feature, “learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions” (p. 25) is similar to the third, “learners formulate explanations from evidence to address scientifically oriented questions” (p.26). The second feature relates more to having students gather and evaluate the characteristics of the evidence, such as making observations and measurements and recording them, while the third feature emphasizes creating relationships between the evidence and providing an explanation.

“Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding” (CSMEE, 2005, p. 27) represents the fourth feature. Students need to evaluate their explanations and consider alternatives, revisions or eliminations, by engaging in discussions to compare and check results with others. The ultimate goal is for a connection to be made between the results and the scientific content. Lastly, “learners communicate and justify their proposed explanations” (p. 27). The students present and justify their explanations and results as well as alternative explanations, giving other students the opportunity to question and suggest other alternatives or agree.
2.2 History of Weather Maps

Because the current study is based on the use of weather maps in middle school classrooms, it is important to build an understanding of the history of weather maps and their uses. In his book *Air Apparent*, Mark Monmonier has written an extensive history of the United States weather map (Monmonier, 1999). The following information has been taken from his book and reinterpreted, except where noted. Though weather data have been recorded throughout history, no one put this information into a map until about 1816. Credit for this invention goes to Heinrich Wilhelm Brandes, a professor of Mathematics and Physics at the Universities of Breslau and Leipzig, who was the first to view weather as a spatial problem and suggest that weather observations be put in map format. Brandes also suggested the idea of isobars (lines of equal pressure) and was given credit for inventing them, though he never actually drew a map including them (Miller, 1931). Between 1816 and 1840 weather maps included plots of pressure, temperature, cloud cover, and wind direction and speed, but isobars and isotherms (lines of equal temperature) were not drawn. In 1840 Elias Loomis, a professor of mathematics and natural philosophy at New York University, created the first map that included isobars and isotherms (Miller, 1931). By 1910 weather maps began to be printed for the public in the United States. These maps included isobars, station symbols with wind direction and cloud cover, and isotherms for extreme heat or cold. Newspapers started producing the weather maps, making them popular with the public.

The concept of fronts was not understood by the meteorological field until the 1920s. Therefore weather maps did not include any data or symbology referring to
fronts. The Bergen School of Norway was the premier leader in frontal theory and in 1924 designed the front symbols still used today. This convention did not spread quickly, however, as fronts did not regularly appear on US maps until 1946.

From 1935 on, US weather maps were influenced primarily by the media. The Associated Press (AP) started their Wirephoto network, a type of facsimile network. A member of the AP Washington D.C. Bureau would take weather maps from the Weather Bureau and recreate a simplified version for the public. Public interest in weather maps grew and the AP started taking recommendations on how the maps should be designed. These recommendations helped the AP weather map evolve so that more people could read and understand the map. By 1948 the Weather Bureau had realized the value of a facsimile network and created their own network to share maps among the different offices and with the public. The United Press International (UPI) joined the bandwagon in 1956, and by 1980 most daily papers had some type of weather map.

*USA Today* introduced the idea of color maps in 1982, at the time creating the largest impact on newspaper weather maps. The popularity of their maps forced national and local papers to completely overhaul their weather maps and buy color presses. The AP responded by using color as well as adding regional maps. This gave local papers an advantage because the *USA Today* included only a national map and/or regional maps focusing on large cities.

Television has actually made map design simpler. In general, most maps seen on television only contain high and low pressure centers, fronts, high and low temperatures, and possibly isobars. Viewers depend on the weathercaster for the more complicated
information told in simpler terms. According to Monmonier (1999), “Doubly advantaged by animated graphics and personable weathercasters, the electronic equivalent of the newspaper weather package is better able to entertain, engage, and educate viewers with more thorough, less scientifically timid tutorials” (p. 176). Today weather maps are part of a complex graphics package containing radar and satellite, looping animations, and other colorful images.

The development of the Internet has led to easier access and provided more variety in weather maps. It has affected the design in that people are now able to interact with the maps themselves and choose what they want the map to display. The internet allows for access to weather maps varying from the simple – much like those on television – to the highly specialized that would interest scientists.

### 2.3 Children’s Spatial Ability

According to Gerber (1993), maps need to be designed to fit the ability of the users, not the abilities of the map designers. To understand the ability of the users, in this case middle school students, it is important to understand how students are exposed to, analyze, and recall maps. It is also important to know about any factors that might influence how the students perform these actions.

When it comes to exposure to maps, television has the largest impact on children (Gerber, 1993). Because of this large impact, Gerber focuses on how these maps are designed and specifically talks about weather maps. “Maps on television, to be effective, must be simplified to the extent that some of the essential elements, e.g. scale and a
legend, are omitted” (p. 155). He then goes on to say that presenting the day’s weather is a perfect example of this simplification process and shows how the simplification causes one idea to be highlighted. Gerber also points out a problem with weather maps on television: “…television maps are relatively inaccurate with a substantial amount of essential information added by a broadcaster or commentator.” He goes on to say “…it is a point of conjecture as to whether the weather maps…really serve an informative purpose or a cosmetic one as a colourful graphic to act as a background for the news presenter” (p. 155). Because of this possible exposure students have to oversimplified TV maps, it is important to identify what is known about their ability to use more technical maps.

In the Geography community there has been much debate between those who believe children develop spatial abilities at a young age (Blaut and Stea) and those who believe Piaget’s theories apply to the development of spatial abilities in children (Liben and Downs). In the 1960s and ‘70s Piaget’s theory of development was the accepted paradigm, implying that children younger than 8 years old did not have the cognitive operations needed to read a map and therefore map-learning was a “late attainment in children” (Blau et al., 2003, p. 168). In the 1980s Liben and Downs (2003) were producing research that supported the Piagetian perspective and concluding that children younger than seven had difficulties understanding viewing distance and the metric concept of map scale, as well as viewing angle. They were not and still are not saying that Piagetian theory is the only way to create theoretical structure for spatial abilities, just that it is useful.
At the same time, Blaut and Stea were doing research to produce evidence that supported their theory – young children do have the ability to “possess significant mapping abilities” (Blaut et al., 2003). Blaut and Stea and their colleagues supported this view with evidence showing young children could interpret black-and-white air photos and showing children use toy-play as representations of landscape features and the surface of the world. They did their studies among different cultures to support their theory that “mapping behavior…is a cultural universal, an ability to cognize and act that is acquired early in life in all cultures” (p. 165).

The debate came to a climax in 1997 as a Forum in the Annals of the Association of American Geographers. Blaut started the debate saying that “Children can”, i.e. young children can learn map skills and understand spatial concepts (Blaut, 1997, p. 152). At the same, he said Liben and Downs were arguing that “Children can’t” based on Piaget’s Cognitive. Liben and Downs replied back saying that “Can-ism” versus “Can’tianism” was too simple of an argument and did not do justice to the theoretical and methodological issues at hand (1997, p.159). They advocated for early beginnings in map education but differed from Blaut in that they did not agree with early mastery of map understanding. In the Forum response Liben and Downs explained that “to understand maps, one must not only identify their referential meaning, but one must also understand that maps are symbolic” (1997, p.161). They used Piaget’s theories to help defend this definition and argued that Blaut’s studies only show the first half.

Blaut ended the Forum by calling Piaget and the resulting educational applications pessimistic, in that students’ abilities and motivation are underestimated
(1997). He argued that Liben and Downs therefore were also pessimistic because they applied Piaget to their geographic education programs. A large section of Blaut’s rejoinder showed all of the studies that challenged and contradicted Piaget’s theories and showed that children develop different levels of understanding earlier. Blaut concluded that Liben and Downs subscribe to the “classical version of Piaget” and are thereby underestimating the mapping abilities of young children. Though the argument appears to continue into present, one thing that both sides can be seen to agree on is a need for improvement in geographic education.

Mackintosh is one author who has explored the constructivist approach in geography specifically “to explore children’s visualization, understanding or ‘alternative conceptions’ of ‘river’” (2005, p. 316). Students (9 to 10 years old), all of whom lived at the mouth of a major estuary and had been on a field trip there, had 5 tasks to complete, including listing rivers, word association, drawing a river, concept mapping, and an interview. According to Mackintosh, the interview provided the most illuminating results, showing that students still did not understand concepts discussed in the other activities and more importantly still did not grasp the fundamental concept that water flows downhill (p. 318). Even though students had visited the estuary, they only registered the section of the river directly in front of them. Mackintosh argues that students must be encouraged to see the bigger picture, with questions pointing out the river flow, asking where the water is coming from and going to, as well as what happens if there is too much rain fall. It would also be important to visit different sites in both rural and urban environments. “Without this children have no cognitive or environmental
image on which to locate, or with which to associate, the terminology and processes they encounter” (p. 321).

The activity used in Mackintosh’s research created a “top-down” teaching model in which teachers have their own personal constructs based on recollections of secondary classes and want the students to know the same constructs without the sufficient graphicacy skills. The “top-down” model ignores students’ alternative conceptual frameworks, i.e. how students view a concept based on their surroundings and experiences. A concept ladder however, allows for a “bottom-up” approach, which creates a progression in learning and takes into account students’ ideas and alternative frameworks (Mackintosh, 2005). The job of constructivist research then is to identify “where the children are at” and “starting points” where teachers need to begin a concept. Once these are identified, constructivist research can also show the gap between these and the suggested national curriculum content. The implications from geographical constructivist research, specifically Mackintosh’s, show that it is more important to concentrate on giving students experience of a place or subject, such as rivers, than it is to concentrate on the terminology.

Lowrie and Smith (2003, p.2) maintain that “visual and spatial skills and abilities are usually enhanced in situations where children are encouraged to visualise, manipulate and construct objects in real and simulated contexts.” To test this statement Lowrie and Logan (2007) did an investigation on the “influence a genuine artifact has on [middle school] students’ spatial reasoning” (p. 15). While the authors’ research focused more on mathematics concepts, maps were part of the study and required the use of spatial skills.
The activity used in the study contained everyday situations that the students were familiar with and required the students to “embed themselves in the situation” (p.15). Being embedded in the situation helped the students to use spatial skills to make sense of mathematical ideas. The students became engaged in the different tasks and commented that they felt like they were actually there in the location (a theme park).

Young (1993) also supports the idea of using realistic contexts, so that students are learning “real-life problem solving.” Students then learn that problems are not just “best-case scenario” but rather are often ill-structured, have complex goals, include relevant and irrelevant information, and offer multiple solutions. Weather maps fit this dynamic, providing multiple sets of data and representing information in more than one way. Lowrie and Logan noted that weather maps are a perfect example of using realistic contexts because they contain “complex visual fields that are displayed around us and have become part of our lives” (2007, p. 14).

Michaelidou et al. (2004) examined how different map designs affected the abilities of students between grades 3 and 6 to analyze maps. They changed the designs by changing map scale, background complexity, number of thematic layers, and methods of landform representation. The effects of map scale varied by the different grades and the authors determined that the differences “may have been due to their experience with maps” (p. 80). Grade 3 students, who had more exposure and experience working with large-scale maps, were more successful using the large-scale maps than the small-scale maps. Grade 5 students, who were only working with the small-scale maps, were more successful with the small scales. The authors concluded that students must have exposure
to both map scales throughout school instead of all large-scale in one year and all small-scale the next.

In this study, students were able to better recognize spatial relationships with simple maps that had a monochromatic background, and they “systematically performed better in extracting spatial relationships from political maps than from physical maps” (Michaelidou et al, 2004, p. 81). However the authors also found that “omitting thematic layers from small-scale maps with no vivid background…and from large-scale general maps resulted in simplistic representations that led to lower performance…” (p. 81). This suggests that maps on television being oversimplified may hurt rather than help students’ understanding of weather. The authors concluded by mentioning that overall the key to students performing better was more exposure to “…small- and large-scale general and thematic maps…” (p. 82), suggesting that students would learn weather from maps best when they’ve been exposed to several different maps.

2.4 Education Content Standards

The importance of introducing students to weather maps is supported in the national and state standards that guide the teaching of science in public schools. The National Research Council developed the National Science Education Standards to “guide our nation toward a scientifically literate society” and “present criteria for science education that will allow that vision to become reality” (National Research Council [NRC], 1996, p.11). The Standards provide a broad overview and division of the science concepts, which states use to develop individual and more detailed standards for their
schools. In the *National Standards* Earth and Space Science are grouped together. In grades K-4 students are supposed to know “Changes in earth and sky” and by grades 5-8 students are supposed to know the “Structure of the earth system, Earth’s history, and Earth in the solar system” (p. 107).

Ohio began developing academic content standards in 1997 and designed a system that includes Grade-level Indicators, Benchmarks, and Standards (Ohio Department of Education [ODE], 2005, p. 4). The indicators are what students should know at each grade level, and they act as checkpoints towards reaching the benchmarks (p. 24). The benchmarks are “key points that monitor progress toward academic content standards” and cover “grade-level bands” including 6-8, which are the benchmarks for the students in this study (p. 24). Content standards are the “overarching goals and themes” and what “all students should know and be able to do” (p. 24).

The standard for Earth and Space science encompasses grades K-12, with the idea that by 12th grade, students will fully comprehend the concepts that are involved in that standard. The standard (ODE, 2005) reads as follows:

Students demonstrate an understanding about how Earth systems and processes interact in the geosphere resulting in the habitability of Earth. This includes demonstrating an understanding of the composition of the universe, the solar system and Earth. In addition, it includes understanding the properties and the interconnected nature of Earth's systems, processes that shape Earth and Earth's history. Students also demonstrate an understanding of how the concepts and principles of energy, matter, motion and forces explain Earth systems, the solar system and the universe. Finally, they grasp an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with Earth and space sciences (p. 14).

There are five benchmarks in Earth and Space science that students should know by the time they have finished 8th grade. The first three benchmarks are ones that
meteorological understanding could help explain (ODE, 2005):

- Describe how the positions and motions of the objects in the universe cause predictable and cyclic events.
- Explain that the universe is composed of vast amounts of matter, most of which is at incomprehensible distances and held together by gravitational force. Describe how the universe is studied by the use of equipment such as telescopes, probes, satellites and spacecraft.
- Describe interactions of matter and energy throughout the lithosphere, hydrosphere and atmosphere (e.g., water cycle, weather and pollution) (p. 34).

There are also indicators at Kindergarten, Grade 2, and Grade 4 that require knowledge of weather. However, it is at Grade 7 where students have to combine the concepts from the years past and apply what they know. All but one of the indicators relate to weather (ODE, 2005):

- Explain the biogeochemical cycles which move materials between the lithosphere (land), hydrosphere (water) and atmosphere (air).
- Explain that Earth's capacity to absorb and recycle materials naturally (e.g., smoke, smog and sewage) can change the environmental quality depending on the length of time involved (e.g., global warming).
- Describe the water cycle and explain the transfer of energy between the atmosphere and hydrosphere.
- Make simple weather predictions based on the changing cloud types associated with frontal systems.
- Determine how weather observations and measurements are combined to produce weather maps and that data for a specific location at one point in time can be displayed in a station model.
- Read a weather map to interpret local, regional, and national weather.
- Describe how temperature and precipitation determine climatic zones (biomes) (e.g., desert, grasslands, forests, tundra and alpine).
- Describe the connection between the water cycle and weather-related phenomenon (e.g., tornadoes, floods, droughts and hurricanes) (p. 49).

The number of standards, benchmarks, and indicators that relate to weather show the need for a curriculum that teaches weather so students can conceptually understand it. Researching students’ development of spatial and learning abilities can help lead to better
designed curriculums. Down the road, research may even lead to a change in the standards, benchmarks, and indicators themselves.
CHAPTER 3: METHODOLOGY

The Northeast Ohio Geoscience Education Outreach program (NEOGEO) is a collaborative effort between the Kent State University Geography and Geology Departments and the Stark County Educational Services Center, with the goal to enhance middle school and high school Earth Science education. Ten graduate fellows worked with teachers in and outside the classroom between 2005 and 2008 to develop curriculum modules that were inquiry-based and scientifically correct. The schools gave permission for the graduate students to be working in the classroom with students and modifying curriculum on a regular basis. My role was to work with middle school teachers in Stark County who were teaching weather units and create weather activities that would help students understand various weather concepts. I also helped create and present a professional development summer workshop where teachers were able to improve their earth science knowledge. Through this work, I was able to make connections with teachers and observe difficulties that students were having with weather concepts. I noticed that teachers were not always looking at current weather data, and if they were, observations were only for current locations.

Considering that teachers only occasionally discuss current weather in the classroom the question was raised as to whether including daily discussions of current weather data weather would help students better understand weather concepts. The objective of the research is thus to answer the question of how the use of current surface
weather maps affects middle school students’ understanding of weather concepts. To meet this objective, volunteer teachers from the NEOGEO program implemented weather maps and weather discussions in the classroom, in order to expose students to the connections between weather maps and weather concepts during their weather unit.

3.1 Implementation

Teachers who agreed to participate in this study received training prior to the beginning of implementation. At this time the entire process was explained to them, including what they would do and what the researcher would do. An implementation timeline was created so that both the teacher and researcher would know when consent forms were being distributed, when the curriculum was starting, when students would take the background surveys and assessments, as well as when all the associated paperwork would be delivered. A website (Figure 1) was created for the teachers so that instructions and daily images were easily accessible, and efforts were made to ensure all teachers could reach the website through their school computers and could print images if needed.
To assess any potential improvement, all participating classrooms were divided into either the “Map” group or the control “No Map” group (Figure 2). Both classroom groups were taught the same weather unit that would typically be taught using a “traditional” method – covering all of the topics and activities and addressing the Science portion of the Ohio Academic Content Standards (OACS). Though the curriculum varies by school, all classrooms covered basic topics including air pressure, warm and cold fronts and their associated weather, as well as reading weather maps and movement of storm systems.

Figure 3.2 Flow chart of divisions
This general curriculum was the extent of what was taught to the “No Map” classrooms. The “Map” classrooms participated in two weeks of daily current weather map discussions in addition to the general curriculum presentation. These discussions occurred at the same time students were learning about the above topics and involved looking at the Current Surface Weather Map from The Weather Channel’s website. A discussion sheet (Appendix A) was developed for the teachers to help guide which topics were covered and to create consistency throughout the different classrooms. The same discussion sheet was used every day for two weeks and incorporated the tracking of high and low pressure centers and fronts, weather occurring along with their movement, and focusing on both the national and local scale. The questions required students to both draw on their own weather maps as well as answer questions in a group. The duration of two weeks is based on the typical length of the weather curriculum at this level.

3.1.1 Classroom Descriptions

Classrooms in three schools, with a total of 6 teachers, were used for data collection. The schools ranged from inner city to suburban school districts (Table 1). Lehman Middle School was the first school to participate, with two teachers, Denise Johnson and Bernie Caldwell. Both teachers used the Full Operation System Science (FOSS) Weather Kit for their curriculum and after the initial meeting it was decided that the research would take place during Units 8 and 9 of the kit. These units specifically covered air pressure, wind, fronts, and reading a weather map – all concepts that were covered on the assessment. Ms. Johnson used the “traditional” method of teaching for all
of her classes, which made up the “No Map” group. Her classes had a wide variety of students ranging from those with exceptional learning needs to honors students. Mr. Caldwell’s classrooms were part of the “Map Group”, with all of his classes receiving the “traditional” approach plus the daily weather discussion. One of Mr. Caldwell’s classes was completely composed of honors students.

Table 3.1 School and classroom information for all participants

<table>
<thead>
<tr>
<th>SCHOOL</th>
<th>TEACHER</th>
<th>MAP/NO MAP</th>
<th>PERIOD</th>
<th># of Students</th>
<th>DATES</th>
</tr>
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<tbody>
<tr>
<td>Louisville Middle School</td>
<td>Laura Esposito</td>
<td>NA</td>
<td>6</td>
<td>26</td>
<td>May 2007</td>
</tr>
<tr>
<td>Comments: Used as a test case, data not used in results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lehman Middle School</td>
<td>Denise Johnson</td>
<td>No Map</td>
<td>All periods</td>
<td>95</td>
<td>January 2008</td>
</tr>
<tr>
<td>Comments: Curriculum: Unit 8 &amp; 9 of FOSS kit, Wide variety of students, more Special Ed than Bernie</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lehman Middle School</td>
<td>Bernie Caldwell</td>
<td>Map</td>
<td>All periods</td>
<td>95</td>
<td>January 2008</td>
</tr>
<tr>
<td>Comments: Curriculum: Unit 8 &amp; 9 of FOSS kit, High number of honors students</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Canton Middle School</td>
<td>Heather Neutzling</td>
<td>Map</td>
<td>1,2,5</td>
<td>66</td>
<td>May 2008</td>
</tr>
<tr>
<td>Comments: Curriculum: Prentice Hall book, Wide variety of students</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Canton Middle School</td>
<td>Heather Neutzling</td>
<td>No Map</td>
<td>3,6</td>
<td>49</td>
<td>May 2008</td>
</tr>
<tr>
<td>Comments: Curriculum: Prentice Hall book, Wide variety of students</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Canton Middle School</td>
<td>Laura Heckathorn</td>
<td>Map</td>
<td>2,3,6</td>
<td>61</td>
<td>May 2008</td>
</tr>
<tr>
<td>Comments: Curriculum: Prentice Hall book, 6th period mix of honors &amp; special ed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Canton Middle School</td>
<td>Laura Heckathorn</td>
<td>No Map</td>
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<td>43</td>
<td>May 2008</td>
</tr>
<tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td>North Canton Middle School</td>
<td>Jeff Breit</td>
<td>Map</td>
<td>3,5</td>
<td>48</td>
<td>May 2008</td>
</tr>
<tr>
<td>Comments: Curriculum: Prentice Hall book, Wide variety of students</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Canton Middle School</td>
<td>Jeff Breit</td>
<td>No Map</td>
<td>1,2,6</td>
<td>71</td>
<td>May 2008</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The second school in the study was North Canton Middle School, which had three teacher participants, Heather Neutzling, Laura Heckathorn, and Jeff Breit, each of whom had five classes. It was determined that each teacher would divide their classes and teach both “Map” and “No Map” groups to eliminate the potential bias of different teaching styles. All three teachers worked as a team and used the same curriculum, *Science Explorer Weather & Climate* from Prentice Hall, and supplemented it with their own handouts. Three chapters in the book covered concepts also on the assessment, but due to a time constraint it was decided that the research would start almost immediately after the weather unit was started and continue for two weeks like the previous school. Ms. Neutzling’s and Mr. Breit’s classes consisted of a wide variety of students in all five classes. Ms. Heckathorn had two classes that were a combination of students with exceptional learning needs and honors students only. She decided to have one be part of the “Map” group and one as part of the “No Map” group to see if there was any difference specifically between the two.

Ted Dudra at Glenwood Middle School participated by himself, and divided his 4 classes into “Map” and “No Map” groups. His weather curriculum was a combination of the same FOSS kit as Lehman Middle School and handouts that he found on his own. Mr. Dudra implemented the background surveys and pre-assessments when he started his weather unit and continued discussions for two weeks. His classes consisted of a wide variety of students. Due to unforeseen circumstances Mr. Dudra was not able to complete the post-assessments and the classroom data were removed from the results.
3.2 Background Surveys and Consent Forms

The background survey (Appendix B) serves two purposes. The first is to determine students’ amount of exposure to weather concepts and weather maps from media sources, and if there was any exposure to weather from other sources. The second is to assess students’ general geographic knowledge. The survey began with questions asking about how much time students spent looking at weather in different media outlets and what they looked at in those sources. Students were then asked about how much time they spent discussing weather outside the classroom and what was discussed. Lastly, questions were asked to determine the students’ interest in weather. The geography knowledge section included questions on general knowledge about maps and their purpose, as well as maps of the US and Ohio on which they had to label different features.

3.2.1 Design Changes

Changes were made to the design of the background survey between the first group of students at Lehman Middle School (Figure B.1) and the second group at North Canton Middle School and Plain Local School (Figure B.2). The multiple-choice questions 1, 2, 3, 6, and 8, which ask how often students were involved with media sources, were redone so that all of the options were the same. The first background survey sent out had different times for each question. Question 10 was also changed so that “1” was equal to no interest at all.
3.2.2 Implementation

Because the background survey was not part of the curriculum, consent forms (Appendix C) from the students and their guardian were required. These were handed out to students one to two weeks before the main research started. Several teachers offered bonus points to their students if the consent forms were returned to motivate the students to take them to the parents. Those students who had returned the consent forms then filled out the background surveys in class on the first day of research. If they ran out of time, students were allowed to work on them outside of class.

3.3 Pre- and Post- Assessments

To evaluate the differences in learning between “map” and “no map” groups, all groups were given pre-assessments before the two-week period of participation, and post-assessments after the two-week period. The pre-assessment test and the post-assessment test were the exact same (Appendix D), so that test score comparisons could be made. The assessments contain both multiple choice and open-ended questions designed to see if students understand basic and more complex weather concepts.

Before assessments were used in the research classrooms, a design was used in a volunteer 7th grade classroom to determine if wording was clear and questions applicable to what was being learned. The design was evaluated by how students answered, in terms of their level of understanding of the question, as well as by the teacher’s input. Questions were split, re-worded, or taken out and a new assessment was ready for the research classroom (Figure D.1).
3.3.1 Implementation

Both teachers at Lehman Middle School gave their pre-assessments at the same point in the curriculum, the day before starting Unit 8 of the FOSS kit. Students were given one class period to complete the assessment and told that it would not count towards their grade. No assessments were done as make-up work; if students were not there they did not take the test. After the test Mr. Caldwell mentioned that station plots are barely covered in the FOSS kit and the decision was made to not evaluate Question 16.

Ms. Johnson went through the FOSS kit as normal without any discussions. Her students were taught the “traditional” way participating only in activities that were already in the curriculum. Mr. Caldwell went through the kit plus two weeks of weather discussions. After two weeks Mr. Caldwell had finished the two Units and was ready for his students to take the post-assessment. Ms. Johnson took longer than two weeks to complete the two Units and did not give the post-assessments until the two Units were completed. Again the assessments were done in class with no make-ups allowed. The assessments were being compared within the general classroom scores, not by individual students.

After the first group of assessments was evaluated it was realized that having one teacher have all “No Map” classrooms and the other teacher all “Map” classrooms may lead to a bias in the results caused by teaching style. The other schools participating next had uneven amounts of teachers, making it hard to divide up teachers into pairs. These two factors led to the decision to have teachers teach both “No Map” and “Map” classes.
At North Canton Middle School, each teacher divided his or her classes into groups differently. Ms. Neutzling divided her classes so that periods 1, 2, and 5 received the “Map” group curriculum and periods 3 and 6 received the “No Map” group curriculum. Ms. Heckathorn divided her classes so that periods 2, 3, and 6 received the “Map” group curriculum and periods 1 and 5 received the “No Map” group curriculum. Mr. Breit divided his classes so that periods 3 and 5 received the “Map” group curriculum and periods 1, 2, and 6 received the “No Map” group curriculum. Pre-assessments were given at the same point in the curriculum for all class periods, in the middle of Chapter One of Science Explorer Weather & Climate from Prentice Hall. Students had one class period to take the pre-assessment and the assessment was not to be completed as make-up work.

All three teachers taught his or her “No Map” classrooms the same, going through the curriculum as normal for two weeks without discussions. At the same time they were teaching the “Map” classrooms, using the same curriculum as well as doing the daily discussions for two weeks. All post-assessments were given for all classes in both groups the day after two weeks were completed. Again the assessments were done in class with no make-ups allowed.

### 3.3.2 Design Changes

The assessment designs were changed between Lehman Middle School (Figure D.1) and North Canton Middle School (Figure D.2) after answers from LMS showed that students still did not understand some of the questions. Questions 3 and 5 were changed
to imply that clouds and precipitation were a hint of how to answer the question, not multiple-choice answers. Students were getting questions 6 and 7 confused, giving the same answer for both or reversing the answers, showing they understood the concepts but technically getting the answers wrong. Question 7 was changed to be more specific without guiding students to the answer. Students also seemed to have misunderstandings about questions 10, 11, and 12 and didn’t realize that the three were meant to be a related series. The questions were rewritten to be more clearly related, as well as to eliminate the same problem as questions 3 and 5. Lastly question 16 was taken out and the U.S. map image was reduced to eliminate the Rocky Mountains and west.

3.4 Teacher Feedback

After reviewing results from all of the assessments, input from the teachers was deemed necessary to fully evaluate the effects of weather discussions on the classrooms. The questions were as follows:

1) How many times have you taught weather previous to this year (2007-2008)?
2) Did looking at weather maps on a daily basis influence your overall teaching?
3) Do you feel that you approached teaching differently between the two groups? If so, how?
4) Did you notice any difference in the level of interest between the map group and the no map group?
5) Did you have any problems with using real-time data in the classroom?
6) Were any changes made in your weather curriculum to allow for map discussion time?
7) Do you think you will continue to use current weather map discussions in the future?
8) What were your thoughts on the usability of my website?
9) Any additional comment on the experience?
Not all of the questions were relevant for each school since different methods of implementation were used, so the questionnaires were individualized for each school. The questionnaires were sent out by email to the teachers and they were asked to respond via email. The North Canton teachers responded by filling out the questionnaire together and only sending one form back with their combined answers. The teachers from Lehman Middle School filled out their forms and sent them back individually. Answers from the teachers were evaluated qualitatively.

3.5 Analysis of Data

3.5.1 Creating a Rubric

All of the assessments had to be graded as fair and consistent as possible. For this reason, a grading rubric (Appendix E) was created. Each question on the assessment had its own point value assigned to an answer. Any student answers that were not on the rubric were given the point value of the response on the rubric to which the answer most closely corresponded. Due to the changes in the assessments, two assessment rubrics (Figures E.1 and E.2) were created, however the point values for those changed questions remained the same.

3.5.2 Data Analysis for Background Surveys

Excel was used to keep all of the teachers, “Map” vs. “No Map”, background survey responses, and assessment scores together. To make analysis easier the background survey was broken into two sections, weather interest and geographic
knowledge. Both section answers were entered into Excel and then exported to SPSS 15.0. For the interest section frequency analysis was done on questions that had multiple-choice answers, to determine percentages of the different responses. The frequency analysis looked at “map” and “no map” together, separated, and also by individual classrooms. Questions that asked about different products used and required written answers were looked at qualitatively.

Mean scores and frequencies were done on the geographic knowledge data. The total mean score for everyone and the total mean scores for each group (“map” and “no map”) were calculated first, followed by mean scores for each classroom. Then the knowledge section was divided into “written knowledge” and “local awareness” and mean scores were calculated for total, each group, and each classroom. Finally the “local awareness” section was divided down to US map scores and Ohio map scores, again for the total, each group, and each classroom. Frequencies were done to determine what percentage of the total, group, and classroom scored correctly on each question.

### 3.5.3 Data Analysis for Assessments

Each assessment’s individual question scores and total score were kept for analysis. Once all of the data were in Excel, they were exported into SPSS 15.0 for statistical analysis. Analysis was done on the total assessment scores for each group as well as the scores of each individual question. The first step taken was to determine the average of the total score for the “map” group on both the pre-assessment and the post-
assessment, followed by the total scores of the “no map” group. Average scores on both the pre-assessment and post-assessment were also determined for each individual teacher.

An independent samples t-test was used to compare the different mean scores and improvements. The total mean score of the pre-assessment for the “map” group was compared to the mean score of the post-assessment to determine if improvement was statistically significant. The same was done for the total mean scores of the “no map” group’s assessments. Improvement between the individual teachers’ pre- and post-assessments was also tested for statistical significance. Once the amount of improvement was calculated for each group, the total mean score improvement of the “map” group was compared to the total mean score improvement of the “no map” group to determine if the difference in improvements was statistically significant.

Each individual assessment question was evaluated as well. Frequency analysis was done on each question on both the pre-assessment and the post-assessment. The analysis looked at the different score percentages and was broken down by “map” and “no map”. Mean scores by each group were calculated on every question, both for the pre- and post-assessment. The independent samples test was used on each question to determine if the “map” group had statistically significant improvement from the pre- to post-assessment, and if the “no map” had it as well. The independent samples test was also used on each question to compare the improvement of the “map” group to the improvement of the “no map” group.
CHAPTER 4: RESULTS

The objective of this research is to determine if using current surface weather maps and discussions help students improve their understanding of weather concepts. In this chapter, the results of the background surveys, pre- and post-assessments, and teacher evaluations are presented in order to evaluate this objective.

4.1 Background Survey

4.1.1 Interest Section

The results for the background survey are broken into two sections. The first half, the interest section, looks at how often students are exposed to weather outside the classroom. The second half, the geographic knowledge section, evaluates students’ written knowledge of geography as well as local awareness. Students could only fill out the survey if a permission slip had been returned, reducing the sample size as compared to the assessments. The Lehman Middle School teachers (Caldwell and Johnson) had around 50 percent fewer students fill out the surveys than the assessments. Almost all of the students at North Canton filled out both background surveys and assessments, in fact in some of the classes there were more students that filled out the surveys. The division of numbers between “map” and “no map” was exactly equal.

To evaluate exposure to weather maps and weather concepts outside of the classroom, students were asked about how much they watched on television, how much
they looked at it online and in the newspaper, and how much they discussed it outside the classroom (Table 4.1). Follow-ups to the online and newspaper questions allowed students to check what weather-related items they were looking at, such as forecast maps, radar, and satellite. However, due to students saying they never looked at anything and then marking different maps, the results from these questions were not evaluated.

Students were also asked on a scale of 1 to 3 to say how interested in weather they were to determine if exposure and interest might be related.

Looking at the total percentages, students seem to have about the same exposure to both the Weather Channel and weather on their local news stations. 38% of students never watch weather on television at all, with 48% and 45% of students watching 1-3 times a week. 17% of students watch the local weather more than 5 times a week compared to 15% watching the Weather Channel. The “map” group has smaller percentages in the Never category for both the Weather Channel (35%) and local weather (36%) than the “no map” group (41%, 39%). The responses to the 1-3 times categories also have a larger percentage for the “map” group (48%, 45%) than the “no map” group (44%, 43%). In the 5-plus response category for both the Weather Channel and local weather the “no map” group and the “map” group were about the same, around 15% and 18%. Breaking the groups down to individual teachers creates a wide variance of responses to each category. The “map” group ranged from Caldwell’s students watching the most weather on television – only 29% and 26% said they never watch weather on television – to Breit’s (39%, 36%) and Neutzling’s (37% and 42%) classes watching the least amount of weather on television. The “no map” group varied as well with only 29%
of Johnson’s students never watching the weather channel as compared to 54% of Heckathorn’s students. Breit had 33% of students not watching weather on local television as compared to 51% of Neutzling’s students not watching local weather on television.

Table 4.1 Percentage of responses to Background Survey Questions

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<tr>
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<th>Watch Weather Channel</th>
<th>Weather on the Local Station</th>
<th>Look at Weather Online</th>
</tr>
</thead>
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<tr>
<td></td>
<td>1-3 Times 5 Plus</td>
<td>1-3 Times 5</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>Never Times</td>
<td></td>
<td>Never Times</td>
</tr>
<tr>
<td>TOTAL</td>
<td>428</td>
<td>38% 48% 14%</td>
<td>38% 45% 17%</td>
</tr>
<tr>
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<td>214</td>
<td>35% 52% 13%</td>
<td>36% 48% 15%</td>
</tr>
<tr>
<td>Caldwell</td>
<td>38</td>
<td>29% 55% 16%</td>
<td>26% 42% 32%</td>
</tr>
<tr>
<td>Neutzling</td>
<td>67</td>
<td>37% 46% 16%</td>
<td>42% 42% 16%</td>
</tr>
<tr>
<td>Heckathorn</td>
<td>65</td>
<td>34% 57% 9%</td>
<td>37% 55% 8%</td>
</tr>
<tr>
<td>Breit</td>
<td>44</td>
<td>39% 50% 11%</td>
<td>36% 52% 11%</td>
</tr>
<tr>
<td>No Map</td>
<td>214</td>
<td>41% 44% 15%</td>
<td>39% 43% 18%</td>
</tr>
<tr>
<td>Johnson</td>
<td>51</td>
<td>29% 61% 10%</td>
<td>35% 49% 16%</td>
</tr>
<tr>
<td>Neutzling</td>
<td>47</td>
<td>43% 43% 15%</td>
<td>51% 28% 21%</td>
</tr>
<tr>
<td>Heckathorn</td>
<td>43</td>
<td>54% 35% 12%</td>
<td>42% 42% 16%</td>
</tr>
<tr>
<td>Breit</td>
<td>73</td>
<td>41% 38% 21%</td>
<td>33% 48% 19%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Weather in the Newspaper</th>
<th>Discuss Outside the Classroom</th>
<th>Interest in Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-3 Times 5 Plus</td>
<td>1-3 Times 5</td>
<td>Not at All Somewhat Very</td>
</tr>
<tr>
<td>n</td>
<td>Never Times</td>
<td></td>
<td>Never Times</td>
</tr>
<tr>
<td>TOTAL</td>
<td>428</td>
<td>73% 24% 4%</td>
<td>27% 58% 14%</td>
</tr>
<tr>
<td>Map</td>
<td>214</td>
<td>76% 21% 3%</td>
<td>26% 59% 15%</td>
</tr>
<tr>
<td>Caldwell</td>
<td>38</td>
<td>61% 37% 3%</td>
<td>21% 71% 8%</td>
</tr>
<tr>
<td>Neutzling</td>
<td>67</td>
<td>84% 15% 2%</td>
<td>21% 58% 21%</td>
</tr>
<tr>
<td>Heckathorn</td>
<td>65</td>
<td>82% 17% 2%</td>
<td>31% 59% 11%</td>
</tr>
<tr>
<td>Breit</td>
<td>44</td>
<td>71% 21% 9%</td>
<td>30% 50% 21%</td>
</tr>
<tr>
<td>No Map</td>
<td>214</td>
<td>69% 27% 4%</td>
<td>29% 58% 13%</td>
</tr>
<tr>
<td>Johnson</td>
<td>51</td>
<td>55% 43% 2%</td>
<td>41% 49% 10%</td>
</tr>
<tr>
<td>Neutzling</td>
<td>47</td>
<td>66% 23% 11%</td>
<td>66% 28% 6%</td>
</tr>
<tr>
<td>Heckathorn</td>
<td>43</td>
<td>74% 21% 5%</td>
<td>26% 61% 14%</td>
</tr>
<tr>
<td>Breit</td>
<td>73</td>
<td>78% 18% 4%</td>
<td>23% 59% 18%</td>
</tr>
</tbody>
</table>
Fewer students look at weather online when compared to watching weather on television. Looking at the total number of responses, 58% never look at weather online, 34% look at it 1 to 3 times a week, and 8% look at it 5 or more times a week. There is not much of a difference between the “map” and “no map” in either of the three response categories, with only a 4% difference or less. However, the response breakdown by class has a much larger range. In the “map” group Breit had the highest percentage in the never responses (68%) and the lowest in the 5 plus responses (5%), while Caldwell had the lowest amount (47%) of never response and highest (13%) of 5 plus responses. In the “no map” group Johnson had 0% in the 5 plus response while Neutzling had 21% say they look at weather online 5 or more times a week. Interestingly enough, Neutzling also had the highest percent (66%) say that they never look at weather online, while Heckathorn had the lowest percent at 51%.

Looking at weather in the newspaper is the least popular way to be exposed to weather. 73% of students said they never look at the weather in the newspaper, only 24% look at it 1 to 3 times a week, and only 4% look at it more than 5 times a week. Based on the never and 1 to 3 times a week responses, the “no map” group (69%, 27%) looks at the newspaper for weather more than the “map” group (76%, 21%). Like the television and internet questions, there is little difference between the two groups but a large difference amongst the teachers in each group. Caldwell in the “map” group has the lowest amount of students that never look at weather in a newspaper (61%) and the largest amount in the 1 to 3 times a week (37%). Neutzling has the highest amount in the never response
(84%) and the lowest amount in the 1 to 3 times a week (15%). In the “no map” group the never and 1-3 times a week responses varied by 25% and the 5 plus varied by 9%.

The total responses showed that 27% of students never discuss weather outside the classroom, 58% do 1-3 times a week, and 14% discuss weather more than 5 times a week outside the classroom. Both the “map” and the “no map” group were right around these averages, only differing by 1%. Once again there were larger differences amongst the teachers. In the “map” group there was approximately a 10% in both the never and 1-3 times a week responses, and 13% difference in the 5 plus responses. In the “no map” group the variances were 46%, 43%, and 12%.

Looking at the Interest in Weather question, Heckathorn’s classes stand out. Both the “map” and the “no map” groups have 35% in the not at all response, 65% in the somewhat response, and 0% in the very interested response. Those classes are the highest percentage in the not at all responses, second to lowest in the somewhat response, and the lowest in the very interested responses. Overall, 24% were not at all interested, 72% somewhat interested, and 4% very interested. The “no map” group had 5% lower in the not at all response and 5% higher in the somewhat interested response, but was equal with the “map” group in the very interested response.

**4.1.2 Geographic Knowledge Section**

The geographic knowledge section had two purposes. The first purpose was to test students’ written knowledge. The questions asked included, “What is the purpose of map?”, “What view does a map provide?”, and “What are latitude and longitude?”. The
second purpose was to test students’ local awareness. Students were asked to label different locations and landmarks around both the United States and Ohio. The scores evaluated were the total geographic knowledge score, the written section by itself, the map section alone, and then each map individually (Table 4.2).

**Table 4.2. Different scores for the Geographic Knowledge section.**

<table>
<thead>
<tr>
<th></th>
<th>Geographic Knowledge Total (24)</th>
<th>Written Total (10)</th>
<th>Local Awareness Total (14)</th>
<th>US Map (8)</th>
<th>Ohio Map (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL</strong></td>
<td>15.08</td>
<td>6.28</td>
<td>8.81</td>
<td>5.33</td>
<td>3.48</td>
</tr>
<tr>
<td><strong>Map</strong></td>
<td>15.45</td>
<td>6.38</td>
<td>9.07</td>
<td>5.53</td>
<td>3.54</td>
</tr>
<tr>
<td>Caldwell</td>
<td>14.21</td>
<td>6.50</td>
<td>7.71</td>
<td>4.82</td>
<td>2.89</td>
</tr>
<tr>
<td>Neutzling</td>
<td>16.31</td>
<td>6.93</td>
<td>9.38</td>
<td>5.68</td>
<td>3.71</td>
</tr>
<tr>
<td>Heckathorn</td>
<td>14.42</td>
<td>5.51</td>
<td>8.91</td>
<td>5.48</td>
<td>3.43</td>
</tr>
<tr>
<td>Breit</td>
<td>16.70</td>
<td>6.73</td>
<td>9.07</td>
<td>5.98</td>
<td>4.00</td>
</tr>
<tr>
<td><strong>No Map</strong></td>
<td>14.72</td>
<td>6.17</td>
<td>8.55</td>
<td>5.14</td>
<td>3.41</td>
</tr>
<tr>
<td>Johnson</td>
<td>10.65</td>
<td>5.29</td>
<td>5.35</td>
<td>3.27</td>
<td>2.08</td>
</tr>
<tr>
<td>Neutzling</td>
<td>17.98</td>
<td>7.21</td>
<td>10.77</td>
<td>6.21</td>
<td>4.55</td>
</tr>
<tr>
<td>Heckathorn</td>
<td>13.38</td>
<td>5.88</td>
<td>7.5</td>
<td>4.74</td>
<td>2.76</td>
</tr>
<tr>
<td>Breit</td>
<td>16.23</td>
<td>6.27</td>
<td>8.55</td>
<td>5.97</td>
<td>3.99</td>
</tr>
</tbody>
</table>

Overall, the “map” group had higher mean scores on the total, as well as every division, than the “no map” group. However, the largest difference between the two groups was only 0.36 of the total score. Across the different teachers, each teacher’s averaged above 50% except for Johnson’s classes with a mean score of 10.65 out of 24. Johnson’s classes were below 50% on everything but the score for the written portion (5.29 out of 10). Heckathorn’s classes were the second lowest mean scores, though
everything was above 50% except for the “no map” classes on the Ohio Map (2.76 out of 6). Neutzling’s classes had the highest mean scores in the “no map” group and in the “map” group, except for the individual maps. Breit’s classes had the highest mean scores in the “map” group on the US (5.98) map by itself and the Ohio (4.00) map by itself.

The written portion of the geographic knowledge section is composed of ten short-answer questions, asking various questions about maps and map concepts. The questions were either marked correct or incorrect, nothing in between. Table 4.3 shows the percentage correct for each question for the total group, “map” and “no map” groups, and each teacher.

Looking at the total, the highest scoring questions were “purpose of maps” (93%), “northern or southern hemisphere” (96%), “purpose of a compass” (94%), and “the 4 cardinal directions” (92%). The “map” and the “no map” groups also scored high for these questions with no difference. Breit’s classes had 100% correct for the questions on the purpose of maps, hemispheres, and the purpose of a compass on a map.

Both Caldwell’s classes in the “map” group and Johnson’s classes in the “no map” group had a lot of students not answer the written section, causing their percentages to be the lowest. Caldwell only had 79% correct for the “purpose of maps” while all the other teachers in both groups had 90% or above. Caldwell and Johnson were the only classes in either group to score less than 90% (82%, 86%) on “the reason for a compass”. Johnson’s were the only classes to score below 90% (86%) on the 4 cardinal directions, while in the “map” group Caldwell’s classes had 87% and Heckathorn’s classes had 89%.
The questions that fall into the middle scoring range relate to map view (44%), what hemispheres say about location (57%), and latitude and longitude (45%, 44%). On the map view question the “map” group did slightly better (47%) than the “no map” (41%) group. The “map” group (62%) had an 11% difference from the “no map” group (51%) on the question relating hemisphere and location. For latitude and longitude the two groups were almost the same, with only a 1% difference between the “map” (45%) and “no map” (44%) group.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>What is the purpose of maps?</th>
<th>What view does a map provide?</th>
<th>What does map scale refer to?</th>
<th>Northern or Southern Hemisphere?</th>
<th>What does hemisphere say about location?</th>
<th>What is the reason for a compass on a map?</th>
<th>What are the 4 cardinal directions?</th>
<th>What is latitude?</th>
<th>What is longitude?</th>
<th>What is a map legend?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL</strong></td>
<td>428</td>
<td>93%</td>
<td>44%</td>
<td>27%</td>
<td>96%</td>
<td>57%</td>
<td>94%</td>
<td>92%</td>
<td>45%</td>
<td>44%</td>
<td>36%</td>
</tr>
<tr>
<td><strong>Map</strong></td>
<td>214</td>
<td>92%</td>
<td>47%</td>
<td>29%</td>
<td>96%</td>
<td>62%</td>
<td>94%</td>
<td>92%</td>
<td>45%</td>
<td>45%</td>
<td>36%</td>
</tr>
<tr>
<td>Caldwell</td>
<td>38</td>
<td>79%</td>
<td>34%</td>
<td>40%</td>
<td>90%</td>
<td>58%</td>
<td>82%</td>
<td>87%</td>
<td>66%</td>
<td>66%</td>
<td>50%</td>
</tr>
<tr>
<td>Neutzling</td>
<td>68</td>
<td>94%</td>
<td>50%</td>
<td>37%</td>
<td>97%</td>
<td>77%</td>
<td>97%</td>
<td>97%</td>
<td>54%</td>
<td>52%</td>
<td>38%</td>
</tr>
<tr>
<td>Heckathorn</td>
<td>65</td>
<td>92%</td>
<td>46%</td>
<td>11%</td>
<td>97%</td>
<td>51%</td>
<td>92%</td>
<td>89%</td>
<td>25%</td>
<td>25%</td>
<td>23%</td>
</tr>
<tr>
<td>Breit</td>
<td>44</td>
<td>100%</td>
<td>55%</td>
<td>34%</td>
<td>100%</td>
<td>61%</td>
<td>100%</td>
<td>93%</td>
<td>43%</td>
<td>46%</td>
<td>41%</td>
</tr>
<tr>
<td><strong>No Map</strong></td>
<td>214</td>
<td>94%</td>
<td>41%</td>
<td>26%</td>
<td>96%</td>
<td>51%</td>
<td>94%</td>
<td>92%</td>
<td>44%</td>
<td>44%</td>
<td>36%</td>
</tr>
<tr>
<td>Johnson</td>
<td>51</td>
<td>90%</td>
<td>26%</td>
<td>14%</td>
<td>90%</td>
<td>29%</td>
<td>86%</td>
<td>86%</td>
<td>33%</td>
<td>33%</td>
<td>41%</td>
</tr>
<tr>
<td>Neutzling</td>
<td>47</td>
<td>96%</td>
<td>49%</td>
<td>45%</td>
<td>100%</td>
<td>64%</td>
<td>98%</td>
<td>100%</td>
<td>60%</td>
<td>53%</td>
<td>57%</td>
</tr>
<tr>
<td>Heckathorn</td>
<td>43</td>
<td>93%</td>
<td>43%</td>
<td>17%</td>
<td>93%</td>
<td>50%</td>
<td>91%</td>
<td>91%</td>
<td>45%</td>
<td>48%</td>
<td>19%</td>
</tr>
<tr>
<td>Breit</td>
<td>73</td>
<td>96%</td>
<td>47%</td>
<td>27%</td>
<td>99%</td>
<td>58%</td>
<td>99%</td>
<td>92%</td>
<td>41%</td>
<td>43%</td>
<td>27%</td>
</tr>
</tbody>
</table>
While the averages for the two groups were relatively close on the middle scoring questions, there was a large variance between the teachers. In the “map” group, Caldwell had the lowest percentage correct (34%) on the map view question, while Breit had the highest (55%). The question relating hemispheres and location had Neutzling scoring the highest (77%) and Heckathorn scoring the lowest (51%). For latitude and longitude, Caldwell had the highest (66% on both) and Heckathorn had the lowest (25% on both). In the “no map” group, Johnson had the lowest scores on all four questions, with the hemisphere question (29%) being 20% below the next lowest score. The map view (26%) question was 17% below the next lowest score and the latitude and longitude (both 33%) were 10% below. Neutzling had the highest scores at 49%, 64%, 60%, and 53%.

The questions about map scale and map legend were the lowest scoring questions at 27% and 36%. It is important to note that if students said that a legend was a map key, but didn’t explain what that meant, they were marked wrong. The “map” group had a slightly higher percentage (29%) than the “no map” group (26%) for the scale question, but the two were equal for the legend question (36%). Once again the variance in teachers in each group was relatively large for both questions. On the map scale question the “map” group varied from 11% (Heckathorn) to 40% (Caldwell) and the “no map” group varied from 14% (Johnson) to 45% (Neutzling). On the map legend question the “map” group varied from 23% (Heckathorn) to 50% (Caldwell) and the “no map” group varied from 19% (Heckathorn) to 57% (Neutzling).

The local awareness portion of the geographic knowledge section came last. Students were given a map of the US and asked to locate and label Ohio, surrounding
states, the Mississippi River, the Rocky and Appalachian Mountains, Los Angeles, Chicago, New York, and the cardinal directions. They then were given a map of Ohio and had to locate their current location (Stark County), Cleveland, Columbus, Lake Erie, the Ohio River, and the cardinal directions. Each feature except for Los Angeles, Chicago, and New York, which were grouped together, was graded individually and worth one point. Table 4.4. shows the percentage correct for each item.

Table 4.4. Percentage correct for local awareness questions

<table>
<thead>
<tr>
<th></th>
<th>US MAP</th>
<th>OHIO MAP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ohio</td>
<td>Surrounding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>States</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Great Lakes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mississippi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>River</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rocky Mountains</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appalachian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Miss</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LA, Chicago,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cardinal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Directions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Your City/County</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cleveland</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Columbus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lake Erie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ohio River</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cardinal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Directions</td>
</tr>
<tr>
<td>TOTAL</td>
<td>428</td>
<td></td>
</tr>
<tr>
<td>Map</td>
<td>214</td>
<td></td>
</tr>
<tr>
<td>Caldwell</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Neutzling</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Heckathorn</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Breit</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Map</td>
<td>214</td>
<td></td>
</tr>
<tr>
<td>Johnson</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Neutzling</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Heckathorn</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Breit</td>
<td>73</td>
<td></td>
</tr>
</tbody>
</table>

On the US map, 97% of students know where Ohio is located. No one actually put Ohio in the wrong place; people just chose not to answer anything on the map. 79% know the 4 cardinal directions, and while there were some people who didn’t put it on there at all, there were students who mixed up East and West. The Great Lakes come in at 71% and were lower due to also due to students not answering vs. labeling in the
wrong location. The “map” group and the “no map” groups were relatively the same on these three questions, with differences of 4%, 2%, and 3%.

The surrounding states, Mississippi River, both mountain ranges, and the cities were missed due to no answers and incorrect labeling. If students correctly labeled 3 or more of the surrounding states or 2 or more of the cities, they were marked correct. A total of 65% of students were able to identify the surrounding states; and 63% were able to identify the cities. More students knew the Rocky Mountains (58%) than the Appalachian Mountains (48%) or the Mississippi River (53%). More students in the “map” group knew the surrounding states (72%), the locations of the Rocky (60%) and the Appalachian (54%) mountains, and the locations of LA, Chicago, and New York (66%) than the “no map” group (59%, 55%, 43%, 60%). The “no map” group had 54% of students know the location of the Mississippi River and the “map” group was almost the same at 53%.

Once again, like on the written portion, a lot of students in Caldwell and Johnson’s classes did not answer the map section. This again caused noticeable differences from the next lowest percentages on the US Map, especially in better-known labels, such as Ohio (16% Johnson), the surrounding states (11% Caldwell, 38% Johnson), and the Great Lakes (25% Caldwell, 33% Johnson). There were a few labels on the US Map that did have variability of more than 10%, even without Caldwell or Johnson. For the “map” group it was just the cardinal directions, where Heckathorn’s classes had 69%, while the others (Breit and Neutzling) had 80% and 88%. The “no map” group had larger variability on the surrounding states (15%), the Rocky (41%) and
Appalachian (36%) Mountains, the three cities (25%), and the cardinal directions (33%). Heckathorn had the lowest percentages on all of these locations, while Neutzling and Breit took turns with the highest percentage.

On the Ohio map the highest percentage was 75% of students knew where Lake Erie is, followed right behind with 74% knowing the cardinal directions. 60% of students knew where the Ohio River while only 53% knew the location of their city and/or county. The least known were Cleveland (44%) and Columbus (43%). The “map” and “no map” group were relatively the same for Lake Erie, the Ohio River, and Cleveland and Columbus, all with a difference of 3% or less. Both current location and Cardinal directions had a difference of 7% between the “map” group (56%, 77%) and the “no map” group (49%, 70%).

The influences of Caldwell and Johnson’s classes are less obvious on the Ohio map than the US map. In the “map” group Caldwell’s classes have a couple standouts: the current location label where they had 40% and the Ohio River where they had 45%. On both of these questions the other classes were between 59% and 62%. In the “no map” group it is Neutzling’s percentages that stand out for being relatively higher than the other teachers. All of the percentages are above 60%, except for one at 57%, and there is a 94% for Lake Erie – the only percentage above 90% on the Ohio map.
4.2 Pre- and Post-Assessment Comparison

4.2.1 Overall scores

The comparison between overall mean achievement scores from before the implementation of the lessons (“pre-assessment”) and following implementation (“post-assessment”) shows statistically significant increases across all groups (p < .001). Table 4.5 shows mean improvement was 7.30 points among all “map” groups and 6.84 points among all “no map” groups. The difference between these two improvements was not statistically significant. Further analysis shows considerable variability in improvement from teacher to teacher, ranging from just over 5 points (Heckathorn) to over 9 points (Breit). The scores on each of the assessments varied as well; the lowest pre-assessment score (Johnson’s “no map”; 5.46) and highest (Neutzling’s “no map”; 15.42) suggest that the students that participated came into the program with considerable differences in their background. All of the teachers, except Heckathorn, had higher pre-assessment score averages for the “map” group than for the “no map” group. It is not known why Heckathorn’s groups did not perform the same as the rest of the classes.
Table 4.5 Total overall scores on pre- and post-assessment by groups. P-values refer to the statistical significance of the difference between pre- and post-assessment for each group.

<table>
<thead>
<tr>
<th></th>
<th>Pre-assessment</th>
<th>Post-assessment</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n Mean score</td>
<td>n Mean score</td>
<td>Mean</td>
</tr>
<tr>
<td>All “Map”</td>
<td>262 11.86</td>
<td>270 19.16</td>
<td>7.30</td>
</tr>
<tr>
<td>Caldwell</td>
<td>98 9.89</td>
<td>96 17.04</td>
<td>7.15</td>
</tr>
<tr>
<td>Neutzling</td>
<td>59 17.53</td>
<td>66 23.67</td>
<td>6.14</td>
</tr>
<tr>
<td>Heckathorn</td>
<td>57 10.16</td>
<td>62 15.63</td>
<td>5.47</td>
</tr>
<tr>
<td>Breit</td>
<td>48 10.94</td>
<td>46 21.89</td>
<td>10.95</td>
</tr>
<tr>
<td>All “No Map”</td>
<td>250 9.28</td>
<td>261 16.12</td>
<td>6.84</td>
</tr>
<tr>
<td>Johnson</td>
<td>93 5.46</td>
<td>98 11.90</td>
<td>6.44</td>
</tr>
<tr>
<td>Neutzling</td>
<td>45 15.42</td>
<td>49 22.31</td>
<td>6.89</td>
</tr>
<tr>
<td>Heckathorn</td>
<td>41 10.44</td>
<td>43 15.63</td>
<td>5.19</td>
</tr>
<tr>
<td>Breit</td>
<td>71 9.72</td>
<td>71 17.99</td>
<td>8.27</td>
</tr>
</tbody>
</table>

4.2.2 Results on Front-Related Questions

Questions on the assessments were divided into three different concepts and then analyzed. The first group of seven questions relates to concepts regarding warm and cold fronts. Three of these questions (questions 10, 11, and 12) deal with how the weather changes as fronts pass by in a consecutive order: 10 is before a warm front, 11 is after a warm front, and 12 is after a cold front. Both the “map” group and “no map” group showed statistically significant improvement from the pre-assessment to the post-assessment on all three questions, with p-values less than .02 (Table 4.6.). Mean improvements on the three questions for the “map” group were 0.17, 0.28, and 0.34, respectively, while the “no map” group had mean improvements of 0.31, 0.36, and 0.38. Interestingly the “no map” group improved more than the “map group” on all three questions, although the difference in improvement was not statistically significant.
Table 4.6 Score breakdown for front-related questions. P-values refer to the statistical significance of the difference between pre- and post-assessment scores for each group.

<table>
<thead>
<tr>
<th>Question 10: What is the weather like BEFORE a Warm Front?</th>
<th>“Map”</th>
<th>“No Map”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct (2pts)</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td></td>
<td>25.6%</td>
<td>32.6%</td>
</tr>
<tr>
<td>Partially Correct (1pt)</td>
<td>31.3%</td>
<td>33.7%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>43.1%</td>
<td>33.7%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.82</td>
<td>0.99</td>
</tr>
<tr>
<td>P-value</td>
<td>0.02</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 11: What is the weather like AFTER a Warm Front?</th>
<th>“Map”</th>
<th>“No Map”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct (2pts)</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td></td>
<td>17.6%</td>
<td>27.4%</td>
</tr>
<tr>
<td>Partially Correct (1pt)</td>
<td>24.8%</td>
<td>33.0%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>57.6%</td>
<td>39.6%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.6</td>
<td>0.88</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 12: What is the weather like AFTER a Cold Front?</th>
<th>“Map”</th>
<th>“No Map”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct (2pts)</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td></td>
<td>19.8%</td>
<td>31.1%</td>
</tr>
<tr>
<td>Partially Correct (1pt)</td>
<td>35.5%</td>
<td>43.3%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>44.7%</td>
<td>25.6%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.75</td>
<td>1.06</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Questions 14 and 15 require the knowledge of what a cold front and warm front look like on a map. Both groups had statistically significant improvement from pre-assessment to the post-assessment (p < .001, Table 4.7). The mean improvement for questions 14 and 15 are relatively the same for each group. The “map” group improved by 0.37 and 0.36 and the “no map” group improved by 0.39 on both. Further analysis shows that the “map” group’s pre-assessment scores for both questions are within 0.02 of each other. The same can be said about the post-assessment scores. The “no map” group
also has close pre-assessment and post-assessment scores. While the “no map” group did improve more, the difference was only a small amount and not significant.

Table 4.7 Score breakdown for front-related questions. P-values refer to the statistical significance of the difference between pre- and post-assessment scores for each group.

<table>
<thead>
<tr>
<th>Question</th>
<th>“Map”</th>
<th>“No Map”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Question 14: Draw a Cold Front.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct (1pt)</td>
<td>36.3%</td>
<td>72.6%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>63.7%</td>
<td>27.4%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.36</td>
<td>0.73</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Question 15: Draw a Warm Front.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct (1pt)</td>
<td>35.1%</td>
<td>71.1%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>64.9%</td>
<td>28.9%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.35</td>
<td>0.71</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Question 18: At Point B what is the forecast for the next 24 hours?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct (3pts)</td>
<td>2.3%</td>
<td>7.4%</td>
</tr>
<tr>
<td>Mostly Correct (2pts)</td>
<td>17.2%</td>
<td>22.6%</td>
</tr>
<tr>
<td>Partially Correct (1pt)</td>
<td>32.1%</td>
<td>39.3%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>48.5%</td>
<td>30.7%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.73</td>
<td>1.07</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Question 19: At Point C name the front.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct (1pt)</td>
<td>29.0%</td>
<td>63.3%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>71.0%</td>
<td>36.7%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.29</td>
<td>0.63</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td></td>
</tr>
</tbody>
</table>

It is interesting to compare questions 15 (draw a warm front) and 19 (identify a front) because 19 requires students to identify a warm front on the map after just having
to draw one. The “map” group improved relatively the same amount on question 19 with a mean score improvement of 0.34, as compared to 0.36 on question 15. The “no map” group also had almost the same mean score improvement on question 15 (0.39) as on question 19 (0.38). The two questions were alike in that the “no map” group had more improvement than the “map” group, although there are no statistically significant differences in rates of improvement across the groups.

Question 18 required the ability to both identify the front on a map and relate it to weather that should be occurring. The same patterns occur with this question as seen above. Both groups had statistically significant improvements from their pre-assessments to post-assessments (p < .001). The “no map” group had a mean score improvement (0.46) that was larger than the “map” group (0.34), but the difference between these was not statistically significant.

Of all of the front-related questions, questions 14 (draw cold front), 15 (draw warm front), and 19 (identify the front) appear to be the best understood front-related concepts in terms of initial and final correctness. For the three questions, 36%, 35%, and 29% of “map” group respondents were correct in the pre-assessment; for the “no map” group, 26% of respondents were correct for each of the questions. Like a majority of the overall results, all of the front-related questions had the “map” group scoring higher on the pre-assessments than the “no map” group.
4.2.3 Results on Pressure-Related Questions

The second group of questions covers the topics of high pressure and low pressure, assessing students’ understanding both of what they look like on a weather map and their associated weather. There are three questions on high pressure and three on low pressure. In terms of high pressure, question 2 asks students to draw the map symbol for high pressure and label the correct color. All students that received 1 point had the correct symbol but did not include the color, so that category is called “symbol only”. Question 3 follows up by asking students to identify the correct weather that goes along with high pressure. The last high pressure question is question 17 which asks students to identify the weather at a certain location on a provided map. The location has a big “H,” as well as several station plots.

All three questions had statistically significant improvement (p<.001) from the pre-assessments to the post-assessments for both the “map” and the “no map” groups (Table 4.8). These questions are different from the front-related questions in that the “map” group had more improvement on the mean score (0.62, 0.54, and 0.62) than the “no map” group (0.54, 0.39, and 0.51). However, the improvement of the “map” group as compared to the improvement of the “no map” group was not statistically significant. Question 2 (draw a weather map symbol) was different from the overall pattern of the “map” group scoring higher on the pre-assessment than the “no map” group. The “map” group had a lower percentage (6.9%) scoring completely correct than the “no map” group (12.0%). However, once the “symbol only” percentages are added on, question 2 once again fits the pre-assessment pattern: 72.2% of the “map” group at least know that an H
on a weather map means high pressure as compared to 58.8% of the “no map” group. The average scores for the “map” group on the pre-assessment were higher than the “no map” group on question 2 as well as on questions 3 and 17, keeping with the overall trends.

**Table 4.8 Score breakdown for high pressure-related questions.** P-values refer to the statistical significance of the difference between pre- and post-assessment scores for each group.

<table>
<thead>
<tr>
<th>Question 2: What symbol is used for high pressure on a weather map? Include color.</th>
<th>“Map”</th>
<th>“No Map”</th>
<th>Change</th>
<th>Pre</th>
<th>Post</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbol &amp; Color (2pts)</td>
<td>6.9%</td>
<td>43.0%</td>
<td>36.1%</td>
<td>12.0%</td>
<td>34.5%</td>
<td>22.5%</td>
</tr>
<tr>
<td>Symbol Only (1pt)</td>
<td>65.3%</td>
<td>54.8%</td>
<td>-10.5%</td>
<td>46.8%</td>
<td>56.3%</td>
<td>9.5%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>27.9%</td>
<td>2.2%</td>
<td>-25.7%</td>
<td>41.2%</td>
<td>9.2%</td>
<td>-32.0%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.79</td>
<td>1.41</td>
<td>0.62</td>
<td>0.71</td>
<td>1.25</td>
<td>0.54</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 3: Describe the weather associated with high pressure.</th>
<th>“Map”</th>
<th>“No Map”</th>
<th>Change</th>
<th>Pre</th>
<th>Post</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct (3pts)</td>
<td>19.8%</td>
<td>29.6%</td>
<td>9.8%</td>
<td>9.2%</td>
<td>17.6%</td>
<td>8.4%</td>
</tr>
<tr>
<td>Mostly Correct (2pts)</td>
<td>17.6%</td>
<td>31.1%</td>
<td>13.5%</td>
<td>18.4%</td>
<td>23.4%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Partially Correct (1pt)</td>
<td>8.8%</td>
<td>5.9%</td>
<td>-2.9%</td>
<td>4.8%</td>
<td>8.0%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>53.8%</td>
<td>33.3%</td>
<td>-20.5%</td>
<td>67.6%</td>
<td>51.0%</td>
<td>-16.6%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>1.03</td>
<td>1.57</td>
<td>0.54</td>
<td>0.69</td>
<td>1.08</td>
<td>0.39</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 17: What is the current weather at location A?</th>
<th>“Map”</th>
<th>“No Map”</th>
<th>Change</th>
<th>Pre</th>
<th>Post</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct (3pts)</td>
<td>6.6%</td>
<td>18.1%</td>
<td>11.6%</td>
<td>6.0%</td>
<td>17.2%</td>
<td>11.2%</td>
</tr>
<tr>
<td>Mostly Correct (2pts)</td>
<td>15.6%</td>
<td>28.1%</td>
<td>12.5%</td>
<td>12.8%</td>
<td>23.8%</td>
<td>11.0%</td>
</tr>
<tr>
<td>Partially Correct (1pt)</td>
<td>24.0%</td>
<td>25.9%</td>
<td>2.8%</td>
<td>28.8%</td>
<td>23.4%</td>
<td>-5.4%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>53.8%</td>
<td>27.8%</td>
<td>-26.0%</td>
<td>52.4%</td>
<td>35.6%</td>
<td>-16.8%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.75</td>
<td>1.37</td>
<td>0.62</td>
<td>0.72</td>
<td>1.23</td>
<td>0.51</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Questions 3 and 17 both test students on their knowledge of the weather circumstances associated with high pressure and are both out of three points. Even though they covered similar concepts, further analysis shows that neither group improved from pre-assessment to post-assessment at the same amount. The “map” group improved their mean score by 0.54 on question 3 and improved their mean score by 0.62 on question 17. The map group also had more improvement on question 17 (0.51) than they did on question 3 (0.39).

Questions 4, 5, and 13 are all related to low pressure. Question 4 is similar to question 2, except that it asks for the map symbol of low pressure instead of high. Question 5 is similar to question 3, except that it asks the weather associated with low pressure. Question 13 is a multiple choice question where students have to identify the most realistic pressure system – a mid-latitude cyclone.

Both the “map” and the “no map” group had statistically significant improvement from the pre-assessment to the post-assessment (Table 4.9) on question 4 (p<.001) and question 5 (p=.002). The difference between the improvements of the “map” group and the “no map” group was not statistically significant for questions 4 and 5. Both questions followed the trend from previous results of the “map” group having higher pre-assessment scores than the “no map” group.
Table 4.9 Score breakdown for low pressure-related questions. P-values refer to the statistical significance of the difference between pre- and post-assessment scores for each group.

<table>
<thead>
<tr>
<th>Question</th>
<th>“Map”</th>
<th>“No Map”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Question 4: What symbol is used for low pressure on a weather map?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Include color.</td>
<td>Correct (2pts)</td>
<td>6.9%</td>
</tr>
<tr>
<td></td>
<td>Partially Correct (1pt)</td>
<td>65.6%</td>
</tr>
<tr>
<td></td>
<td>Incorrect (0pt)</td>
<td>27.5%</td>
</tr>
<tr>
<td></td>
<td>Mean Score</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Question 5: Describe the weather associated with low pressure.</td>
<td>Correct (3pts)</td>
<td>18.3%</td>
</tr>
<tr>
<td></td>
<td>Mostly Correct (2pts)</td>
<td>28.6%</td>
</tr>
<tr>
<td></td>
<td>Partially Correct (1pt)</td>
<td>21.4%</td>
</tr>
<tr>
<td></td>
<td>Incorrect (0pt)</td>
<td>31.7%</td>
</tr>
<tr>
<td></td>
<td>Mean Score</td>
<td>1.34</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>0.002</td>
</tr>
<tr>
<td>Question 13: Choose the most realistic pressure system.</td>
<td>Correct (1pt)</td>
<td>28.2%</td>
</tr>
<tr>
<td></td>
<td>Incorrect (0pt)</td>
<td>71.8%</td>
</tr>
<tr>
<td></td>
<td>Mean Score</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Question 13 (realistic pressure system) strays from the patterns of other questions. The “map” group has statistically significant improvement on question 13 (p<.001), however the “no map” group was just near statistical significance (p = .11). The concept of what a pressure system looks like appears to be the least understood by either group – both before and after. It has the lowest pre-assessment scores for both groups, with the “map group” having a mean score of 0.28 and the “no map” group at 0.24. The lowest post-assessment mean scores also occurred on this question at 0.45 for the “map” group
and 0.31 for the “no map” group. While the improvement of the “map” group was statistically significantly better than the “no map” group ($p = .06$), the improvement amounts for both groups were still the lowest of all pressure questions.

Further analysis comparing question 2 (draw a high pressure symbol) and question 4 (draw a low pressure system) shows similarities between the two data sets, implying that both concepts were similarly understood. For both questions, the “map” group and the “no map” group showed statistically significant improvement ($p < .001$) between the pre- and post-assessments. The “map” group improved their mean score 0.62 on question 2 and by 0.60 on question 4. The “no map” group improved their mean score 0.54 on question 2 and 0.53 on question 4. For neither question was there statistical significance in the difference in improvement between the “map” group and the “no map” group.

Questions 3 (weather associated with high pressure) and Question 5 (weather associated with low pressure) are related questions like questions 2 and 4 are related. However, questions 3 and 5 do not have the same patterns in results that 2 and 4 have. The “map” group had a mean score improvement of 0.51 on question 3 as compared to a mean score improvement of 0.29. However, the “map” group also started out with less previous knowledge of high pressure weather (mean score 1.03) than on low pressure weather (mean score 1.34). The “no map” group also seemed to have a similar understanding of high pressure with a higher mean improvement on question 3 (0.39), while also having a lower pre-assessment score (1.08).
4.2.4 Results on Wind and Movement-Related Questions.

The last group of questions focuses on the movement of weather systems and wind. Question 1 is a multiple-choice question asking what general direction weather moves. Questions 6 and 7 ask about isobars and wind patterns associated with them. Questions 7 and 8 ask students about wind flow around low and high pressure. All of the questions had statistically significant improvement from the pre-assessment to the post assessment (Table 4.10) in both the “map” (p < .002) and “no map” (p<.002) groups. They also all followed the previously mentioned pattern of the “map” group starting out with higher pre-assessment scores than the “no map” group.

Questions 1, 8, and 9 appeared to be the best understood concepts for the entire test in both groups, having the highest percentages score full points. The “map” group had post-assessment scores ranging from 70.7% to 73.7%, with the highest percentage belonging to question 1 (weather system movement). The “no map” group had post-assessment scores ranging from 61.7% to 68.6%, also with question 1 having the highest percentage. While both the “map” and “no map” groups statistically significantly improved on all three questions, for none of these questions was there a statistically significant difference in improvement between the “map” and “no map” groups.
Table 4.10 Score breakdown for low wind and movement-related questions. P-values refer to the statistical significance of the difference between pre- and post-assessment scores for each group.

<table>
<thead>
<tr>
<th>Question</th>
<th>“Map”</th>
<th>“No Map”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Correct (1pt)</td>
<td>61.5%</td>
<td>73.7%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>38.5%</td>
<td>26.3%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.61</td>
<td>0.74</td>
</tr>
<tr>
<td>P-value</td>
<td>0.002</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 6: What do isobars represent? Draw an example.</th>
<th>“Map”</th>
<th>“No Map”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Correct (6 pts)</td>
<td>1.1%</td>
<td>6.7%</td>
</tr>
<tr>
<td>Correct (5 pts)</td>
<td>1.5%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Correct (4 pts)</td>
<td>5.3%</td>
<td>8.9%</td>
</tr>
<tr>
<td>Correct (3 pts)</td>
<td>8.8%</td>
<td>18.5%</td>
</tr>
<tr>
<td>Correct (2 pts)</td>
<td>11.8%</td>
<td>27.8%</td>
</tr>
<tr>
<td>Correct (1 pt)</td>
<td>8.8%</td>
<td>20.7%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>62.6%</td>
<td>14.4%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.95</td>
<td>2.22</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 7: If isobars are close together what does that tell you? Far apart?</th>
<th>“Map”</th>
<th>“No Map”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correct (3pts)</td>
<td>Mostly Correct (2pts)</td>
</tr>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Correct (3pts)</td>
<td>3.1%</td>
<td>15.9%</td>
</tr>
<tr>
<td>Mostly Correct (2pts)</td>
<td>5.0%</td>
<td>10.7%</td>
</tr>
<tr>
<td>Partially Correct (1pt)</td>
<td>11.8%</td>
<td>21.9%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>80.2%</td>
<td>51.5%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.31</td>
<td>0.91</td>
</tr>
<tr>
<td>Significance of Change</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
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</table>

<table>
<thead>
<tr>
<th>Question 8: Does wind flow into or away from low pressure?</th>
<th>“Map”</th>
<th>“No Map”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correct (1pt)</td>
<td>Incorrect (0pt)</td>
</tr>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Correct (1pt)</td>
<td>55.0%</td>
<td>71.1%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>45.0%</td>
<td>28.9%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.55</td>
<td>0.71</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 9: Does wind flow into or away from high pressure?</th>
<th>“Map”</th>
<th>“No Map”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correct (1pt)</td>
<td>Incorrect (0pt)</td>
</tr>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Correct (1pt)</td>
<td>54.2%</td>
<td>70.7%</td>
</tr>
<tr>
<td>Incorrect (0pt)</td>
<td>45.8%</td>
<td>29.3%</td>
</tr>
<tr>
<td>Mean Score</td>
<td>0.54</td>
<td>0.71</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;.001</td>
<td>0.002</td>
</tr>
</tbody>
</table>
Questions 6 (what are isobars/draw an example) and 7 (tight and spaced out isobars) appear to be the least understood concepts coming into the pre-assessment. For question 6, 62.6% of the “map” group and 75.2% of the “no map” group received zero points for the question. 80.2% of the “map” group and 83.6% of the “no map” group received zero points for question 7. Questions 6 and 7 also saw the largest improvements between pre-assessments and post-assessments of the entire test. For question 6 both groups had statistically significant improvements (p<.001), the “map” group increasing 1.27, and the “no map” group improving 1.04. The difference between the “map” group’s improvement and the “no map” group’s improvement was not statistically significant, but it was the second largest of any of the questions at 0.23. Question 7 did have a statistically significant difference (p=.009) between the “map” group’s improvement (0.60) and the “no map” group’s improvement (0.31).

4.3 Teacher Feedback

The responses from the five participating teachers give a hint to how the actual application of the research went in the classroom, as well as how the classroom environments differed. Mr. Caldwell and Mrs. Johnson filled out their questionnaires individually, while the North Canton Middle School teachers – Mrs. Neutzling, Mrs. Heckathorn, and Mr. Breit – filled out their survey together. The range of experience teaching weather ranged from this being the first year (Johnson and Heckathorn) to 4 years (Breit and Neutzling). All of the teachers thought that the website was user friendly and helpful. There were only problems with using real-time data when the website or
server was down, something that all teachers mentioned. Mrs. Johnson could not really comment on the usage of maps in the classroom, but the whole process had made her consider using them in the future. She did report that the general interest in weather seemed at the “medium interest level”, but didn’t “know if it would have changed by implementing [a] daily weather discussion”.

Mr. Caldwell, who had all classes of “map” group, had questions similar to the North Canton Middle School (NCMS) teachers that taught both “map” and “no map” groups. However, most of Mr. Caldwell’s answers varied from those of NCMS. He was able to squeeze in the daily weather discussions and did not make any changes to his curriculum due to the discussions. Mr. Caldwell had a positive outlook of the influence on his teaching saying it “kept [him] up to date”. The three teachers at NCMS felt less positive about the daily weather discussions, saying they “influenced time the most”, causing the teachers to feel rushed to complete the daily discussions and the curriculum before the end of the year. The teachers from NCMS did feel “forced…to incorporate the use of maps/real world experiences” and used the maps “as teachable moments to try and fit in our concepts”. The NCMS teachers were also asked how their approach to teaching varied between the two groups. Besides time, they mentioned that the map group received the “application of real world real time weather” to create predictions as opposed to “textbook generated maps”.

Both Mr. Caldwell and the North Canton Middle School teachers were also asked about student interest, with somewhat contrasting answers. Mr. Caldwell, comparing his “map” groups to weather classes he had taught in the past, felt that the maps kept his
students more interested, and specifically mentioned that his “students were asking more intelligent questions”. The NCMS teachers were asked about the difference in interest between their “map” groups and “no map” groups and said that there was “none really”. They mentioned that the “map” group became bored of filling out the discussion sheet and map “too many times in a row”, however they did enjoy the actual discussion.

Unfortunately, the curriculum has changed at Lehman Middle School so that the 6th grade has the weather unit and not the 7th grade. Neither Mr. Caldwell nor Mrs. Johnson will have a current opportunity to apply current weather maps and weather discussions in their classrooms. Mrs. Johnson did mention that she would like to learn more about the usage of current weather map discussions in the classroom for the future. The North Canton Middle School teachers said they believed they would use current weather map discussions in the future, but more as group work and “less on student recording”. The discussions would also be more “based on time available” than on doing them everyday.
CHAPTER 5: DISCUSSION

The goal of this thesis is to evaluate the use of current surface weather map discussions as an aid to students’ learning and understanding of weather fundamentals. This chapter discusses findings of the study in order to assess the impact of maps in the classroom and to look at the limitations faced when doing this type of research in the classroom.

5.1 Overall assessment results

Both the “map” group and the “no map” group showed significant improvement from the pre-assessment mean score to the post-assessment mean score. The expectation was that while both groups would improve, the map group would improve significantly more. The “map” group did improve more than the “no map” group, but not significantly enough to say definitively that using weather maps in the classroom improves students’ broad understanding of weather. It is important to note, however, that the “map” group scored higher on the pre-assessment for almost every question, perhaps limiting the amount that they could improve as compared to the “no map” group. Further analysis of the results and limitations of the research shows that there are other factors that led to such a small difference between the “map” group and “no map” group. A definite conclusion cannot be made as to whether current weather maps in the classroom make a significant difference, and thus further research is required.
Background surveys were done to help determine if one group might have more interest and/or exposure to weather information that would influence their scores. The results from the interest portion of the background survey showed that both groups had relatively the same amount of interest in weather, with 70% of the “map” and 75% of the “no map” group being somewhat interested in weather and 4% of both groups being very interested in weather. Neither group had the advantage of demonstrating a lot more interest than the other, thus eliminating the possibility that “interest” boosted assessment mean scores.

Exposure was also evaluated via the background surveys, due to the fact that while students themselves might not be interested in weather, parents might be interested, thus increasing exposure within the family unit. Exposure to maps, in particular, was also important to assess because according to Michaelidou et al. (2004), the key to students performing better and understanding maps is through greater exposure. Students with more exposure to weather maps via the television, internet or newspaper should have better map skills and therefore have the advantage on assessment questions relating weather concepts and weather maps. Overall exposure to weather on television, on the internet, in the newspaper, as well as weather discussions outside the classroom showed that both the “map” and “no map” group were relatively similar. Comparing what students said they were looking at (radar, satellite, surface maps, and forecast maps) showed that both groups were getting relatively the same amount of map exposure as well. The lack of difference in overall exposure implies that the amount of exposure did not give either group an advantage in overall assessment scores.
Weather maps on the television and internet also give students exposure to “real world” experiences, which help to enhance students’ visual and spatial skills (Young, 1993, Lowrie and Smith, 2003, Mackintosh, 2005). Weather has been seen as a spatial problem since 1816 when weather was first put into map format (Monmonier, 1999). A geographic knowledge section was added to the background survey to determine the general spatial skills of middle school students to determine “where the children are at” for constructivist research (Mackintosh, 2005). It was also done to determine if one group might have more students with higher spatial skills, and therefore an advantage at learning weather concepts. The “map” group scored less than a point above the “no map” group on the overall geographic knowledge section. Breaking down the scores into written knowledge and local awareness yielded the same results; the “map” group had a higher score, but the “no map” group was within a point. Neither group stood out as having exceptional spatial skills.

While the background survey was informative, it did nothing to suggest why the “map” group and “no map” group had close to the same improvement rate on the assessments. The teachers who participated were sent follow-up questionnaires to get information on the research process being used. North Canton teachers mentioned that their teaching varied between the groups in that the “map” group used real time weather maps, as opposed to the “no map” group using text book generated maps, to create predictions. Little detail was given from Lehman teachers, so it is not known if the “no map” group had exposure to maps or not.
Not only did the feedback show variability in how real-time maps were incorporated in the classroom, but also in teaching styles. This is important because in the education field it is commonly accepted that one of the most important variables in a child’s learning is the teacher, (V. Myers, pers. comm.) North Canton teachers appeared to put as much emphasis on the recording as on the discussion, creating a less inquiry-based environment. They did say that they tried to use the map information as teachable moments to fit in the concepts as much as possible, but the general feeling of the questionnaire is that it created more difficulty than ease in teaching. Mr. Caldwell on the other hand felt like the maps helped his teaching, commenting that it kept him up to date.

Test scores are not the only way to determine if current weather maps help students learn: evaluating if/how the learning environment was affected can also demonstrate the impact of using current weather maps. The learning environment plays an important part in student learning, especially in the role of inquiry (Hassard, 2005). The teacher questionnaires were designed to determine if using current weather map discussions had influences on the learning environment and students’ thinking processes. These responses varied as well. Mr. Caldwell mentioned that he noticed a higher level of interest and students asking more intelligent questions. On the other hand, all three teachers at North Canton Middle School mentioned that their students became bored with the map work and repetitive labeling, although they did not mind the discussion. Through the feedback from the teachers and looking at how mean total scores varied from teacher to teacher (examined in more detail later), differences in teaching styles and
classroom environment become a logical explanation for why no definite conclusion can be made from the assessment results.

5.2 Specific Concepts Within the Assessment

While assessing only total assessment score improvement did not yield results that were noteworthy, looking at the questions individually did. The “map” group improved more than the “no map” group on half of the questions, with two of those improvements being statistically significant. The “no map” group had no improvements over the “map” group that were statistically significant. When looking at the questions based on the mean differences in improvement, content themes start to emerge (Table 5.1).

Table 5.1 Differences between the mean improvements of the two groups. Numbers highlighted in bold are statistically significant.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean Difference (Map - No Map)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7: If isobars are close together what does that tell you? Far apart?</td>
<td>0.29</td>
</tr>
<tr>
<td>6: What do isobars represent? Draw an example.</td>
<td>0.23</td>
</tr>
<tr>
<td>3: Describe the weather associated with high pressure.</td>
<td>0.15</td>
</tr>
<tr>
<td>17: What is the current weather at Point A?</td>
<td>0.11</td>
</tr>
<tr>
<td>13: Choose the most realistic pressure system.</td>
<td>0.10</td>
</tr>
<tr>
<td>2: What symbol is used for high pressure on a weather map? Include color.</td>
<td>0.08</td>
</tr>
<tr>
<td>4: What symbol is used for low pressure on a weather map? Include color.</td>
<td>0.07</td>
</tr>
<tr>
<td>9: Does wind flow into or away from high pressure?</td>
<td>0.03</td>
</tr>
<tr>
<td>8: Does wind flow into or away from low pressure?</td>
<td>0.01</td>
</tr>
<tr>
<td>14: Draw a cold front.</td>
<td>-0.02</td>
</tr>
<tr>
<td>15: Draw a warm front.</td>
<td>-0.03</td>
</tr>
<tr>
<td>1: What direction does the weather move?</td>
<td>-0.03</td>
</tr>
<tr>
<td>12: What is the weather like AFTER a cold front?</td>
<td>-0.04</td>
</tr>
<tr>
<td>19: At point C name the front.</td>
<td>-0.04</td>
</tr>
<tr>
<td>5: Describe the weather associated with low pressure.</td>
<td>-0.05</td>
</tr>
<tr>
<td>11: What is the weather like AFTER a warm front?</td>
<td>-0.08</td>
</tr>
<tr>
<td>18: At Point B, what is the forecast for the next 24 hours?</td>
<td>-0.12</td>
</tr>
<tr>
<td>10: What is the weather like BEFORE a warm front?</td>
<td>-0.14</td>
</tr>
</tbody>
</table>
The “map” group improved more than the “no map” group by a difference of 0.1 or more on 5 questions, but only two were statistically significant. The “map” group made the largest improvements of either group on the questions about isobars especially on the wind patterns, which was one of the statistically significant differences. This makes sense as isobars are very much a visual and spatial concept. Exposure on a daily basis to maps with isobars should have given the “map” group more of an “experience of a subject” (Mackintosh, 2005) and allowed them to “visualize and manipulate the isobars in real contexts” (Lowrie & Smith, 2003). The students would have been able to “embed themselves in the situation”, which may have helped students to use their spatial skills as well as their weather knowledge (Lowrie and Logan, 2007). This fits with Piaget’s theory that many early adolescent students better understand abstract concepts when given concrete examples, that is, they function as concrete operational thinkers (Santrock, 2003).

The second question for which the difference in improvement was statistically significant was where students had to correctly identify a “realistic pressure system”, i.e. a mid-latitude cyclone. It is possible that repetitively seeing high pressure alone and low pressure with fronts helped students to realize that fronts do not attach to high pressure. While there would be some odd looking pressure systems on a “real time” map, there would never be a high pressure system with fronts. By being exposed to the realistic contexts in a concrete, visual display, the “map” group would have learned “real-life problem solving” and how to evaluate relevant and irrelevant information (Young, 1993).
While there were no questions where the “no map” group improved statistically significantly more than the “map” group, it is important to note that they did occur. Future studies should consider the possibility that there may be some uses of weather maps in the classroom that may actually confuse students. Knowing that current weather maps may help the learning of some concepts while hurting others would be useful for teachers when having to plan for and teach various standards, benchmarks, and indicators. When using current weather maps teachers should be able to understand that “textbook” weather cases are the best-case scenario and emphasize the difference between the real world situation and the textbook to the students. The lesson teachers should take away is that a combination of inquiry and lecture may help students best understand weather fundamentals.

5.3 Limitations

The first and most obvious limitation, and one that can not be controlled, is the weather. The standards, benchmarks, and indicators geared toward middle school students deal with weather fundamentals, which do not account for the unpredictability or the complexity of day-to-day weather. Using current weather maps in the classroom can bring up situations that do not fit the “textbook example” that students are learning. While students would be observing that weather maps are dynamic and represent weather in more than one way (Lowrie and Logan, 2007), they might not yet have developed “real-life problem solving skills” required to deal with the data (Young, 1993). This would then create even more subject matter for a teacher to communicate on an already
tight schedule. Also, students may not even have developed into Piaget’s *formal operational thinker* stage yet, which would hurt their ability to even think at an abstract level (Santrock, 2003) and discern the difference between “textbook example” and “real world example”. Additionally, using current weather maps may introduce more complicated concepts beyond both the students’ and teachers’ understanding.

In some cases, current weather can be changed from a limitation to an inquiry opportunity by following the National Research Council’s five essential features (*Inquiry and the National Science Education Standards*, 2005). A weather event that does not fit what the students know can be turned into a chance to ask scientifically oriented questions. From there students can look for evidence and formulate their own explanations. These explanations can then be presented and evaluated in group discussions, which can lead to even more new learning opportunities. Through this process the student becomes “a seeker of information and a problem solver” (Hassard, 2005, p. 237). However, inquiry can only go so far if the situation is beyond the teacher’s understanding of meteorology. Since most middle school teachers do not have a strong background in meteorology, most are less likely to be able to explain certain real world situations, and therefore inquiry is limited in the classroom.

In this study there was large variability in pre- and post-assessment scores within each group. For example, on the pre-assessment in the “map” group Caldwell had the lowest mean score at 9.89 while Neutzling had the highest at 17.53. At the same time, the “no map” group ranged from Johnson having a mean score of 5.46 to Neutzling again having the highest at 15.42. The improvements stood out as well. The “map” group
ranged from Heckathorn with an improvement of 5.47 to Breit with an improvement of 10.95. These two teachers also had the lowest and highest in the “no map” group (5.19, 8.27). The large variability influenced the group mean scores and improvements and ultimately the outcome of the study. The variability could be explained by the limitations of distribution of students, different teaching styles and abilities, curriculum, and overall classroom environment.

On almost every question the “map” group had a higher pre-assessment score than the “no map” group, implying that the “map” group had more weather knowledge coming into the assessment than the “no map” group. There is nothing in the data from either the background survey or the assessment scores to explain why the “map” group came in knowing more. The most likely explanation is the luck of the draw in students and a possible unequal distribution of student abilities.

While the study had a fairly large number of participants, they were not randomly placed in the different “groups”. It is very possible that the “map” group may have had overall higher academic abilities. Of course in the education field it is almost impossible to randomly place students in different groups, but there are other ways to address the student characteristics. A future study might address the issue of differences related to students’ abilities by creating a measure of academic achievement, such as proficiency scores in science. The decision of which class would receive which treatment would be made by comparing the scores and attempting to put similar classes into each treatment group. For example, one could rank the classes by achievement and then split the two highest into “map” and “no map” followed by the next two highest, and so forth.
As stated earlier, one of the most important variables of a student’s learning is the teacher. Vygotsky’s claim that cognitive skills originate in social relations helps support this (Santrock, 2003). Different teachers were used for both groups, which helped create variability in what students learned, hence some of the variability in scores. Two teaching abilities are particularly important to this study and constructivist research in general – the teacher’s knowledge of the subject matter and the teacher’s ability to assess “where students are at” and take them beyond (Santrock, 2003).

The more “expert” a teacher is at a particular subject, in this case meteorology, the better he/she can “scaffold” the instruction to meet the students’ needs. In terms of Vygotsky’s zone of proximal development (ZPD), the teacher is better able take a student from a task that is too difficult to master on his/her own to a level where she/he can begin to understand or begin to perform a task with the instructor (Santrock, 2003). The teacher knows what supports need to be “built” to help students better understand. It was Heckathorn and Johnson’s first year teaching weather, while Caldwell, Breit, and Neutzling had all been teaching weather for several years, creating variability in the “expert” category. However, all of the teachers were learning about how to use maps, becoming better experts and giving them a better understanding what knowledge students needed to grasp concepts.

Vygotsky saw students as “cognitive apprentices” and the teachers as “experts”, making the teacher’s ability to assess when students are “getting it” and when they are not very important (Santrock, 2003). To teach effectively, a teacher needs to know when a student does not understand a concept (e.g., looks on faces, responses to questions) or
sees the concept in an alternative framework, so the teacher knows at what level to begin
the concept (Mackintosh, 2005). At the same time the teacher also needs to know how to
give hints and feedback to take the student to the next step of understanding. The
teachers were not observed during the research period so there is no way to say who had
or did not have this ability, but either way it still plays a role in both the “map” group and
the “no map” group.

The teacher feedback surveys are the only source for specific clues about how the
teaching approach varied. Johnson and Caldwell started the data collection at the
beginning of the spring semester and had no problem squeezing everything in, allowing
for more of a relaxed attitude. Heckathorn, Breit, and Neutzling were collecting data at
the end of the semester and felt rushed to complete everything, creating more of a
stressed and rushed atmosphere. The results from Johnson and Caldwell each doing all
of one group first gave the hint of teaching styles being a confounder, so the next school
was changed to teachers teaching both groups. The hope was that having teachers teach
both the “map” group and the “no map” would help eliminate influence of teaching
styles. It did help some. Breit had the greatest improvement in scores from pre-
assessment to post-assessment, whether “map” or ‘no map”, and Heckathorn had the
smallest improvement in scores, whether “map” or “no map”. However there was still
variability in scores from Breit to Heckathorn, with Neutzling in the middle, suggesting
that teacher effectiveness and the abilities mentioned above may be a greater variable
than the maps.
This study does show that teacher effectiveness should not be ignored in future studies, but rather taken into important consideration. The limitation could be addressed by having one teacher teach both a “map” and “no map” group and then replicate the process over several years. If multiple teachers are used, the limitation can be addressed by developing an observation instrument to measure teachers’ abilities to scaffold instruction and by giving participating teachers more instruction on how to better conduct the weather discussion and better connect the discussion to weather concepts mentioned in the standards, benchmarks, and indicators.

Teaching styles are going to influence how the curriculum is applied and curriculum is going to influence teaching styles. Lehman Middle School (Johnson and Caldwell) used a completely different curriculum from North Canton Middle School (Neutzling, Heckathorn, and Breit). Lehman used Full Option System Science (FOSS), which is a curriculum program designed to be inquiry-based and start with the basics (density, water cycle, etc) and build up to the large weather concepts (air pressure, fronts, maps, etc). The FOSS kit includes all the needed materials and is designed to take nine weeks or more. Caldwell and Johnson conducted the research during the last two units of the program, after students had been learning about and following weather for a while. North Canton used a weather textbook from Prentice Hall that was supplemented by their own notes and activities that had been gathered from other resources. The only curriculum that could be controlled between the two groups was the actual weather discussion sheet, and even how that was taught could not be entirely controlled. North
Canton mentioned in their questionnaire that they not only used the weather map provided, but also other maps on the Weather Channel Website.

In this study, assessment may also have been affected by outside sources brought into the classroom. For example, it was discovered after both assessments had been taken that both Johnson and Caldwell have interactive maps that portray high pressure and low pressure with the incorrect colors; high pressure as red and low pressure as blue. Though neither teacher used this map during the assessment time frame, both had used them earlier in the year. Ms. Johnson mentioned that it was her students who pointed out the mistake, suggesting that it might not have influenced the assessment answers.

The limitations on this research hindered a final answer on whether or not current surface weather maps make a difference on overall understanding of weather concepts. However, it did provide new insight into how students learn and understand weather and brought to light the importance of the role of teacher effectiveness. It also provided ideas of ways to evaluate students’ learning for the future. When dealing with curriculum and testing it is important to make sure there is enough difference between the two groups to yield results. At the same time it is important to avoid disenfranchisement of the learners. Students in the “no map” group cannot be denied the chance to learn about weather maps, especially because there is a specific indicator saying that students must be able to read weather maps (ODE, 2005). In the future, the weather discussions should be designed more to highlight “real time” and time-lapse aspects and the entire project designed to take into account that it is not truly “map” versus “no-map” but rather “real-time” and “repetitious” versus a “snapshot” of a best-case scenario.
CHAPTER 6: CONCLUSION

The effectiveness of incorporating current surface weather map discussions in the classroom was evaluated in this thesis to determine if they help students learn and understand weather fundamentals. A total of 531 seventh-grade students and 5 teachers from 2 schools in Stark County, Ohio participated in the study, separated into “map” and “no map” groups. The students in the “map” group received the standard textbook curriculum plus daily exposure to current weather map discussions. The students in the “no map” group only received the standard textbook curriculum.

The “map” group had statistically significant improvement from the pre-assessment to the post-assessment for the total score and all of the individual questions. The “no map” group also had statistically significant improvement from the pre-assessment to the post-assessment for the total score and all but one of the individual questions. However, the improvement of the “map” group was not statistically significantly greater than the improvement of the “no map” group. Thus, these results do not suggest that the overall use of current weather maps in the classroom make a definitive positive impact on total understanding. However, when the assessments were broken down by individual questions, an impact was seen.

There were individual questions where the “map” group had much more improvement than the “no map” group, with several being statistically significant. Interestingly, there were also questions where the “no map” group improved more than
the “no map” group. However, for none of those questions were the differences statistically significant. Based on the findings from individual questions, current weather map discussions seem to help students better understand isobars and the associated wind patterns, weather related to high pressure, and recognition of mid-latitude cyclones. Although the findings were not statistically significant, students may better understand the weather associated with the passing of fronts without current weather map discussions, perhaps due to the fact that day-to-day weather maps do not always represent “textbook” scenarios.

Findings from this study advanced understanding of how students comprehend weather and provided insight on how to proceed in future studies. Future research should continue to gather data about how current weather map discussions affect students’ learning and understanding. These studies should be more inquiry-based, possibly with more focus on discussions and small groups and less emphasis on filling out worksheets. In addition, future studies could also focus on long-term retention of meteorological concepts by carrying out additional delayed post-assessments to see if students using maps retain their understanding longer than those not using maps. Future studies could also make changes to the “map” versus “no map” design. Instead of doing “map” versus “no map”, a greater emphasis should be placed on “real-time repetitious maps” versus a “snapshot” (best-case scenario) map from a textbook. This would create a greater contrast between the two groups without disenfranchising students.

An important conclusion to this study is that the development of science standards needs to reflect appropriate understanding of students’ cognitive development. Based on
Piaget’s stages of cognitive development (Santrock, 2003), many seventh grade students are still operating out of a concrete operational approach to learning, meaning they learn best when exposed to teaching methods that include concrete or semi-concrete approaches. The findings from this study demonstrated that students could comprehend the relationship between air pressure and the presence of wind when given visual representations in the form of isobars. Additionally, students comprehended the relationship between low pressure and fronts when selecting the correct representation of a mid-latitude cyclone. These findings suggest that science standards for junior high-aged students should reflect concepts and activities that include more concrete examples of abstract meteorological concepts.

Meteorological outreach would benefit from increased dialogue between the meteorology and education communities. Both communities need to work together to promote and conduct more research in understanding how students learn weather concepts. The educational community needs to understand that meteorology ultimately contains many abstract concepts. One solution is for meteorologists to interact with and educate teachers, so that they increase their comprehension of the abstract concepts within the field of meteorology. Only by understanding the correct abstract concepts can teachers create the concrete models that allow students to learn. At the same time, teachers can help meteorologists better understand learning theory. Once meteorologists better understand the cognitive development and methods and styles of student learning, they will be better prepared to help teachers create the types of models and activities that
make for effective student learning. With these types of collaboration, the effectiveness of meteorological outreach will be greatly increased.
WORKS CITED


What is FOSS? Retrieved August, 2006 from

APPENDIX A

DISCUSSION SHEET
FIGURE A.1: Discussion Sheet used in all “Map” Group Classrooms

CURRENT WEATHER DISCUSSION SHEET

Name: ___________________
Date: ___________________

Draw the following from the Teacher’s current map and the map from the previous day:

<table>
<thead>
<tr>
<th>X – Where Low pressure was yesterday</th>
<th>L – Current Low Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z – Where High pressure was yesterday</td>
<td>H – Current High Pressure</td>
</tr>
<tr>
<td>Current Cold/Warm Front location(s)</td>
<td>Connect Yesterday &amp; Current pressure systems with an arrow</td>
</tr>
</tbody>
</table>

Shade in areas of precipitation

DISCUSSION QUESTIONS:
1) Where have the high and low pressure systems moved since yesterday? How does this compare with what you predicted?
2) Where do you think they will move tomorrow?
3) Where are the winds the strongest? (isobars closest together)
4) Where are the winds the weakest? (isobars furthest apart)
5) Where are the warmest temperatures? How does this compare to yesterday?
6) Where are the coldest temperatures? How does this compare to yesterday?
7) Focus on Ohio: What is the current weather today in our area? How has that changed from yesterday?
8) Focus on Ohio: What is your prediction for tomorrow?
9) Are there any other areas that are “big weather stories”?

Focus on Ohio: What is the current weather today in our area? How has that changed from yesterday?
APPENDIX B

BACKGROUND SURVEY
FIGURE B.1: Background Survey given to Lehman Middle School Classes

Background & General Map Knowledge Survey

1) How often do you watch the Weather Channel?
   1. Never
   2. 1 day/week
   3. 2-4 days/week
   4. 5-7 days/week

2) How often do you watch the weather on your local news station?
   1. Never
   2. 1-3 times/week
   3. 5-7 times/week
   4. More than 7 times/week

3) How often do you look at weather online?
   1. Never
   2. 1-5 times/week
   3. 5-10 times/week
   4. More than 10 times/week

4) What weather website do you use the most?

5) When you look at the weather online, what sorts of things do you look at? (Check all that apply)
   - Local Radar
   - Local Satellite
   - National Radar
   - National Satellite
   - Current Weather Conditions
   - Surface Weather Map
   - Forecast for your location
   - Forecast Weather Map
   - Other

6) How often do you look at weather in the newspaper?
   1. Never
   2. 1-5 times/week
   3. 5-10 times/week
   4. More than 10 times/week
7) What weather do you look at in the paper? (Check all that apply)

- [ ] Current Weather Conditions (or “Real Feel”)
- [ ] Surface Weather Map
- [ ] 5-Day forecast for your location
- [ ] Forecast Weather Map (Regional or National)
- [ ] Almanac
- [ ] Weather History/Trivia
- [ ] Lake Erie
- [ ] Regional/National/World Temperatures
- [ ] UV/Air Quality Index
- [ ] Other

8) How often do you talk about the weather with anyone else outside of school?
   1. Never
   2. 1-5 times/week
   3. 5-10 times/week
   4. More than 10 times/week

9) What do you discuss relating to the weather?

- [ ] Current Weather Conditions
- [ ] Weather maps
- [ ] Forecast for Next Day
- [ ] Forecast for the next week
- [ ] What to Wear
- [ ] Severe Weather
- [ ] Weather on television
- [ ] Science behind the weather

10) On a scale of 1 to 5, how interested in weather are you?
    1. Very disinterested
    2. Not interested
    3. No opinion
    4. Interested
    5. Very interested

11) What interests you the most about weather?
GEOGRAPHIC KNOWLEDGE

Basic Map Questions

1) What is the point of having maps?

2) What view does a map provide?

3) What does map scale refer to?

4) Are we in the Northern Hemisphere or the Southern Hemisphere?

5) What does the hemisphere we’re in tell you about our location?

6) What is the reason for having a compass on a map?

7) What are the four cardinal directions?

8) What is latitude?

9) What is longitude?
10) What is a legend and why is it on a map?

**Map of US**
1) Locate and label the general area of the following things on your map of the U.S.:
   a. Ohio
   b. The 5 states surrounding Ohio
   c. The Great Lakes
   d. Mississippi River
   e. Rocky Mountains
   f. Appalachian Mountains
   g. Los Angeles, Chicago, New York
   h. The 4 Cardinal Directions

**Map of Ohio**
1) Locate and label the general area of the following things on your map of Ohio:
   a. Your city or township
   b. Cleveland
   c. Columbus
   d. Lake Erie
   e. Ohio River
   f. The 4 Cardinal Directions
FIGURE B.2: Background Survey given to North Canton Middle School Classes

Background & General Map Knowledge Survey

1) How often do you watch the Weather Channel?
   1. Never
   2. 1-3 times/week
   3. 5-7 times/week
   4. More than 7 times/week

2) How often do you watch the weather on your local news station?
   a. Never
   b. 1-3 times/week
   c. 5-7 times/week
   d. More than 7 times/week

3) How often do you look at weather online?
   a. Never
   b. 1-3 times/week
   c. 5-7 times/week
   d. More than 7 times/week

4) What weather website do you use the most?

5) When you look at the weather online, what sorts of things do you look at? (Check all that apply)

   ____ Local Radar
   ____ Local Satellite
   ____ National Radar
   ____ National Satellite
   ____ Current Weather Conditions
   ____ Surface Weather Map
   ____ Forecast for your location
   ____ Forecast Weather Map
   ____ Other

6) How often do you look at weather in the newspaper?
   a. Never
   b. 1-3 times/week
   c. 5-7 times/week
   d. More than 7 times/week
7) What weather do you look at in the paper? (Check all that apply)

- Current Weather Conditions
- 5-Day forecast for your location
- Almanac
- Lake Erie
- UV/Air Quality Index
- Surface Weather Map
- Forecast Weather Map
- Weather History/Trivia
- Regional/National/World Temperatures
- Other

8) How often do you talk about the weather with anyone else outside of school?
   a. Never
   b. 1-3 times/week
   c. 5-7 times/week
   d. More than 7 times/week

9) What do you discuss relating to the weather?

- Current Weather Conditions
- Forecast for Next Day
- What to Wear
- Weather on television
- Weather maps
- Forecast for the next week
- Severe Weather
- Science behind the weather

10) On a scale of 1 to 4, how interested in weather are you?
    a. Not interested
    b. Interested only when something exciting happens
    c. Somewhat Interested
    d. Very interested

11) What interests you the most about weather?
GEOGRAPHIC KNOWLEDGE

Basic Map Questions

1) What is the point of having maps?

2) What view does a map provide?

3) What does map scale refer to?

4) Are we in the Northern Hemisphere or the Southern Hemisphere?

5) What does the hemisphere we’re in tell you about our location?

6) What is the reason for having a compass on a map?

7) What are the four cardinal directions?

8) What is latitude?

9) What is longitude?
10) What is a legend and why is it on a map?

Map of US
1) Locate and label the general area of the following things on your map of the U.S.:
   a. Ohio
   b. The 5 states surrounding Ohio
   c. The Great Lakes
   d. Mississippi River
   e. Rocky Mountains
   f. Appalachian Mountains
   g. Los Angeles, Chicago, New York
   h. The 4 Cardinal Directions

Map of Ohio
1) Locate and label the general area of the following things on your map of Ohio:
   a. Your city or township
   b. Cleveland
   c. Columbus
   d. Lake Erie
   e. Ohio River
   f. The 4 Cardinal Directions
APPENDIX C

CONSENT FORMS
FIGURE C.2: Consent forms handed out to students

CHILD CONSENT FORM: Evaluation of US Surface Weather Maps in Meteorology Education

My name is Vanessa Myers, and I am trying to learn more about how using current surface weather maps in the classroom helps you to better understand weather basics. I would like you to take a background survey asking questions about how interested in weather you are, as well as your geographic knowledge. You will also take two tests, one before you learn about weather and one after. These will be taken during the class period, but will not count towards or against your grade. If you have any questions, please talk to me when I visit the classroom.

Thank you,
Sincerely,

Vanessa Myers

CONSENT STATEMENT
I agree to participate in this project. I know what I will have to do and can stop at any time.

Signature Date
FIGURE C.1: Consent forms handed out for parents

ADULT CONSENT FORM: Evaluation of US Surface Weather Maps in Meteorology Education

I would like to do research to evaluate how using current surface weather maps in the classroom helps middle school students to learn weather fundamentals. I would like to do this to better understand what methods allow students to retain the most correct weather information so that meteorological outreach can be improved. I would like your child to take part in this project. If you decide to allow your child to do this, the child will be asked to participate in a background survey on exposure to weather and pre-assessment and post-assessment tests. The survey and tests will be administered in the classroom as part of the lesson plan, but will not count towards or against grades.

If your child takes part in this project both the meteorology and education communities will benefit. The meteorology community will be able to improve their outreach programs and gear them more towards the middle school audience. Your local education community will gain an evaluation of the current teaching styles and students will have an opportunity to learn weather fundamentals in a new form. The larger education community will gain a better understanding of how students learn about weather and be able to adjust curriculum to fit that understanding.

If you want to know more about this research project, please call me at (330) 672-2045 or my advisor, Dr. Scott Sheridan at (330) 672-3224. The project has been approved by Kent State University. If you have questions about Kent State University’s rules for research, please call Dr. Peter C. Tandy, Acting Vice President and Dean, Division of Research and Graduate Studies at (330) 672-2704.

You will get a copy of this consent form.

Sincerely,

Vanessa Myers

CONSENT STATEMENT
I agree to let my child take part in this project. I know what he or she will have to do and that he or she can stop at any time.

Signature  Date
APPENDIX D

ASSESSMENTS
FIGURE D.1: Pre- and post-assessment given to Lehman Middle School

WEATHER ASSESSMENT

1) On most days, from what direction to what direction does weather move across North America?
   a. North to South
   b. South to North
   c. East to West
   d. West to East

2) What is the weather map symbol for an area of high pressure? Make sure to include any colors.

3) Describe the weather associated with high pressure (Precipitation? Clouds?).

4) What is the weather map symbol for an area of low pressure? Make sure to include any colors.

5) Describe the weather associated with low pressure (Precipitation? Clouds?).

6) What do isobars represent on a weather map? Draw what the isobars look like.
7) What patterns can be seen when looking at isobars on a weather map?

8) Do the winds flow into or away from a **low pressure area**?

9) Do the winds flow into or away from a **high pressure area**?

10) A warm front is about to pass through your location. What is the weather like before (Clouds? Precipitation? Temperature?)

11) How did the weather (Clouds? Precipitation? Temperature?) after the warm front passed?

12) Now a cold front is about to pass through. How does the weather (Clouds? Precipitation? Temperature?) change again?
13) Which drawing shows a realistic pressure system?

14) Draw what a cold front looks like on a weather map.

15) Draw what a warm front looks like on a weather map.
16) Interpret the station plot below:

Use the weather map provided to answer the following questions.

17) At point A what is the current weather like?

18) At point B what is your forecast for the next 24 hours?

19) At point C name the front.
FIGURE D.2: Pre- and post-assessment given to North Canton Middle School

WEATHER ASSESSMENT

1) On most days, from what direction to what direction does weather move across North America?
   e. North to South
   f. South to North
   g. East to West
   h. West to East

2) What is used on a weather map to show an area of high pressure? Make sure to include any colors.

3) Describe the weather associated with high pressure (precipitation, clouds, etc.).

4) What is used on a weather map to show an area of low pressure? Make sure to include any colors.

5) Describe the weather associated with low pressure (precipitation, clouds, etc.).

6) What do isobars represent on a weather map? Draw what the isobars look like.
7) If the isobars are tight together on a weather map, what does this tell you? What if the isobars are far apart?

8) Do the winds flow into or away from a low pressure area?

9) Do the winds flow into or away from a high pressure area?

10) A warm front is about to pass through your location. What is the weather like BEFORE the warm front passes? (clouds, precipitation, temperature, etc.)

11) How does the weather change AFTER the warm front passes?

12) Now a cold front is about to pass through. How does the weather change AFTER the cold front passes?
13) Which drawing shows a realistic pressure system?

14) Draw what a cold front looks like on a weather map.

15) Draw what a warm front looks like on a weather map.
16) At point A what is the current weather like?

17) At point B what is your forecast for the next 24 hours?

18) At point C name the front.

Use the weather map provided to answer the following questions.
APPENDIX E

ASSESSMENT GRADING RUBRIC
WEATHER ASSESSMENT

1) On most days, from what direction to what direction does weather move across North America?
   i. North to South
   j. South to North
   k. East to West
   l. West to East
   1 – Correct (Letter D)
   0 – Wrong
   2) What is used on a weather map to show an area of high pressure? Make sure to include any colors.
   2 – Correct Symbol & Color (Big H, blue)
   1 – Correct Symbol or Color
   0 – Neither
   3) Describe the weather associated with high pressure (precipitation, clouds, etc.).
      3 – Fully clear understands clear/little clouds, no precipitation & doesn’t mention other weather
      2 – Understands no clear/little clouds, no precip, but mentions other non-applicable weather (ie hot/cold)
      1 – Mentions either clear/little clouds or no precip, with or without other weather (hot/cold)
      0 – Clouds, rain, any other weather that is not associated with high pressure (hot, cold)
   4) What is used on a weather map to show an area of low pressure? Make sure to include any colors.
      2 – Correct Symbol & Color (Big L, red)
      1 – Correct Symbol or Color
      0 – Neither
   5) Describe the weather associated with low pressure (precipitation, clouds, etc.).
      3 – Fully clear understands lots of clouds, precipitation & doesn’t mention other weather
      2 – Understands clouds, precipitation, but mentions other non-applicable weather (ie hot/cold)
      1 – Mentions either lots of clouds or some precipitation, with or without other weather (hot/cold)
      0 – Clear skies, Sunny, no precipitation, any other weather that is not associated with low pressure (hot, cold), no answer
   6) What do isobars represent on a weather map? Draw what the isobars look like.
      Isobars
      3 – Equal lines of pressure
      2 – Mentions both high and low pressure
      1 – Mentions wind strength, general pressure
      0 – No answer
Drawing
3 – Multiple clear line patterns with H & L
2 – Draws clear line patterns, Several lines
1 – Squiggly lines
0 – No Answer/ 1 or 2 lines

7) If the isobars are tight together on a weather map, what does this tell you? What if the isobars are far apart?
3 – Wind patterns, tight together = strong winds, far apart = light winds/tight = low press, far = high
2 – High & Low pressure placement (close together, far apart)
1 – Just mentions wind patterns, or only gets one right, mentions weather
0 – No Answer

8) Do the winds flow into or away from a low pressure area?
1 – Flows Into
0 – Flows Away/No Answer

9) Do the winds flow into or away from a high pressure area?
1 – Flows Away
0 – Flows Into/No Answer

10) A warm front is about to pass through your location. What is the weather like BEFORE the warm front passes? (clouds, precipitation, temperature, etc.)
2 – Low clouds, light precipitation, mild temperatures
1 – Mentions a few correct & a few wrong
0 – No Answer/Wrong

11) How does the weather change AFTER the warm front passes?
2 – Clouds are higher, clouds have decreased, sun, temperatures warmed up, no precipitation
1 – Mentions a few correct & a few wrong
0 – No Answer/Wrong

12) Now a cold front is about to pass through. How does the weather change AFTER the cold front passes?
2 – Lots of clouds, storms and/or increased precipitation, colder temperatures
1 – Mentions a few correct & a few wrong
0 – No Answer/Wrong
13) Which drawing shows a realistic pressure system?

1 – Correct (Letter C)
0 – Wrong

14) Draw what a cold front looks like on a weather map.
1 – Draws a line with triangles on it
0 – No Answer/ Incorrect drawing (draws both a cold & warm front together)

15) Draw what a warm front looks like on a weather map.
1 – Draws a line with half circles on it
0 – No Answer/ Incorrect drawing (draws both a cold & warm front together)
16) At point A what is the current weather like?
3 – Sunny, Clear, No Clouds etc
2 – Sunny or Clear and Warm
1 – High pressure
0 – No Answer

17) At point B what is your forecast for the next 24 hours?
3 – Colder, Cloudy, Precipitation
2 – Colder, Precipitation
1 – Colder OR Precipitation
0 – No Answer

18) At point C name the front.
1 – Warm Front
0 – No Answer