## A Project

entitled

## Using the Theory of Multiple Intelligences to Enhance Science Education

by

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Submitted as partial fulfillment of the requirements for The Master of Education degree in Secondary Education

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#### An Abstract of

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Gardner's theory of multiple intelligences suggests that students acquire and convey knowledge by using eight intelligences: linguistic, logical-mathematical, spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal, and naturalistic. Teachers can use the knowledge of the theory to develop teaching practices that enhance instruction. This project presents an overview of science educational reforms in America, a review of literature regarding Gardner's theory, and science lessons and evaluation strategies that reflect the multiple intelligences approach.

# Dedication

This project is dedicated to Julia.

I hope you will always love to learn.

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I thank:

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### **Chapter 1: Introduction**

Educating today's youth is a goal all teachers strive to achieve. Educators, politicians, scholars, and administrators usually have differing opinions on the best way to successfully help students learn. This is true for all educational topics. Science, unlike math or writing, is one of the few subjects that continually change as discoveries are made and technology develops. This is the one of the reasons science education has undergone several reforms over the years.

The concept of science education began in the 1800's. The goal was to teach students not only the scientific facts but also the methodology of discovery (Blough & Schwartz, 1990). The debate begins when the *amount* of fact and methodology taught in school is discussed. Science education's purpose is dictated by the needs of society (Yager, 2000). As society changes, so do the underlying goals of science education. This happens in every subject area. In fact, forty major educational reform efforts occurred in the first 150 years of U.S. history (Hurd, 1991). These reforms tried to make schools and learning reflect what was important to the society at the time (Yager, 2000).

The evolution of science education is imperative to know because it allows a person to look back at changes with more objectivity. Educators can use what was learned in the past to make the future methodology of science education more relevant to the generations of students to come.

As mentioned, science is not just facts in a textbook. It is a way of learning about our world that includes the skills of observing, measuring, describing, classifying, experimenting, and predicting so that students can make their own conclusions and theories about science (Blough & Schwartz, 1990). Educators must try to instill a sense of curiosity so that students continue to learn about science long after graduation (Blough & Schwartz, 1990). In order for this to happen, schools need to teach students that scientific knowledge will provide benefits for and insights into their everyday life. World events, the economy, technology, and many other factors cause the American society to dictate what is important. The brief overview of the science educational reforms and influential reformers in America that follows shows how attitudes have changed over the decades.

Science was not part of the educational curriculum in America and Europe until the 19<sup>th</sup> century (DeBoer, 2000). Until then, education focused on teaching literature, history, and philosophy. Scientists needed more people to help continue advancements of science and technology of the time. Therefore, they needed to convince scholars that science would "provide intellectual training at the highest level - not the deductive logic that characterized most of formal education, but the inductive process of observing the natural world and drawing conclusions from it" (DeBoer, 2000). This concept was desirable to many people because teaching independent thinking would also allow individuals to participate more fully and effectively in America's democratic society (DeBoer, 2000).

The main objective of education in the 19<sup>th</sup> and early 20<sup>th</sup> century was to learn skills and theories that could be used in everyday life. Learning factual details was not the

main focus. In 1893, the report of the National Education Association's (NEA) Committee of Ten wrote:

Effective power in action is the true end of education, rather than storing up of information...The main object of education, nowadays, is to give the pupil the power of doing himself and endless variety of things which, uneducated, he could not do. (Eliot, 1898)

John Dewey, a respected philosopher and educator, was an advocate of this science philosophy throughout the early 1900s. Despite the NEA's recommendations in 1893, many teachers still focused on factual information when dealing with science. Dewey tried to change this practice through his writings. He believed in teaching through inquiry – the method of scientific reasoning (Rudolph, 2003). Dewey wrote *How We Think* in 1910. Many teacher-training institutes adopted it as a guide for the scientific method. It influenced many educators into believing that science was an intellectual process (Ryan, 1995). He also believed in using everyday objects and materials when science was taught. He thought this would increase the likelihood that the students would assimilate scientific reasoning into the everyday world (Rudolph, 2003). Dewey's theories were eventually widely accepted and had a great influence on schools' curricula.

In the late 1930s and 1940s, World War II made educators take another look at school curricula. Because of the War, people realized that science could destroy society. Yet, because of advancements in security and technology, science also had the potential to protect society (DeBoer, 2000). Some people thought that too much emphasis was put on the process of science and not enough time was spent on the broad understanding of the natural world and the way it affected a person's personal and social lives (DeBoer, 2000). Reformers felt that it was important for students to learn about the social implications of technological advancements. Science educational goals had to shift to

fulfill society's requirements for social issues and provide an equal balance of factual knowledge and the scientific method.

In the late 1950s, everything changed when the Soviets launched the Sputnik satellite. Scientists led the way for educational reforms. They wanted students to understand the natural universe, the work a scientist does, and the processes used by scientists (DeBoer, 2000; Yager, 2000). Inquiry was emphasized once again, yet the use of textbooks still caused direct instruction to be used most of the time (Yager, 2000). Technology was taken out of the science curriculum and taught only to students attending vocational schools. The new science courses, fact-based and very complex, rarely connected information to real-life situations (DeBoer, 2000). The scientific community needed schools to build the educational foundations that could get America to the moon and beyond.

Factual information continued to be emphasized in the 1960s. Joseph Schwab, a well-known educational reformer, disagreed with the path science education continued to take. He thought equal amounts of content and method should be taught in school (Rudolph, 2003). Schwab felt that scientific facts and conclusions "are unintelligible or misleading unless they are known in the context of inquiry which structured and bounded the matters to which they refer" (Schwab, 1958). Despite Schwab's opinions, a perceived lack of scientific knowledge in America's youth motivated educators to focus on the facts throughout the rest of the decade (DeBoer, 2000).

Waning public support for science in the 1970s created another shift in science educational goals. Educators finally realized that is was unwise to focus on science content and ignore the interests and developmental needs of the learner (DeBoer, 2000).

In 1971, the National Science Teachers Association (NSTA) felt that science education should make students scientifically literate. This meant that a student needed to "use science concepts, process skills, and values in making everyday decisions as he interacts with other people and with his environment" (National Science Teachers Association, 1971). A study called Project Synthesis mirrored the NSTA's opinions by describing four major goals that emphasized teaching not only the science content but also the student. (Harms, 1977). The first goal was to prepare students to use science and technology to improve their own lives. The second specified that science education should produce informed citizens. Making students aware of the wide variety of science and technology-related careers was the third goal. Finally, the fourth goal was to provide the appropriate amount of science knowledge to students who were likely to pursue science academically and professionally. Unfortunately the emphasis on the student was short-lived due to changes which occurred in the next decade.

The economic climate of America was in a steep decline in the early 1980s. It was thought that the capabilities of other industrialized countries like Japan and Germany were superior to those of the United States (Yager, 2000). In 1983, the National Commission on Excellence in Education issued a report called "A Nation at Risk." The report stated that the national education standards were too low, causing American youth to have extremely poor math and science test scores (Brown, 2003; DeBoer, 2000). America's decline was blamed on the educational system.

There were many effects of the report. President George H. W. Bush endorsed establishing national performance goals to heighten educational standards in order for America to become internationally competitive again (U. S. Department. of Education,

1991). The National Science Education Standards were created by 1996. This document contained a set of content standards that all students needed to master. In response, the nation's schools needed to become more academically rigorous in order to live up to the high expectations (DeBoer, 2000). Once again, the focus of science education shifted toward knowledge of more factual information. The easiest way to determine the success of this standards-based reform was to test the students. Using high-pressure, standardized tests is currently one of the few ways society uses to gauge the success of the educational system in America.

There are several negative effects of the tests. Teachers are encouraged to spend a great amount of time giving practice tests to help students become familiar with the questions (Bellanca, Chapman, & Swartz, 1994). This prolonged time in a test-like environment not only bores and frustrates both students and teachers but also restricts the ability of teachers to relate the scientific facts to the real world. Therefore, it can also be assumed that the memorization of facts lead to poor retention of information as time goes by.

To illustrate this, Figure 1 shows proficiency test science averages for the state of Ohio (Ohio Department of Education, 2004). Ohio gives annual proficiency tests to all 4<sup>th</sup>, 6<sup>th</sup>, and 9<sup>th</sup> grade students. Students who do not pass the test in the 9<sup>th</sup> grade must take it again the following year. The proficiency test is based on the Ohio Science Content Standards (State Board of Education & Ohio Board of Regents, 2002) which reflect the requirements in the National Science Education Standards (National Research Council & National Committee on Science Education Standards and Assessment, 1996). Since the



Figure 1. State of Ohio Proficiency Test - Annual State Science Averages

inception of these tests in 1997, the scores have generally risen each year. Yet, the percentage of students who pass the test is still somewhat low, especially in the elementary grades. This has meant that the creation of the National Science Standards has not made a significant impact on the way students learn science at a local level.

It is not clear if the results are due to a problem with the test itself or the methods educators use to teach the information. The test is multiple choice and highly objective. Because the answers are either right or wrong, partial knowledge of the content of a question cannot be measured. Problems may also exist with teaching methods because the detailed standards cause educators to focus more thoroughly on the specified content known to be on the test. This leaves less time for enrichment activities and taking advantage of "teachable moments" when student actions or questions lead to a valuable opportunity to connect the information to real-life experiences and enhance learning.

Although the creation of the National Standards and the implementation of standardized testing were the main effects of a "A Nation at Risk" (National Commission on Excellence in Education, 1983), one very important and unforeseen influence on education will forever change the way educators think about teaching students. The National Science Foundation made funds available to study how humans learn (Yager, 2000). Cognitive abilities of children were the subject of several studies. Until this time, teachers lacked knowledge of the human intelligence theory even though they were responsible for the intellectual development of their students (Campbell & Campbell, 1999). The information discovered in the research is now the basis of science educational reform in the 21<sup>st</sup> century (Yager, 2000). The importance of child-centered instruction is again becoming apparent to educational reformers. The scientific facts and methods still exist, but now it is known that how students learn is just as important as what they learn.

In 1983, Howard Gardner published his own theory of multiple intelligences (MI) in a book called *Frames of Mind*. Although it was not originally intended to reform education, he made the educational world rethink what it means to be smart. In society, the definition of intelligence implies that a person has good linguistic and mathematical skills. Gardner expanded the view of intelligence to also include spatial, musical, bodilykinesthetic, interpersonal, intrapersonal and naturalistic skills. The multiple intelligence theory provides a framework to allow teachers to foster a love of learning by focusing on each child's strengths. Teachers all over the world have embraced the concepts due to the

theory's seemingly endless advantages. Finally science educational reformers have once again realized that the students are the most important part of the educational system.

The following chapters explain Gardner's theory of multiple intelligences and its use in the world of education. Teaching strategies that incorporate multiple intelligences are easily adopted into any classroom. Science educators are currently using teaching methods that mirror some of the theory's concepts. To illustrate that, a unit discussing the factors that influence the weather has been constructed to show how the multiple intelligences can be incorporated into the middle school science curriculum. A variety of activities are used to help motivate students and increase their success.

## **Chapter 2: Literature Review**

#### The Search for the Source of Intelligence

The prime author and mover of the universe is intelligence. Therefore, the final cause of the universe must be the good of the intelligence and that is truth...Of all human pursuits, the pursuit of wisdom is the most perfect, the most sublime, the most useful, and the most agreeable. The most perfect, because in so far as a man gives himself up to the pursuit of wisdom, to that extent he enjoys already some portion of true happiness.

St. Augustine (as quoted in Gardner, 1993a, p.6)

What is intelligence? According to Webster's New World Dictionary, intelligence is "the ability to learn or understand from experience, to acquire and retain knowledge, to respond quickly and successfully to a new situation, to use the faculty of reason in solving problems, and directing conduct effectively" (Neufeldt, 1988). Philosophers and psychologists have been trying to formulate theories to explain intelligence and the function of the brain for centuries. In ancient times the Egyptians had placed the ability to think in the heart and judgment in the head or kidneys. Aristotle thought the heart controlled the body, while Descartes felt the source of the soul was in the pineal gland (Gardner, 1993a). Knowledge of brain function has come a long way since those times.

In the early 19<sup>th</sup> century, phrenology was made popular by Franz Joseph Gall (Gardner, 1993a). This theory hypothesized that the shape and size of a person's head determined their mental capacities. In the light of current knowledge the concept sounds

absurd, but Gall was one of the first to identify the brain's different functions such as memory, attention, language skills, and musical ability.

Since that time, a variety of theories have come to light. In 1904, Spearman formulated that most people have various abilities that are considered to be part of a general intelligence – the g factor (Morgan, 1996). It was this belief that led to the rise of Intelligence Quotient (IQ) tests.

Alfred Binet lived in Paris in the early 1900's. He was asked to devise a test that predicted if children would succeed or fail in the primary grades of Paris schools (Gardner, 1993b). This evaluation tool, known as the IQ test, produced a single score that tried to reflect the general intelligence of the child (Morgan, 1996). It was the first real assessment tool designed to measure intelligence. Until that time, people had to rely on intuitive assessments to determine how smart individuals were (Gardner, 1993b). The need to evaluate people for specific purposes such as placements in schools, industrial organizations, or the military fueled the popularity of IQ tests (Gardner, 1993a). In fact, the test was used during World War I to evaluate the intelligence of over one million American recruits (Gardner, 1993b). The IQ test is still widely in use today.

Critics of the IQ test point out a key flaw of this assessment tool. It is known that the test reliably predicts a child's performance in school. Unfortunately, there is no correlation between the results of the IQ test and an individual's success in the real world (Gardner, 1993b). Perhaps the reason for this is that the IQ test measures mainly linguistic and logical-mathematical abilities (Hoerr, 2000). A traditional school may use these intelligences most of the time, but careers in the real world require a variety of skills such as the ability to work with other people, write reports, give and receive feedback, visualize images, and use imagination.

L.L. Thurstone was one of the first cognitive scientists to think humans were too complex to just have a general intelligence (Morgan, 1996). In 1938, he formulated a theory of Primary Mental Abilities. He suggested intelligence included verbal ability, deductive reasoning, spatial ability, and perceptual speed (Morgan, 1996). Although Thurstone felt these abilities worked independently of one another, most scientists at the time considered the skills to be part of general intelligence.

Throughout the years, Thurstone's theory became obsolete, but in the early 1980's, Howard Gardner felt it was time to consider the theory again. He worked with normal and gifted children as well as brain-damaged adults (Viadero, 2003). He often noticed some functions and talents were independent of one another. A stroke victim, for example, could lose the ability to speak and write, yet the victim's other abilities functioned normally; or an autistic child could not relate to other people, yet he could solve complex math problems or play the piano with ease. Gardner used his knowledge of developmental psychology and neuropsychology to develop his own theory of intelligence. His ideas have influenced cognitive scientists and educators for over 20 years.

#### Gardner's Theory of Multiple Intelligences

Gardner (1993b) defines intelligence as the ability to solve problems or to fashion products that are valued in one or more cultural or community settings. For example, a person unable to read or write well can still become very successful in life in a skilled trade like plastering. He thus provides needed services in the housing industry,

contributes to the community, and is paid very well for his talents without the ability to read or write well. Contributions like these involve the intelligences that an IQ test cannot measure. Gardner (1993a) feels that "... if we expand and reformulate our view of what counts as human intellect [we will] be able to devise more appropriate ways of assessing it and more effective ways of educating it" (p. 4).

In 1983, Howard Gardner wrote *Frames of Mind*, a book that changed the concept of intelligence. Gardner believed that human cognitive competence consisted of a set of abilities, talents or mental skills, which are called intelligences. When a situation presents a difficulty, a person's intelligences work together in varying degrees to solve the problem or create products (Gardner, 1993b). The eight intelligences identified by Gardner (1993a) are described in the following paragraphs.

#### *Linguistic intelligence*

This intelligence is responsible for the production of language. The sensitivity to the meaning and order of words is taken into account when individuals tell stories and jokes, write poetry, use abstract reasoning and symbolic thinking, read, and perform any other activities that use language. Linguistic intelligence is used by novelists, public speakers, comedians, playwrights, and poets.

#### Logical-mathematical intelligence

The capacity to recognize patterns and order and to work with abstract relationships and/or connections between separate and distinct pieces of information is associated with this intelligence. Scientists, computer programmers, accountants, lawyers, mathematicians, and bankers exhibit this intelligence.

#### Musical intelligence

When a person has a sensitivity to pitch, melody, rhythm, and tone, they have strong musical intelligence. Musicians, composers, and music teachers have developed this intelligence.

#### Bodily-kinesthetic intelligence

This is the ability to use the body to express emotion, to play a game, and to create a new product. This intelligence can be seen in such people as actors, athletes, mimes, dancers, and inventors.

#### Spatial intelligence

Architects, artists, and cartographers have a strong spatial intelligence because they not only have the ability to perceive the world accurately, but they are also able to recreate or transform aspects of the world. Not only does this involve the sense of sight but also the ability to form mental images.

#### Interpersonal intelligence

A person with high interpersonal intelligence has the ability to work cooperatively with others in a group as well as the ability to communicate both verbally and nonverbally with other people. Counselors, teachers, therapists, politicians, and religious leaders have strong interpersonal intelligence because they have a capacity to notice distinctions such as contrasts in moods, temperament, motivations, and intentions in other people.

#### Intrapersonal intelligence

This intelligence involves the knowledge of internal aspects of the self, such as knowledge of feelings, the range of emotional responses, thinking processes, selfreflections, and a sense of spiritual realities. It allows us to step back from ourselves and evaluate our own actions as an outside observer. This intelligence is exhibited in philosophers, psychiatrists, spiritual counselors, and cognitive pattern researchers. *Naturalist intelligence* 

The ability to recognize and classify numerous species of flora and fauna in the environment defines this intelligence. Farmers, hunters, zookeepers, gardeners, cooks, veterinarians, nature guides, and forest rangers are strong in this intelligence because they have a sense of wonder, awe, and respect for the natural world.

Since the concept of these intelligences developed, a score on a test no longer determines the definition of being smart. Being smart is now determined by the variety of ways in which a student can learn (Hoerr, 2000). Educators need to help students develop the various intelligences. If they do, it will help learners feel more engaged and competent. Newly discovered confidence will encourage the student to serve society in a more constructive way (Gardner, 1993b).

#### **Criticisms of the Theory**

Some researchers are critical of Gardner's theory. Klein (1997) feels the multiple intelligence (MI) theory is not supported by adequate evidence. Gardner (1993a) says in the tenth anniversary edition of *Frames of Mind* that the intelligences work independently from one another, but does not give a clear explanation when asked about an activity that uses several intelligences at once. For example, how can a person dance if the musical intelligence cannot communicate with the bodily-kinesthetic intelligence? Gardner and Walters (Gardner & Walters, 1993) suggest there may be a "dumb executive" that facilitates communication between the intelligences. If that is the case, the intelligences

cannot be considered independent. The MI theory once again falls within the confines of general intelligence (Klein, 1997).

Because evidence to support the MI theory is weak, Klein (1997) feels there are several pedagogical problems with the theory. First, the MI theory encourages balanced programming to strengthen a student's weak intelligences and provide enrichment for the strong intelligences. This can be done, but as yet there is no reliable way to assess the intelligences, although researchers have been trying for years. Teachers do not have a valid way to determine a student's progress.

Second, because Gardner did not provide educational models, many educators misinterpret the theory. According to the MI theory, the intelligences operate independently of one another and represent only a specific kind of content. Yet it is often thought that if students do not understand information when it is taught one way, the method can be changed to be taught with another intelligence. This would be considered using different learning styles, not the multiple intelligences.

Third, Klein feels the MI theory is not practical because it increases the workload of the teacher. It requires extra thought, planning, and organization when teachers expose students to the multiple intelligences in lessons throughout the school day. Large class sizes and lack of time may discourage some educators from implementing it into their classrooms.

Another critic of Gardner, Harry Morgan (1996), agrees with the concept itself but feels the concept of multiple intelligences is not a new theory. Instead, it is just a restatement of old theories that others have defined as cognitive styles, the methods individuals use to organize and process information. These methods become preferences

and strategies that the person uses each time information is remembered or problems are solved (Morgan, 1996). All of these processes are considered to be part of general intelligence.

Many psychologists are opposed to the word "intelligences". They think they should be called "talents" instead. In *Frames of Mind*, Gardner (1993a) refutes the critics. He could accept the word "talents" if *all* brain capacities were considered talents. He finds it unreasonable that someone who is proficient in language and logic is considered smart, but an athlete or artist is just talented.

Evidence from neuroscience may help to support Gardner's theory. Brain-images taken while subjects did a variety of activities show that movement, language, musical, and mathematical skills may work through different neural systems (Viadero, 2003). This may prove to be the information needed to refute the concept of general intelligence.

Despite the critics, the MI theory continues to be popular. A search in any educational database would produce hundreds of articles supporting the use of MI. It does not matter to educators if the concept is not new or if every tiny detail of the theory is supported by evidence. Educators embrace the theory because it gives them a way to expand upon their old teaching methods. The theory of multiple intelligences did not reinvent the wheel. Instead, it added a few spokes to help strengthen the educational system.

#### Reasons for Adopting the Multiple Intelligences Into the Curriculum

Throughout the years numerous publications have suggested nationwide educational goals to ensure student success in America's schools. Due to heightened attention for educational reform in the 1980's, several educational studies have

researched classroom management, student motivation, grouping arrangements, scheduling configurations, and teaching techniques, just to name a few. These studies have helped teachers realize that they will have to create learner-centered conditions in the classrooms in order for the students to be successful (Brown, 2003).

The studies motivated the American Psychological Association to create the Learner-Centered Psychological Principles: Guidelines for School Redesign and Reform (APA Task Force on Psychology in Education, 1993). All twelve of the principles can be used to support using the MI theory to create a successful school environment. In the following six principles especially, the underlying concepts of the MI theory and the guidelines seem to be one and the same: learner-centered classrooms must be successoriented; learning must be active, not passive; instruction must address many different learning styles; students must be allowed to work together; teachers must provide students with choices; and many different forms of assessment must be employed. The APA's guidelines help to support the idea that incorporating the MI theory into a school's curriculum will result in positive outcomes.

There are many reasons why educators feel the MI theory would work well in their schools. Teachers and principals are finding that using the multiple intelligences not only increases opportunities for students to learn because of its flexible structure but also gives adults more avenues and ways to grow professionally and personally because teachers have to work together (Hoerr, 2000). One study surveyed hundreds of educators and revealed that the MI theory supports what teachers already know, helped to extend and organize their teaching methods, and complimented the educators' existing beliefs because they already used some methods that fit with the theory (Kornhaber, 2004). These reasons help to explain why teachers have adopted the theory with a great amount of enthusiasm.

Teachers also like the MI theory because it provides a language to perceive and exhibit a greater amount of student talent. Multiple intelligences produce less frustration among teachers and students because success is not limited to the traditional mathematical and linguistic skills. The other intelligences allow for a greater opportunity to witness a student's competence. This raises an educator's expectations which, in turn, raises the learner's beliefs about his or her own abilities (Campbell & Campbell, 1999).

Some surveys report more student-centered reasons to incorporate the multiple intelligences. Established schools that wanted to move toward teaching with the MI theory did so to enhance student achievement (Campbell & Campbell, 1999). Administrators and staff at Mountlake Terrace High School in Washington felt the MI theory would motivate students with a low socioeconomic status. Incorporating the theory would focus on a person's strengths. This encourages growth in other areas because of an increase in confidence. Lincoln High School in California thought it would make learning more exciting and memorable for their diverse student population (Campbell & Campbell, 1999). In these cases, the traditional secondary instruction was not successful. Therefore a fresh, innovative approach was needed.

Schools such as EXPO Elementary School in Minnesota and Key Learning Community in Indiana were founded with the MI theory at the center of their curriculum. They did so because they wanted to develop a program that built upon the strengths of every child (Campbell & Campbell, 1999). They did not believe in remediation. Luckily,

Gardner's theory is flexible enough to fit the requirements of any school and produce the positive outcomes that are desired.

Once MI theory is incorporated into the curriculum, it is important that instructors change from their traditional way of teaching. In many cases, that is easier said than done because educators have used the same teaching methods to cope with crowded, self-contained classrooms for over 150 years (Cuban, 2004). These practices are hard to change even though teachers and administrators agree that MI has its benefits.

For this reason, a study tested to see if the MI theory makes a difference in teacher practices (Kornhaber, 2004). It was found that there was at least an extension or change in two or more of the following areas: curriculum, assessment, pedagogy, and school structure. The amount of change depended on the school. If the school already included music and the arts in the curriculum, the teachers used the multiple intelligences as more of an extension to their current practices. The methods of educators in traditional schools changed more significantly than the schools with the arts already established in the curriculum because the transition from teacher-centered to student-centered instruction requires a lot of work (Kornhaber, 2004). This study shows that teachers try to do a better job of educating the students when the MI theory is adopted into the classroom.

#### The Positive Effects of Using the Multiple Intelligences

It is known why the MI theory is adopted into the curriculum, but are actual results produced? Many studies, books and articles found schools that enthusiastically report the positive outcomes of using Gardner's theory of multiple intelligences.

#### Higher Standardized Test Scores

The Project on Schools Using MI Theory (SUMIT) performed a 3.5-year study to find the benefits of the multiple intelligences (Kornhaber, Fierros, & Veenema, 2004). Phone interviews were conducted with personnel at 41 schools that used MI for over three years. Ten schools were also visited to observe and interview teachers. One result of the study was that almost 80% of the schools reported higher scores on standardized tests (Kornhaber et al., 2004). This improvement could, in part, be caused by teachers looking at the curriculum in more depth and developing units that require students to use a variety of sources and methods of presentation (Kornhaber, 2004). Reading, writing, and rote facts are still important in classrooms that use Gardner's theory, but multiple intelligences cause the instruction to be student-centered instead of content-centered. This gives the teachers more tools to help students learn and to make learning interesting (Hoerr, 2000).

Linda and Bruce Campbell (1999) studied six schools that had the MI theory at the core of their curriculum. In all cases, the schools performed at or above the district and state averages on standardized tests no matter what the school district's socioeconomic status (SES) or percentage of minority students (Campbell & Campbell, 1999). This is a very significant result in favor of the MI theory because studies find that SES is responsible for a majority of the differences in test scores when different schools, towns, or states are compared (Kohn, 2001).

The MI schools feel that good scores are a wonderful achievement, but the teachers at the MI schools do not feel compelled to "teach to the tests" because they think the tests do not "communicate the whole story of student accomplishment" (Campbell &

Campbell, 1999, p. 96). Standardized exams often focus on the logical-mathematical and linguistic intelligences. Unfortunately that leaves six intelligences unmeasured. At schools where the theory is not incorporated, many children possessing knowledge in the other intelligences slip through the cracks because educators feel the students are not smart enough to learn.

#### Improvements in Learning-Disabled Students

Another result of the SUMIT study reported that 80% of the schools reported improvements by students with learning disabilities (Kornhaber et al., 2004). This benefit is a result of focusing on the child's strengths as well as weaknesses. The students gained confidence in their abilities and the high level of engagement allowed them to work sideby-side with students of high ability. This helped to foster an environment of respect and caring (Kornhaber, 2004).

Students with Attention Deficit Hyperactivity Disorder (ADHD) are often lumped into the group of students who cannot achieve in school. Due to frequent failures and low teacher expectations, research has found that students with ADHD have a low selfconcept (Damico & Armstrong, 1996). It is a different story, though, at schools that incorporate the MI theory. Researchers have identified the schools in Project SUMIT that effectively use MI strategies in their classrooms (Schirduan, Case, & Faryniarz, 2002). Schirduan (2000) found that over 50% of the 87 ADHD students tested were strongest in the naturalistic and spatial intelligences. These students were also determined to have average self-concept and average achievement (Schirduan, 2000). This means students with ADHD are smart but not in traditional ways. This knowledge helps educators to realize that they need to use the MI theory to connect a student's areas of weakness to the student's strengths (Schirduan et al., 2002). If a child with naturalistic intelligence loves the outdoors, the teacher could inspire the child by having several plants and fish in the classroom. A naturalistic child's attention span might lengthen in math class if story problems could incorporate elements from nature instead of nonliving objects. Students could be given choices in writing in language arts. The students could then enjoy composing essays more because the topic interests them. These are just a few examples, but these minute changes could improve a child's whole outlook on learning.

#### Improvements in Student Behavior

Project SUMIT reported that 80% of the schools that incorporated the MI theory into the curriculum also reported an improvement in student behavior (Kornhaber et al., 2004) because students that have strong intelligence in areas other than logical –mathematic or linguistic become more engaged in learning (Kornhaber, 2004). This finding is corroborated by a research project conducted by Highland, McNally and Peart (1999). They found that students in kindergarten and first grade classrooms were 77% more likely to be well-behaved when engaged in an activity that used the student's strongest intelligence (Highland, McNally, & Peart, 1999).

#### Improved Parent Involvement

Eighty percent of Project SUMIT schools also reported that parent involvement improved (Kornhaber et al., 2004). Multiple intelligence schools often incorporate units that require volunteers for activities, audiences for performances, judges for presentations, and many other forms of community involvement. These opportunities

help parents of all educational levels feel at ease participating in student activities (Hoerr, 2000; Kornhaber, 2004).

#### Students Have More Positive Feelings for Teachers

A study by Haley (2004) found another benefit of teaching techniques that use Gardner's theory. Haley helped teachers incorporate MI-based instruction into foreign/second language classrooms. A survey revealed that students had more positive feelings about teachers using a variety of teaching methods and assessment techniques that reflected the multiple intelligences. The teachers felt the students' reactions were the result of the greater degree of flexibility, variety, and choices that MI strategies allowed (Haley, 2004).

In conclusion, studies have shown Gardner's theory of multiple intelligences to have numerous benefits. Teachers throughout the world can find inspiration in the theory because it helps to unlock the true potential of every student. That is no small feat. Educators have been trying to unlock student potential for thousands of years, and with the help of Gardner's theory they will be helping children learn for many years to come.

## **Chapter 3: Teaching Implications of the Multiple Intelligence Theory**

Saying that everyone is smart in his or her own way summarizes the MI theory. Each and every classroom teacher has a responsibility to discover how the students learn most efficiently. "The purpose of school should be to develop intelligences and to help people reach vocational and avocational goals that are appropriate to their particular spectrum of intelligences. People who believe so feel more engaged and competent and therefore more inclined to serve the society in a constructive way" (Gardner, 1993b).

#### Ways Multiple Intelligences Can Be Incorporated Into the Classroom

Teachers must become familiar with the eight basic intelligences to help guide the students in the right direction. Educators need to ask the following questions while planning to incorporate the MI theory into their lessons and classroom environment (Armstrong, 1994b):

### Logical-Mathematical Intelligence

How can I bring in numbers, calculations, logic, classification, or critical thinking skills?

How is time structured in the classroom? Do students have opportunities to work on long-term projects without being interrupted? Is the school day sequenced to make optimum use of students' attention spans (morning best for focused academic work, afternoon best for more open-ended activities)?

#### Linguistic Intelligence

How can I use the spoken or written word?

Are there a variety of supplies available for writing (paper, chalk boards, markers, crayons, chalk)?

### Spatial Intelligence

How can I use visual aids, visualization, color, art, or metaphor?

Is the classroom attractive to the eye (e.g. artwork on the walls, plants on the window sills)?

Are students exposed to a variety of visual experiences, (e.g. optical illusion,

cartoons, illustrations, videos, great art)?

Is there a feeling of spaciousness in the environment?

#### Musical Intelligence

How can I bring in music or environmental sounds? Can I set key points in a

rhythmic or melodic framework?

Does the auditory environment promote learning (e.g. background music,

silence)?

How does the teacher use his or her voice? Does it vary in intensity, inflection, and emphasis?

#### Bodily-Kinesthetic Intelligence

How can I involve the whole body or use hands-on experiences?

Do students have frequent opportunities to get up and move around in exercise breaks and hands-on experiences?

Do students receive healthy snacks? Are they allowed to hydrate their systems with water breaks?

Are there materials in the classroom that enable students to manipulate hands-on activities?

#### Interpersonal Intelligence

How can I engage students in peer sharing, cooperative learning, or large-group simulations?

Does an atmosphere of belonging and trust permeate the classroom?

Are there established procedures for mediating conflict between classroom members?

Do students have opportunities to interact in positive ways through peer teaching, discussions, and group projects?

#### Intrapersonal Intelligence

How can I evoke personal feelings or memories, or give students choices? Do students have opportunities to work independently, develop self-paced projects, and find time and space for privacy during the day? Are the students exposed to experiences that heighten their self-concept through self-esteem exercises, genuine praise and positive reinforcement, and frequent success experiences in their schoolwork?

Do students have the opportunity to share feelings in the classroom?

#### Naturalist Intelligence

How can I bring the outdoors inside the classroom?

Do students have the opportunity to go outside?

Can I discuss relationships in nature in different subject areas?

The previous questions must always be on a teacher's mind when lesson plans are developed. A teacher's goal in a MI classroom is to help the students become more comfortable when using the various intelligences. This requires lessons to use a variety of the intelligences, but time and energy often prevent the teacher from effectively creating MI lessons. The following paragraphs discuss ways that Hoerr (2000) suggests to efficiently incorporate the multiple intelligences in the classroom. With creative teaching techniques, all the intelligences can be included over the course of just a few lessons.

Curriculum-based learning centers use specific intelligences to learn a skill or subject matter. After reading a novel, a teacher might design several learning centers, with each center's activity based on a different intelligence. The music center, for example, may ask the student to write a song that summarizes the main events of the novel. The spatial center would ask the student to paint a picture that symbolizes his or her emotions at the end of the story. In this way, the content is discussed using all eight of the intelligences.

Intelligence-based learning centers have no specific content. The variety of activities is developed to help the students become more proficient in each of the intelligences. These centers often have activities that are more in-depth and time-consuming compared to curriculum-based learning centers.

Instead of paper and pencil tests, projects, exhibitions, and presentations (PEPs) are used to help the students use their intelligences to convey what they know with other people. For example, a student could create a poster and describe the information to an audience in an oral report. Not only will the project help the student learn the information, but it will also help to develop his or her spatial and linguistic skills. If an audience is invited, PEPs are good ways to help community members see how effective the MI theory can be as a learning tool.

Students learn best when content is meaningful. Thematic units help to relate information throughout the curriculum. If the theme for the spring semester is baseball, the science class would discuss the physics of moving objects. Math class would learn about percentages and relate them to the players' statistics. Students would write stories about baseball in language arts. Social studies class would discuss the impact baseball had on society. Baseball would also be incorporated into art, physical education, and music. This unity helps students remember the content because it is related to real life and is constantly reinforced.

Flow rooms, areas that contain numerous MI-based activities, can be set up at the school. These areas allow students to pursue what they do best and enable them to use their strongest intelligence. Even if students struggle with subject matter in the classroom, the flow room can give the students the opportunity to feel successful at school.

Learning pods help students gain a skill while they are taught how to use an intelligence. Pods might focus on such things as cooking, gardening, archery, magic tricks, woodworking, or quiet reflection. All the adults within the school, including cooks, office staff, and custodians, can serve as instructors of the pods. Students choose

their pod, and an hour or two is set aside each week for the whole school to do activities. Once again this allows students to use their strongest intelligence or develop other ones.

Role models provide a great opportunity for the students to see the intelligences in action. Guest speakers could give talks to the students and explain how their intelligences helped them choose an appropriate career. With older students, a mentorship program allows them to work with someone whose livelihood is based on proficiency in an intelligence. These experiences expand a student's knowledge of the importance of developing all intelligences.

The following table gives examples of teaching activities and materials that can be used with each intelligence (Hoerr, 2000; Lazear, 1999; *Learning Styles*, 2000; *Lesson planning ideas*, 2000).

Intelligence	<b>Teaching Activity Examples</b>	<b>Teaching Material Examples</b>
Linguistic	Reading, writing, story telling,	Computers, games,
	word games, lectures,	multimedia, books, tape
	discussions, debates	recordings
Logical-Mathematical	Brain teasers, problem	Calculators, math
	solving, science experiments,	manipulatives, science
	mental calculations, number	equipment, math games
	games, critical thinking,	
	sequencing, Venn diagrams,	
	demonstrations, cause and	
	effect relationships, outlines	
Spatial	Visual presentations, art	Models, graphics, charts,
	activities, imagination games,	photographs, drawings, video,
	mind-mapping, metaphor,	television, text with pictures/
	visualization, design and build	charts/graphics, LEGO <sup>®</sup> sets,
	objects, movies, looking at	cameras, optical illusions
	pictures, drawing maps and	
	mazes	

Figure 2. Activities and Materials that Help to Develop the Multiple Intelligences
<b>Bodily-Kinesthetic</b>	Hands-on learning, drama,	Building tools, clay, sports
5	dance, sports that teach, tactile	equipment, manipulatives.
	activities, relaxation exercises.	tactile learning resources
	role playing, demonstrations,	
	sewing model making	
Musical	Rapping songs that teach	Tape recorder tape/CD
	using music to reduce stress	collection musical
	creating musical mnemonics	instruments radio
	teaching history and	
	geography through the music	
	of the period and place	
Internersonal	Cooperative learning peer	Audio conferencing video
inter per sonar	tutoring community	conferencing writing e-mail
	involvement social	time and attention of
	atherings simulations	instructor board games party
	interviewing leading	supplies props for role plays
	discussions loarning through	supplies, props for fore plays
	playing games with other	
	studenta group projecta	
Intuanauganal	Individualized instruction	Salf abaaling materials
Intrapersonal	independent study, self esteem	sen-checking materials,
	huilding activitiag allowing	Journals, materials for
	dunding activities, anowing	projects, books, privacy, time
	students to work at own pace,	
	writing in journals, providing	
	opportunities to give and	
	receive reedback	
N - 4 1242-		11
Naturalistic	Using the outdoors as a	identification guides,
	classroom, naving plants and	binoculars, pet care materials,
	the students to some for	experiment supplies
	the students to care for,	
	conducting nands-on	
	experiments, creating a nature	
	area on the playground	

Figure 2. (continued) Activities and Materials that Help to Develop the Multiple Intelligences

# Assessing Knowledge in Multiple Intelligence Classrooms

Schools must devise a way to discover the amount of information each student is

learning. Assessment is "the obtaining of information about skills and potentials of

individuals, with the dual goals of providing useful feedback to the individuals and useful data to the surrounding community" (Gardner, 1993b, p. 174). In a classroom that uses the MI theory, evaluation should search for genuine problem-solving skills or product-fashioning skills in individuals.

Assessment is needed for many reasons (Hoerr, 2000). Teachers must accurately measure what students understand so areas of weakness can be strengthened. Feedback from assessment helps students learn from their mistakes and develop their intrapersonal intelligence. Parents will come to appreciate the MI theory more after viewing evaluation techniques that accurately show students' progress. When the community sees the products of student achievement, a greater confidence is generated that the MI schools are preparing students to succeed in society. Standardized tests are used to show government officials that the schools are fulfilling the requirements of the state and national standards. Evaluation is a very important element in a successful MI school.

Educators often use multiple intelligences when they teach but rarely use it during assessment. Unfortunately, this is due to the fact that teachers neither have the time nor training to measure student knowledge with a variety of assessment types (Bellanca et al., 1994). Instead, they create paper and pencil tests and give the state-mandated standardized tests that are based mostly in the verbal and logical-mathematical domains (Armstrong, 1994a). In reality, these tests are very inefficient forms of assessment because their questioning strategies only narrowly measure what the students truly know.

In order to accurately measure the skills, assessment strategies should include three components (Gardner, 1993b). The definitional component determines if students understand the problem and why it is important. A task component asks the students to

accomplish an assignment by using targeted skills that have been taught in the unit. When the task is completed, the metatask component requires the student to evaluate if the performance was successful, and if not, what could be done to improve or revise the strategy used. Assessment tools that include these components often require more creative evaluation methods than the traditional paper/pencil test.

Multiple intelligences can be evaluated in many different ways. For example, a teacher may ask the student to present information in a poem or song form; observation of cooperation among groups during experimentation can be recorded; or when mistakes are made, a student can be asked to discuss how to correct the problem by using information already known. This method of assessment is referred to as authentic assessment and is said to measure a student's knowledge more accurately than a traditional written test (Ochanji, 2000). The assessment material needs not only to measure the instructional process but also to determine it.

Incorporating the MI theory into a classroom means a change in what is assessed and how it is assessed (Hoerr, 2000). Reading and writing are still necessary components of education and evaluation, yet whenever possible students should be allowed to convey learned information through their strongest intelligences instead of being forced to write it down (Hoerr, 2000). The following authentic and active learning activities can easily be used by a teacher to assess a student's knowledge (Bellanca et al., 1994).

Journals/logs – When students write thoughts and actions down on paper, it enables them look back at past entries to make connections and apply ideas to the curriculum. (Example: Students sketch a diagram of a science experiment or critique their own work after a project was completed.)

Performance – Students share talents with various audiences by taking part in a show. (Example: Poems are read, or plays about drug abuse are written and performed.)

Demonstrations – Students show others how to do a process. (Example: In physical education, a student shows the rest of the class how to stretch for warm ups.)

Products – Students make objects that apply information learned in a unit.
(Example: Students make a video or a mobile based a character in a novel.)
Graphic organizers – Students use visual formats to gather, analyze, and evaluate material. (Example: A concept map of a science unit is created as a review. Venn diagrams are created to help compare two characters of a story.)
Projects – Students develop meaningful long-term projects that incorporate several intelligences. (Example: A student solves a problem through experimentation and presents it at a science fair.)

Exhibits – Students research information and make a display of what they have learned. (Example: An art student shows a sample of artwork. Poster boards made to enhance a research project are displayed during parent-teacher conferences.)

When these activities are done, teachers can evaluate student levels of proficiency by using a variety of tools including rubrics, interviews, observation checklists, open-ended guided response questions, and teacher-made tests.

Authentic assessment measures a student's growth of knowledge over time. Both teacher and student must observe and document activities, experiences, and achievements that the learner makes (Ochanji, 2000). A portfolio is a collection of work and project

samples that give a picture of a student's growth (Hoerr, 2000). It may contain works in progress; achievements; pictures of posters, projects, and 3-D models; works that show a lack of skill; evidence of self-reflection; and anything else the student would like to include can be contained in a portfolio (Bellanca et al., 1994; Hoerr, 2000; Lazear, 1999). A portfolio is most useful when it contains organized, selective works that represent all the multiple intelligences. Through observation, the teacher can evaluate progress within the context of the program. This allows the teacher to develop instruction that will help the student to succeed and further the student's motivation for learning.

Incorporating the MI theory into the classroom will result in many changes. Teachers need to change not only their instructional techniques but also their methods of assessment. To benefit the student, "our best hope is to develop accurate, valid, and reliable assessments and focus them on improving the teaching process and helping all students take greater command of, and responsibility for, how they learn" (Bellanca et al., 1994, p. x).

In conclusion, developing a classroom that incorporates the MI theory can take a lot of planning and hard work. The effort is worth it because "we want to educate youngsters so that they can cope successfully with a world that has already changed dramatically and that is changing more rapidly still" (Gardner, 1999, p. 61).

#### Science Activities that Use Multiple Intelligences to Enhance Learning

The units that follow are developed from the learning objectives in the Science Course of Study from the Diocese of Toledo in Toledo, Ohio (Doyle, 2001). The subject matter is studied over the course of a school year. Each category contains just a few

representative activities that would be done throughout the unit to incorporate the various multiple intelligences.

In the appendix, a three-week unit on weather has been developed in detail. It shows how each of the intelligences can be used several times over just in the course of eleven lessons. This reduces boredom by varying the activities and allows for all students to learn the subject matter in the way they most understand.

#### Unit 1: Waves

Unit objectives:

- 1. Compare and contrast the types of waves.
- 2. Identify and demonstrate the properties of waves.
- 3. Demonstrate the transmission of waves.
- 4. Interpret the electromagnetic spectrum.
- 5. Investigate the impact waves have on life.

Activities:

Students use a Slinky<sup>®</sup> to simulate transverse and longitudinal wave motion.

(bodily-kinesthetic, spatial)

Five students make transverse waves by joining hands and moving arms. Another group member measures height, length, and speed of the waves. The whole group uses formulas to calculate the amplitude, wavelength, and frequency.

(interpersonal, logical-mathematic, spatial)

Students use formulas to do sample story problems on the chalkboard. (logicalmathematical, linguistic) Students design a poster that identifies all the waves in the electromagnetic spectrum. (spatial, linguistic, naturalist)

Students use prisms to discover all of the colors in white light. (bodily-kinesthetic, spatial)

After class every day, each student keeps a journal describing what was learned and their thoughts about it. (intrapersonal, linguistic)

A poem is written describing the differences between diffraction and refraction. (musical, linguistic)

Students make and decorate kaleidoscopes in art class. (bodily-kinesthetic,

spatial)

Students play telephone with two cans attached with a string to illustrate that sound travels through a medium. (interpersonal, bodily-kinesthetic)

The teacher and students use musical instruments to illustrate constructive interference. (musical)

After learning about waves, students share life experiences that have been made possible due to waves. (intrapersonal)

The class is taken outside, and students look for examples of waves. (naturalist, bodily-kinesthetic)

### Unit 2: Weather

Unit objectives:

1. Investigate the characteristic layers of the atmosphere.

- 2. Use weather instruments to measure common conditions.
- 3. Compare and contrast weather fronts and their effects.

4. Identify conditions needed to determine climate in a given area.

5. Analyze the effects of the movement of winds, ocean currents, and air masses on weather and climate.

6. Using collected data, including weather maps, forecast the weather for any given area.

7. Identify types of clouds, precipitation, and storms.

Activities:

In a jar, the teacher makes carbon dioxide by mixing baking soda and vinegar and then carefully "pours the air" on a lit candle in order to extinguish it. In groups, students hypothesize what happened and why. (interpersonal, spatial, linguistic) Students write an acrostic poem using the word "atmosphere". (linguistic, musical)

Teacher shows current weather map from the Internet. Each student predicts the weather for the next day. (intrapersonal, spatial)

Groups write a song describing the different layers of the atmosphere.

(interpersonal, musical)

Students go outside to identify cloud types. (bodily-kinesthetic, spatial, naturalist) After class each day, each student keeps a journal describing what was learned and their thoughts about it. (intrapersonal, linguistic)

Students gather current weather information from going outside and looking on the Internet in order to create a station model and present a weather report to the class. (logical-mathematical, linguistic, spatial, naturalist)

See appendix for detailed lesson plans on weather.

### Unit 3: Forces, Motion and Energy

Unit objectives:

1. Investigate and demonstrate Newton's laws.

2. Use varied models to demonstrate energy transformation.

3. Use formulas to calculate the force, mass, and motion of machines.

Activities:

Students play with toys and predict if they would work the same in space where there is no gravity. Teacher shows a video of astronauts on the space shuttle playing with the same toys. (bodily-kinesthetic, logical-mathematical, spatial) On a desktop, one coin is placed at the end of a ruler. While the center of the ruler is held in place with one hand, another coin is quickly slid against the other end of the ruler causing the first coin to move. (bodily-kinesthetic, spatial, intrapersonal) Teacher gives group of students several tools. They demonstrate how tools are used and determine what class of lever each tool is. (bodily-kinesthetic, logicalmathematical, spatial, interpersonal)

Students use formulas to determine speed, velocity, and acceleration of toy cars. Results are graphed. (linguistic, logical-mathematical, bodily-kinesthetic, interpersonal, spatial)

Groups create a song about simple machines (interpersonal, linguistic, musical) Each student designs a compound machine that contains a lever, pulley and inclined plane. It must lift a dictionary three inches off table. In class, groups decide what member has the best design. Groups build it together. (interpersonal, intrapersonal, logical-mathematical, bodily-kinesthetic, spatial) Each student draws a poster illustrating an example of conservation of energy.

(spatial, linguistic, intrapersonal)

After class each day, each student keeps a journal describing what was learned and their thoughts about it. (intrapersonal, linguistic)

### Unit 4: The Human Body

Unit objectives:

1. Identify the body systems and their structures.

2. Examine the functions of each system.

3. Investigate the interrelationships of the body systems.

Activities:

Students look at cheek cells under the microscope. (spatial)

After class each day, each student keeps a journal describing what was learned and their thoughts about it. (intrapersonal, linguistic)

Students explore owl pellets and compare rodent bones to human bones. (bodily-

kinesthetic, logical-mathematical, interpersonal)

Class role-plays what happens when a person gets a cut. Desks are moved in rows to simulate blood vessels. Students "circulate" through vessels. Props are used to show how clot is made. (spatial, bodily-kinesthetic, interpersonal, linguistic) Students use colored water to simulate blood transfusions. (spatial, bodilykinesthetic, logical-mathematical)

Students determine their own heart rate and then calculate the number of times their heart will beat in an average lifetime. (logical-mathematical) Students use musical instruments to determine who has the greatest lung capacity. Students are timed to determine how long they can make a sound using one breath. (bodily-kinesthetic, musical)

Students write a poem about the lymphatic system. (linguistic, musical, intrapersonal)

In groups, students dissect a frog. (interpersonal, bodily-kinesthetic, spatial) Students make a poster of all the different organ systems inside the body. (spatial, intrapersonal)

### **Chapter 4: Conclusion**

The aim of science education is to teach students factual science content as well as problem-solving skills. Over the years, science education reforms have varied the emphasis on those two areas depending on the current needs of society. Science education in the early 19<sup>th</sup> and 20<sup>th</sup> centuries focused on the skills a person would use in everyday life. At the time of World War II, the emphasis of science instruction was equally divided between scientific fact and problem-solving skills. Science educators taught factual information in the 1950s and 1960s because they thought students lacked the basic knowledge to reach the moon before the Russians. The cultural revolution of the 1970s renewed the importance of an equal amount of facts and problem-solving skills (DeBoer, 2000). All of these changes were made to create individuals who could contribute to the needs of an ever-changing society.

The reforms made in the 1980s and 1990s still affect the way science is taught in the early 21<sup>st</sup> century. Achievement test scores of American students were found to lag behind students from other developed countries (Yager, 2000). This prompted the U.S. Department of Education to formulate the National Education Standards in 1996. Since then, state and local science curriculums have focused on the factual information identified in the standards (DeBoer, 2000). The standards have not improved achievement rates on standardized tests as quickly as educators and administrators had hoped. Throughout the years, many teachers have conveyed the scientific content by using a teacher-centered approach. Recent studies are helping teachers see that student-centered approaches create more effective learning conditions (Brown, 2003).

For years, most cognitive scientists have agreed that all people possess a general intelligence easily measured with an IQ test (Morgan, 1996). Disagreeing with this assumption, Gardner (1993a) proposed his theory of multiple intelligences (MI) which stated that people are smart in many different ways. To solve problems or design products that are valued by the culture or community, people use eight intelligences: linguistic, logical-mathematical, spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal, and naturalistic (Gardner, 1993a).

The MI theory has influenced the way students are taught. Use of the multiple intelligences can extend current teaching practices. In MI classrooms, activities are learner-centered, with information conveyed and knowledge measured in a variety of ways. Because of Gardner's theory, teachers know that "an intelligence can serve both as the content of instruction and the means or medium for communicating that content" (Gardner, 1993b, p. 32). Traditional schools tend to use teaching strategies limited to the linguistic and logical-mathematical intelligences. The addition of six other intelligences introduces a wider range of classroom approaches.

Studies have identified several benefits of using the MI theory in classrooms. Standardized test scores improve (Campbell & Campbell, 1999; Kornhaber et al., 2004). Learning-disabled students gain confidence and earn higher grades because knowledge

can be learned and expressed using their strong intelligences (Kornhaber, 2004; Schirduan, 2000; Schirduan et al., 2002). Behavior improves because students are engaged in learning activities instead of being off-task (Kornhaber et al., 2004). More parents participate in school functions (Kornhaber et al., 2004). Haley (2004) found that students report more positive feelings for teachers who use the MI theory. Using MI theory results in more flexibility, a greater variety of activities, and increased excitement for learning.

For the last 20 years, educators have used the MI theory to develop quality instructional methods. The theory has the potential to exert considerable influence on education in the future. A need for more accurate standardized tests may lead to using a combination of fact-based and performance-based assessment questions. Authentic assessment and the use of portfolios may come into wider use if teachers utilize the multiple intelligences in evaluation (Hoerr, 2000). These measurement tools would provide a more accurate picture of student knowledge.

Some people incorrectly assume that teaching is an easy job. Teachers must devote great amounts of time, effort, and creativity to incorporate the MI theory into the curriculum. This dedication increases professionalism among educators and allows society to develop a greater respect for the teaching profession (Hoerr, 2000).

Use of the MI theory may increase the perceived value of the fine arts, physical education, and sports teams in secondary education. These activities allow students to experience flow, a feeling of accomplishment when their strongest intelligences are used. Experiencing success in those areas may motivate the learner to devote greater effort to mastering subjects that are more challenging because they require use of the student's

weaker intelligences. A school that values MI will not eliminate courses in the arts to balance the budget.

The theory of MI may also gain credibility as a teaching strategy in higher education. Students would develop a clearer understanding of course content if professors used a variety of teaching methods in addition to lecture. Fine arts, physical education, and interpersonal communication courses in a student's core curriculum would develop intelligences that are useful in a career. The "intelligences always work in concert, and any sophisticated adult role will involve a combination of several of them" (Gardner, 1993b, p. 17). Unfortunately, the "discipline-based orientation of many faculty members may slow the use of MI in post-secondary education" (Hoerr, 2000, p. 76). The future of the MI theory is unclear, yet the possible influences it could have on society are endless.

Knowledge of the MI theory will change the way I teach in the future. Having taught seventh grade science and language arts for nine years, my teaching methods reflected the multiple intelligences. However, linguistic intelligence was generally used to assess knowledge. Seeing some students working hard to learn but earning a D or F on a paper and pencil test was very frustrating. Using a variety of assessment strategies will let the students demonstrate knowledge with their strongest intelligences. This will allow me to truly understand what the students know. The appendix contains lessons and examples of assessment that I plan to use in my classroom. Devising the activities required extra time and creativity, but the end-result will lead to great satisfaction for both my students and me.

During a parent-teacher conference, a student's mother once told me that her son came home from the first day of school and excitedly reported that he now understood

why he always felt restless and talkative in school. He had discovered that he learns best when he moves. As the 7<sup>th</sup> grader explained the bodily-kinesthetic intelligence to his mother, she recognized the advantages of his placement in my classroom where he would have opportunities to learn by using his strongest intelligence. Although that occurred several years ago, the impact of the MI theory on that student will not be forgotten.

Gardner's theory of multiple intelligences has provided a new framework that will enhance the understanding and capabilities of every student in my classroom. Implementing this theory in the classroom may require extra preparation, but educators must depart from their traditional teaching methods in order to do what is best for the student.

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# **Factors that Influence the Weather**

Unit Plan compiled by Amy Schwert

Lesson 1: Energy from the Sun Lesson 2: Energy in the Atmosphere Lesson 3: Heat Transfer through Conduction, Convection and Radiation Lesson 4: How Does Heat Travel? Lesson 5: Differences in Heating the Land and Water Lesson 6: Local Winds Lesson 7: Global Winds Lesson 7: Global Winds Lesson 8: More Practice with Global Winds Lesson 9: The Water Cycle Lesson 10: Cloud Identification Lesson 11: Precipitation

Unit Assessment

Diocese of Toledo Seventh Grade Course of Study Learning Objectives Covered: Use weather instruments that measure common conditions. Identify conditions needed to determine climate in a given area. Analyze the effects of the movement of winds, ocean currents, and air masses on weather and climate. Identify types of clouds, precipitation, and storms. The following unit plan contains teaching methods that incorporate Gardner's theory of multiple intelligences. The lessons are correlated to the Diocese of Toledo seventh grade course of study learning objectives and the Ohio Science Content Standards. The following chart records the type of intelligences used in each of the unit's lessons.

					]	Lessoi	n				
	1	2	3	4	5	6	7	8	9	10	11
Logical-Mathematical	1		✓	<b>\</b>	✓	<b>\</b>				✓	
Linguistic	1	<b>√</b>	<b>√</b>	<b>\</b>	✓	<b>√</b>	<b>\</b>	<b>\</b>	<b>√</b>	<b>√</b>	~
Spatial	1	✓	✓	<b>\</b>	<ul> <li>Image: A start of the start of</li></ul>	<ul> <li>Image: A start of the start of</li></ul>	<b>\</b>		✓	1	✓
Musical			1		1			1	1		✓
<b>Bodily Kinesthetic</b>	1	✓	✓	<b>\</b>	<ul> <li>Image: A start of the start of</li></ul>	<ul> <li>Image: A start of the start of</li></ul>	<b>\</b>		✓		✓
Naturalist	1			<b>\</b>					✓	1	
Interpersonal	1	1	1	✓	1	1	1	1	1		✓
Intrapersonal	1		<b>√</b>		<b>√</b>	✓			<b>√</b>		

Figure 3. The multiple intelligences used in "Factors that Influence the Weather."

Grade:	7	
Duration:	1 (50 minute) class period	
<b>Ohio Science</b>	Physical Sciences: Nature of Energy	Identify different forms of energy.
Content		
Standards:		

**Overview:** The lesson will help the students understand that electromagnetic waves from the sun are the source of all energy on the earth.

#### **Objectives:**

After completing the lesson, the students will be able to:

State in what form energy travels from the sun to earth.

Explain what happens to energy from the sun once it reaches the earth.

Identify the terms electromagnetic waves, radiation, infrared radiation, and ultraviolet radiation.

#### **Materials:**

several sheets of light- and dark-colored construction paper bandanas or other material for blindfolds heat lamp toaster and bread prism sunscreen lotion

### A. Engage (intrapersonal, linguistic)

Students close their eyes and teacher says:

Imagine a hot, summer day. The sun is beating down on your back, and the sweat is rolling down your face. You convince your parents to take you and your friends to the swimming pool. When you get there, you realize you forgot to put on shoes. How will it feel to walk on the black top? If there is grass nearby, will you try to walk on it? Why?

### **B.** Explore (bodily-kinesthetic, naturalist)

- 1. Point out to students that all parts of the Earth's surface are not heated equally by energy from the sun. Demonstrate this point by placing several pieces of construction paper in direct sunlight on a sidewalk outside. Use white, black, and at least one or two other light and dark colors.
- 2. After the papers have been in the sun for at least five minutes, ask volunteers to put on blindfolds.
- 3. Rearrange the order of the papers and have the volunteers try to tell which papers are light colored and which are dark colored based on how warm or cool they feel to the touch (Padilla, Miaoulis, Cyr, & Simon, 2000).

### C. Explain (spatial, linguistic)

Energy from the sun comes in three types of electromagnetic waves.

- 1. Infrared A heat lamp and a toaster will be used to represent heat. Bread will be toasted.
- 2. Visible light Show students a prism and explain that its angled sides bend the different colors in sunlight by different amounts, splitting the light into a rainbow. Demonstrate by placing the prism in sunlight.
- 3. Ultraviolet Discuss sunburns, skin cancer. Show sunscreen lotion. Discuss that bees and insects see flowers using ultraviolet light.

### **D. Extend (logical-mathematical)**

Pretend a student applied sunscreen with Sun Protection Factor (SPF) 45. Calculate the amount of time a student can be in the sun without getting a sunburn.

### E. Evaluate (interpersonal, linguistic)

Have the students share two things they learned today with the person next to them. For homework, a review worksheet would be given.

### Lesson 2: Energy in the Atmosphere

Grade:	7	
Duration:	1 (50 minute) class period	
<b>Ohio Science</b>	Physical Sciences: Nature of Energy	Identify different forms of energy.
Content		
Standard:		

**Overview:** The lesson teaches the students that the atmosphere can scatter and absorb energy from the sun.

### **Objectives:**

After completing the lesson, the students will be able to:

Identify the terms electromagnetic waves, scattering, and greenhouse effect. Explain why sunrises and sunsets are shades of red.

### Materials needed for each group:

2 glass beakers or other clear	glass containers
water	2 thermometers
flashlight	plastic bag
pipette	2 small pieces of paper
milk – $1/2$ cup	tape
white paper	

### A. Engage (interpersonal, linguistic)

Ask: Yesterday we discussed that white light is made up of all the colors of the rainbow. Can anyone guess what this has to do with a colorful sunrise or sunset?

### B. Explore (bodily-kinesthetic, interpersonal)

- 1. Each group of students is given milk, 2 water-filled beakers, flashlight, pipette, and white paper.
- 2. Shine flashlight through clear water onto the white paper. Students should make observations of the color of the light on the paper and predict what will happen to the light if milk is dropped in the water.
- 3. With the pipette, one drop of milk is dropped into one beaker. Other beaker is kept clear to use as a control. Students observe the color of the light on the paper. (light turns orange)
- 4. Students continue to drop milk into water and observe.
- 5. Groups discuss results and try to explain why results occur (Stepans, 1996).

### C. Explain (linguistic, spatial, bodily-kinesthetic)

Illustrate the following explanation on the board or overhead.

As light bounces off of particles floating in the atmosphere, it causes the light to be scattered. When the sun is rising or setting, light from the sun passes through a greater thickness of the atmosphere than when the sun is higher in the sky. More light from the blue end of the spectrum is removed by scattering before it reaches your eyes. The remaining light from the sun contains mostly red and orange light.

We know that particles in air scatter the visible light and as it comes into the atmosphere. What kind of effect do you think the atmosphere has on infrared radiation? Activity: Does a Plastic Bag Trap Heat?

Give each group 2 thermometers, plastic bag, 2 small pieces of paper, and tape

- 1. Record the initial temperatures on two thermometers (You should get the same reading.)
- 2. Place one of the thermometers in a plastic bag. Put a small piece of paper in the bag so that it shades the bulb of the thermometer. Seal the bag.
- 3. Place both thermometers on a sunny window ledge or near a light bulb. Cover the bulb of the second thermometer with a small piece of paper. Predict what you think will happen.
- 4. Wait five minutes, then record the temperatures on the two thermometers (Padilla et al., 2000).

The bag has trapped the heat causing the temperature to rise. The bag can be compared to our atmosphere. It holds our heat near the earth. This is caused by the Greenhouse Effect. Sometimes pollution causes too much of the heat to be trapped.

### **D.** Extend (linguistic, spatial)

Teacher shows picture of astronaut on the moon. *Would there ever be a colorful sunset or sunrise on the moon?* (*No, there is no atmosphere around the moon.*)

### **E. Evaluation (linguistic)**

Homework: Find some information (from newspaper, internet, encyclopedia, etc.) on the negative effects of extra amounts of carbon dioxide in the atmosphere. Write two paragraphs on the topic.

Grade:	7	
Duration:	1 (50 minute) class period	
<b>Ohio Science</b>	Physical Sciences: Nature of Energy	Identify different forms of energy.
Content		
Standards:		

# Lesson 3: Heat Transfer through Conduction, Convection and Radiation

Overview: The lesson will teach that heat can be transferred in three different ways.

### **Objectives:**

After completing the lesson, the students will be able to:

Identify the terms conduction, convection, and radiation.

Give examples of conduction, convection, and radiation in the real world.

#### Materials:

popcorn (unpopped)	vegetable oil
bowls	air popcorn popper
hot plate	small pan with lid
hot pad	1 package of microwave popcorn
microwave	10 tennis balls

### A. Engage (linguistic)

How can energy help you cook a meal?

### **B.** Explore (linguistic, spatial)

There are three ways to heat the atmosphere. These ways include conduction, convection, and radiation. Let's use an analogy to help you remember these terms. Demonstrate the three ways to cook popcorn (Popcorn lesson (Three Methods of Heating)).

- 1. Put oil in the bottom of a pan. Cover the bottom of the pan with popcorn kernels. Place the pan on the hot plate and turn on the burner to medium heat. Cover the pan with a lid. Periodically shake the pan so the kernels move around in the oil.
- 2. Obtain an air popcorn popper. Place the popcorn kernels in the popper. Hot air will transfer heat to the kernels, making them expand and pop.
- 3. Microwave a bag of microwave popcorn.

### C. Explain (linguistic)

All forms of matter, whether a solid, liquid, or gas, are made of atoms or molecules in constant motion. Because of this constant motion, all atoms have thermal (heat) energy. Whenever a substance is heated, the atoms move faster and faster. When a substance is cooled, the atoms move slower and slower. The "average motion" of the atoms that we measure is what we call temperature.

Heat is the energy that flows due to temperature differences. Heat is always transferred from warmer to cooler substances. Each of these methods of cooking popcorn is really an example of the three ways heat can be transferred.

Conduction. This method of heat transfer is most familiar to people. If you have ever burned yourself on a hot pan because you touched it, you have experienced this first-hand. Conduction is heat transfer through matter. Metals conduct heat well because the molecules are very close together. As a means of heat transfer, conduction is the least significant with regard to heating the earth's atmosphere. The only air heated by the earth is the air at the earth's surface. Which popcorn example does it relate to? (#1). The heat is transferred by direct contact from the pan, to the oil, to the kernels of popcorn.

Convection. Convection is heat transfer by the movement of matter from one place to another. It can take place only in liquids and gases. Heat gained by conduction or radiation from the sun is moved about the planet by convection. The radiation from the sun heats the air of the atmosphere. This hot air rises, allowing cooler air to move in underneath the warm air. This is the cause of wind. *In our popcorn example this relates to #2. The hot air transfers the heat to the* cooler kernels, and when enough hot air heats the kernels they pop. Radiation is the only type of heat transfer that can move through the relative emptiness of space. All other forms of heat transfer require motion of molecules like air or water to move heat. The majority of our energy arrives in the form of radiation from our sun. The particles that reach earth from the sun are within a wavelength that the earth's atmosphere will absorb. When the sun heats the earth, the earth gets warmer in that location and re-radiates heat into the atmosphere. *This relates to popcorn example #3. The kernels are heated by the radiation in the* microwave, and the kernels heat up, giving off more heat to the kernels surrounding it.

Radiation is the primary way that air is heated in the atmosphere. Convection currents move that heated air around the earth, and the difference between warm and cold air provide the energy needed to create weather. (Popcorn lesson (Three Methods of Heating))

#### **D. Extend (spatial)**

Many people wrap a pop can with aluminum foil to keep it cool (show wrapped can). Do you think this works? (No, conduction causes it to heat faster.)

#### E. Evaluate (bodily-kinesthetic, interpersonal)

Separate class into groups of three. Give each group a tennis ball. Challenge the students to model the three different types of heat transfer by using the ball to represent heat and students to represent air molecules. Ask:

*How would you move the ball to represent radiation?* (toss or roll it)

*How would you move the ball to represent conduction?* (pass it from one student to the other)

*How would you represent convection?* (have one student walk with it)(Padilla et al., 2000)

Grade:	7	
Duration:	2-3 (50 minute) class periods	
Ohio	Physical Sciences: Nature of Energy	Identify different forms of energy.
Content		
Science	Scientific Inquiry: Doing Scientific	Formulate and identify questions
Standards:	Inquiry	to guide scientific investigations
		that connect to science concepts
		and can be answered through
		scientific investigations

**Overview:** This lesson will help the students understand the 3 ways heat is transferred. This will lead to greater understanding of weather patterns and winds.

#### **Objectives:**

After completing the lesson, the students will be able to:

Name and describe the three ways heat is transferred.

Identify a real life example of heat transfer as conduction, convection, or radiation.

### Materials/Set up:

*Station 1*: candle, metal spiral cut from an aluminum pie pan, 4 goggles, thread, and lighter or matches.

Teacher must hang the spiral with the thread from the ceiling. Place the candle beneath it (Padilla et al., 2000).

Station 2: hot plate, hot pad, glass beaker, water, ice, food coloring, and 4 goggles Teacher needs to fill the beaker with water and places beaker on the hot plate.

Station 3: wooden spoon, metal spoon, ice, plastic container, and thermal temperature indicator

Teacher needs to place the two spoons into the container filled with ice. *Station 4*: heat lamp (or regular lamp works too) and several heat sensitive receipts from stores like Target or Kroger.

Teacher needs to cut the receipts into strips and plug in the lamp. *Station 5*: markers and butcher paper

Station 5: markers and butcher paper

Teacher should put a heading on the paper: "Ways the 7<sup>th</sup> grade can conserve energy."

Station 6: the classroom heater

*Station 7*: computer with Internet connection to a web site on heat http://www.greatauk.com/wqheat.html

#### A. Engage (linguistic)

Yesterday, we identified the terms conduction, convection and radiation. Today, we will be exploring real life examples of these three types of heat transfer.

### Lesson 4: How Does Heat Travel?

### B. Explore (bodily-kinesthetic, interpersonal, logical-mathematical, naturalist)

Students will be put in groups of 3-4. Each group will spend 10 minutes at each of the 8 stations that are set up around the room. They will follow the directions and answer the questions on the worksheet provided. (Worksheet is provided at the end of this lesson)

## C. Explain: (linguistic)

*Station 1-* The candle heats the air above it causing it to rise. The spiral turns due to the convection current.

*Station 2-* The ice melts. The cold water drops to the bottom and takes the food coloring with it. The heat from the hot plate warms the water and causes it to rise. This is a convection current.

*Station 3-* The metal handle is colder than the wooden handle because the molecules are very close, and they pass the energy (heat) down the handle. This is caused by conduction.

*Station 4-* The receipt is coated with heat sensitive chemicals. When in contact with heat, the chemicals turn black. (Notice that only one side of the receipt gets black because the chemical is only on one side.) If the students touched the paper to the light bulb, it would be conduction. If they held it near the bulb, it would be radiation.

*Station 5-* Conserving energy is very important to our environment. The amount of energy consumed by the United States is enormous! The energy production is causing extra carbon dioxide to be formed. This is leading to global warming (Padilla et al., 2000).

*Station 6-* The heater warms the air above it and causes it to rise and circulate around the room. This is convection.

Station 7- Answers are given on the web page.

### D. Extend: (spatial)

Show a picture of a cumulonimbus cloud. Why do you think it is so tall? (Warm convection currents rise and bring humidity into the cloud to make it even taller.)

### E. Evaluate (linguistic)

The teacher will discuss with the students what happened at each station. The worksheet will be collected and graded to assess each student's understanding.

### How Does Heat Travel? Lab Directions

### Station 1

Directions: Put on your goggles! Keep all flammable materials away from fire!!! Light candle. Observe what the spiral does when the candle is placed under it. 1. Why is the candle causing the spiral to turn? Draw a picture and explain your drawing.

2.	The movement is cause	ed by	
	a. conduction	b. convection	c. radiation

### Station 2

Directions: Put on your goggles! Keep all flammable materials away from hot plate!!! Heat water. Put an ice cube in the warm water. Put 1 drop of food coloring next to the ice cube. Observe.

3. What happens to the drop of food coloring when you drop it in the water? Draw a line and arrow in the beaker below to show the movement of the color. Explain why that happens.



4. The movement is caused by

a. conduction b. convection c. radiation

### Station 3

Directions: Feel the two spoon handles. Measure the temperature of the handles with the thermal temperature indicator.

Type of handle	Temperature of handle (°C)
Wooden	
Metal	

- 5. Which mallet handle is colder? Metal or wood
- 6. Why do you think it is colder?
- 7. The movement of heat is caused by

a. conduction b. convection c. radiation

#### Station 4

Directions: Take a piece of a receipt and touch it to the light bulb. (Be careful! The bulb is HOT!) Observe.

8. After you touch the receipt to the warm light bulb, what happens to the paper?

9. The movement of heat and color change is caused by a conduction b. convection c. radiation

### **Station 5**

Directions: Please neatly write what you can do to conserve energy. Write your name at the end.

10. Is conserving energy a hard or easy thing to do? Why?

### **Station 6**

Direction: Feel the heater. Observe.

11. Since the heater is not blowing heat out, how does the heat get to the other side of the room? (Use conduction, convection or radiation in your answer.)

### Station 7

Directions: On the computer go to http://www.greatauk.com/wqheat.html Have your group try to answers the questions BEFORE you check your answers. (Make sure you look at #2,9,13,16,20,29,30 carefully.)

Grade:	7	
Duration:	1 (50 minute) class period	
Ohio Science	Physical Sciences: Nature of Energy	Identify different forms of energy.
Content		
Standards:	Scientific Inquiry: Doing Scientific	Use graphs, tables and charts to
	Inquiry	study physical phenomena and
		infer mathematical relationships
		between variables.

### Lesson 5: Differences in Heating the Land and Water

**Overview:** The lesson helps the student understand that land and water heat up at different rates. This information will be used when formations of local winds are discussed in later lessons.

#### **Objectives:**

After completing the lesson, the students will be able to:

Develop hypotheses about how quickly sand and water heat and cool. Measure the temperature of sand and water while they are heating and cooling. Create a data table to record their measurements.

Conclude from their data whether sand or water heats and cools more quickly.

#### Materials needed per group:

2 thermometers	ring stand and ring clamp
2 400mL beakers	sand, 300mL
water, 300mL	lamp with 100-W bulb
metric ruler	clock or stopwatch
string	graph paper

### A. Engage (intrapersonal, musical)

(Play ocean sounds CD in background.)

Remember a time when you were walking barefoot on a beach on a hot summer day. What was the temperature of the sand like? (hot)

When you reached the water, how did it feel by comparison to the hot sand? (cooler) Have you ever walked barefoot on the beach at night? Which felt warmer, the sand or water? (water)

### B. Explore (bodily-kinesthetic, logical-mathematical, interpersonal, spatial)

Activity: Heating the Earth's Surface (Padilla et al., 2000)

- 1. Form hypothesis. Do you think sand or water will heat up faster? Which one will cool off faster? Record your hypothesis in the form of an "if...then..." statement.
- 2. Copy a data table into notebooks that looks like the following table. Add enough rows to record data for 30 minutes total (15 with light on, 15 with light off).

Temperature with light on (C)			Temperature with light off (C)		
Time	Sand	Water	Time	Sand	Water
(min)			(min)		
Start			16		
1			17		
2			18		
3			19		
4			20		
5			21		
(etc).			(etc.)		

- 3. Fill one beaker with 300 mL of dry sand.
- 4. Fill the second beaker with 300 mL of water at room temperature.
- 5. Place one thermometer in each beaker.
- 6. Suspend the thermometers from the ring stand with string.
- 7. Adjust the string so that the bulb of each thermometer is covered by about 0.5 cm of sand or water in a beaker.
- 8. Position the lamp so that it is about 20 cm above the sand and water. There should be no more than 8 cm between the beakers. Be careful not to splash water on the hot light bulb.
- 9. Record the temperature of the sand and water in your data table.
- 10. Turn on the lamp. Read the temperature of the sand and water every minute for 15 minutes. Record the temperatures in the Light On column in the data table.
- 11. Turn the light off. Read the temperature of the sand and water every minute for another 15 minutes. Record the temperatures in the Light Off column.
- 12. Draw two line graphs to show the data for the temperature change in sand and water over time. The horizontal axis shows time, and the vertical axis shows temperature. Draw both graphs on the same piece of graph paper. Use a dashed line to show the temperature change in water and a solid line to show the temperature change in sand.
- 13. Calculate the total change in temperature for each material.

#### C. Explain (linguistic, spatial)

Look at the graphs you have created. You should have both lines steadily rising during the first 15 minutes and steadily falling the last 15 minutes. The data should show that the sand had a greater increase in temperature and then cooled down quicker than water. The water took a longer time to heat, but it held its heat longer therefore causing it to cool down at a slower rate.

These results explain why the beach sand is often hot and the water is still cool during the day. At night, the water retains its heat and is warmer than the sand at night.

#### **D.** Extend (linguistic)

If you had a job driving a snowplow in the winter, how would this information help you do your job?

# E. Evaluate (musical, linguistic)

Write a poem about heat, water and land. Include a summary of the information learned in today's lab and a real-life example of heating of land or water in nature.
# Lesson 6: Local Winds

Grade:	7	
Duration:	1 (50 minute) class period	
Ohio Science	Earth and Space Sciences: Earth	Explain the biogeochemical cycles
Content	Systems	which move materials between the
Standards:		lithosphere (land), hydrosphere
		(water) and atmosphere (air).

**Overview:** This lesson will help the students understand that unequal heating of the earth in a specific area causes local winds.

## **Objectives:**

After completing the lesson, the students will be able to:

Explain what causes wind.

Use and read an anemometer accurately.

Describe the difference between a land breeze and sea breeze.

## Materials needed per group:

pen/paper wind vane anemometer that indicates wind speed

### A. Engage (linguistic, intrapersonal)

(Turn on a fan and point it towards the students.) *Imagine a cold, windy day. As you walk outside, a cold blast sends wind to your face, inside your shirt and to your ungloved hands. You shiver, put your hood up, and then walk faster to your destination. You wonder where the wind gust came from. It was calm earlier. Can anyone tell me why the wind blows?* 

### **B.** Explore (bodily-kinesthetic, logical-mathematical, interpersonal)

1. In groups of 3 or 4, have students measure the wind direction and wind speed on each side of the school. It is important that they stand at least 2-3 meters away from the building and not take measurements near the corners of the building or by large plants. They will copy a data table similar to the one below into their notebooks.

Location	Wind Direction	Wind Speed

2. Back in the classroom, students look at their charts and discuss why the wind measurements were different.

## C. Explain (linguistic, spatial)

(Draw a diagram of this explanation on the chalkboard.) Yesterday we learned that sand and water heat up at different rates. We also know that convection currents are caused when hot air rises and cool air falls. When we connect these two concepts, we can realize that as the air over land heats up, it causes the air above it to rise. Cooler air from a different location rushes in to replace the risen air. This is how local winds are formed. As the air moves, it flows around objects in its way and this can cause wind to flow in different directions.

## **D. Extend (Linguistic)**

Some homeowners plant trees around their house. What are some benefits to having trees in the yard? (shade, block the wind, reduce erosion)

## E. Evaluation (interpersonal, linguistic)

In small groups of 3-4, have students explain one thing that was learned today. No one may repeat something said by another person.

## Lesson 7: Global Winds

Grade:	7	
Duration:	1 (50 minute) class period	
Ohio Science	Earth and Space Sciences: Earth	Explain the biogeochemical cycles
Content	Systems	which move materials between the
Standards:		lithosphere (land), hydrosphere
		(water) and atmosphere (air).

**Overview:** The students will explore why winds blow in different directions in different parts of the world.

### **Objectives:**

After completing the lesson, the students will be able to:

Identify where the major global wind belts are located.

Identify the Coriolis effect and describe how it affects the direction of the wind.

Materials:	globe	(Needed for each group)
	small flashlight	marker
		heavy-duty tape
		pencil
		large smooth ball (or a round balloon)

## A. Engage (spatial, interpersonal)

Yesterday, I said that wind is created because certain areas of the land are heated to different temperatures. This causes air to rise and convection currents to form. Why does the earth heat unevenly?

Demonstration:

- 1. Students model the earth and the sun using a globe and a flashlight. With the room lights dimmed, one student holds the globe, and the other shines the light on the equator.
- 2. The teacher calls the students' attention to the fact that the light is direct and bright over the equator but angled and dim at the poles.

How do these differences in energy cause global winds?

The more concentrated energy falling directly on the equator causes air to heat up and rise, while air over the poles cools and drops down, leading to the convection currents that cause global winds (Padilla et al., 2000).

### B. Explore (spatial, bodily-kinesthetic, interpersonal)

Now we know why convection currents form on the earth. What happens if the earth is spinning as the winds are blowing toward the equator?

### Activity:

Do this activity with a partner. Think of the ball as a model of the earth and the marker as representing wind.

- 1. Using heavy-duty tape, attach a pencil to a large smooth ball so that you can spin the ball from the top without touching it.
- 2. One partner holds the pencil and slowly turns the ball counterclockwise (when seen from above).
- 3. While the ball is turning, the second partner will use a marker to try to draw a straight line from the "North Pole" to the "Equator" of the ball (Padilla et al., 2000).

(Expected Outcome- the lines that students draw should veer to the west as the marker goes from the "North Pole" to the "Equator" of the ball.)

### C. Explain (linguistic, spatial)

The spinning of the earth causes the winds to turn toward the west in most areas. This is called the Coriolis effect. Show overhead or go to the following web address for a picture and explanation of the global wind belts.

http://www.islandnet.com/~see/weather/whys/globalwinds.htm

The global wind belts are formed by two main factors: the unequal heating of the earth by sunlight and the earth's spinning. The unequal heating makes the tropical regions warmer than the polar regions. As a result, the cold air falls causing higher air pressure at the poles and warm air rises causing lower air pressure at the equator. Wind flows from high to low pressure. So the atmosphere tries to send the cold air toward the equator at the surface and warm air northward toward the pole at higher levels.

Unfortunately, the spin of the earth prevents this from being a direct route, and the flow in the atmosphere breaks into three zones between the equator and each pole. These form the six global wind belts: 3 in the Northern Hemisphere (NH) and 3 in the Southern (SH). They are generally known as:

The Trade Winds, which blow from the northeast (NH) and southeast (SH), are found in the subtropical regions from about 30 degrees latitude to the equator. The Prevailing Westerlies blow in the middle latitudes. The wind goes southwest in the NH and northwest in the SH. Most of North America fits into this belt and that is why our weather usually comes from west.

The Polar Easterlies that blow from the east in the polar regions.

*This is a basic explanation, but of course in the everyday situation there are major variations.* 

### **D. Extend: (spatial)**

(At home or the next lesson) Look at the Weather Underground web address. Look for wind directions and satellite maps from around the world. http://www.wunderground.com/

#### **E.** Evaluation (linguistic)

Write 2 paragraphs for homework that answer the question "What did I learn today?"

# Lesson 8: More Practice with Global Winds

Grade:	7	
Duration:	1 (50 minute) class period	
Ohio Science	Earth and Space Sciences: Earth	Explain the biogeochemical cycles
Content	Systems	which move materials between the
Standards:		lithosphere (land), hydrosphere
		(water) and atmosphere (air).

**Overview:** This lesson gives the student more time to remember and discuss the global wind belts.

## **Objectives:**

After completing the lesson, the students will be able to:

Identify where the major global wind belts are located. Describe why the major global wind belts form.

# Materials:

pencil/paper encyclopedias or social studies textbooks

## A. Engage (linguistic)

I went through the wind belts very quickly yesterday. Today I want to give you a chance to explore them in more depth.

## **B.** Explore (interpersonal, linguistic)

Divide the students into groups of 3. Provide each group with information about the global winds from different sources such as an encyclopedia or a social studies textbook. Allow time for groups to read.

## C. Explain (interpersonal, musical)

Each group needs to come up with a poem or song lyric about the assigned type of global wind belt. It must be a minimum of 10 lines long (poem) or one verse and chorus (song). It must have specific information in it so that the poem or song can be used for studying.

## D. Extend (linguistic)

Teacher shows students pictures and other information on world explorers from a social studies book, encyclopedia, or Internet. *How did the global winds help new worlds to be discovered?* 

## E. Evaluation (linguistic, musical)

Each group must read their poem or sing their song for the rest of the class. One copy will be collected, copied and given to the rest of the students for study aids.

## Lesson 9: The Water Cycle

Grade:	7	
Duration:	1 (50 minute) class period	
Ohio Science	Earth and Space Sciences: Earth	Describe the water cycle and
Content	Systems	explain the transfer of energy
Standards:		between the atmosphere and
		hydrosphere.

Overview: This lesson will simulate the movement of water through the water cycle.

### **Objectives:**

After completing the lesson, the students will be able to:

Describe the movement of water within the water cycle.

Identify the states of water as it moves through the cycle.

### Materials for each group:

hot plate	glass beaker
water	aluminum pie pan
ice	2 oven mitts
paper towels	paper/pencil

### A. Engage (intrapersonal, linguistic, musical, naturalist)

Have students individually list all possible places and forms that water could be in on the earth. Have water sounds (from a CD or fountain) playing while students are generating a list. The student with the most listed wins a bottle of water.

### **B.** Explore (bodily-kinesthetic, interpersonal, spatial)

(Caution: Burn Hazard! Teacher may choose to do this activity as a demonstration.)

- 1. Students will put two inches of water in the beaker and heat it until it steams.
- 2. Turn hot plate off. Using the oven mitts, the students will place the ice-filled aluminum pie pan on top of the beaker.
- 3. Students look through the beaker to observe what is happening on the bottom of the pie pan. (water droplets form and drop)
- 4. Students write down observations.

## C. Explain (linguistic, spatial)

When water is heated, it evaporates and rises. Since the pan was cold, the water vapor condensed on the surface. The droplets gather until they get too heavy to stay on the surface, and then they fall. This is precipitation.

Please remember that the water cycle is not this simple. The water could be in many different places such as in the soil, a plant, an animal, a river, the clouds, the ocean, a lake, in ground water, or in a glacier. The water could stay in these places for many years.

# **D.** Extend (linguistic)

Why do the car windows fog up when it is raining outside?

# E. Evaluate (linguistic)

Write a creative story or prepare a short play with 2-3 other people about the water cycle from the perspective of a small puddle.

# Lesson 10: Cloud Identification

Grade:	7	
Duration:	1 (50 minute) class period	
Ohio	Earth Space and Sciences: Earth	Make simple weather predictions
Science	Systems	based on the changing cloud types
Content		associated with frontal systems.
Standards:		

Overview: The students will learn how to identify cloud types.

#### **Objectives:**

After completing the lesson, the students will be able to:

Explain how clouds form.

Identify the seven types of clouds.

#### **Materials:**

computer with an Internet connection and a projector. cloud poster 2-liter soft drink bottle hot water oven mitt or potholder funnel

### A. Engage (linguistic)

Yesterday we discussed the water cycle. Let's review it quickly by listing all the places and forms water takes during its long journey through the cycle.

### **B. Explore (spatial)**

Teacher pours hot water into a 2-liter bottle. Students observe what happens. *"Why did the side of the bottle get foggy?" "How does this relate to cloud formation?"* 

### C. Explain (linguistic, spatial, logical-mathematical, naturalist)

The hot water inside the bottle warmed up the air inside the bottle, but the sides were cold because it has contact with the air on the outside of the bottle. The air right next to the sides cooled down. That air couldn't hold as much water, so the vapor condensed into water droplets.

Clouds of all kinds form when water vapor in the air becomes liquid water or ice crystals. The process in which molecules of water vapor in the air become liquid is called condensation. Cold air can hold less water vapor than warm air. As air cools, the amount of vapor it can hold decreases. Some of the water vapor in the air condenses to form droplets of liquid water.

Cloud development in the atmosphere depends on temperature, humidity, and the presence of dust in the air. The seven main types of clouds are stratus, cumulus,

nimbostratus, cumulonimbus, altostratus, altocumulus, and cirrocumulus. (Show poster or pictures of clouds.) This may seem confusing. Let's break down the meanings of the words.

Cumulus = puffy Stratus = flat Nimbo = precipitation Alto = Middle cloud Cirro/ Cirrus = High cloud

Show cloud pictures from the following Internet sites. Help students learn clouds through their characteristics. (*This cloud is puffy and high. What type of cloud is it?*)

Cerritos College Cloud Identification for Earth Science 110 http://www.cerritos.edu/earth-science/tutor/Clouds/cloud\_identification\_es10-2a.htm Geography 101 Cloud Tutorial http://www.cerritos.edu/rkreger/cloudtutorial/tutorialpage1.html Plymouth State University Meteorology Program Cloud Boutique http://vortex.plymouth.edu/clouds.html

### **D. Extend: (spatial)**

Go to the window of the classroom. *What types of clouds are in the sky? Should we prepare for rain?* 

### E. Evaluation (spatial, linguistic, naturalist)

Have students take a cloud quiz from the following site to see how much they have learned.

Cloud Identification Chart http://webphysics.ph.msstate.edu/cl-id/clouds/clouds1.html

## Lesson 11: Precipitation

Grade:	7	
Duration:	1 (50 minute) class period	
Ohio	Earth Space and Sciences: Earth	Make simple weather predictions
Science	Systems	based on the changing cloud types
Content		associated with frontal systems.
Standards:		
		Describe the water cycle and
		explain the transfer of energy
		between the atmosphere and the
		hydrosphere.

**Overview:** The lesson will describe the various forms of precipitation that fall from the clouds and the expected weather from certain cloud types.

### **Objectives:**

After completing the lesson, the students will be able to:

Identify the common types of precipitation.

Identify the types of clouds that produce rain.

### Materials for each group:

transparent plastic lid dropper pencil water white paper scissors

### A. Engage (bodily-kinesthetic, musical)

Thunderstorm simulation ("The Thunderstorm," 1995): Have students stand up. Explain that when the teacher faces in the direction of the students they should mimic the teacher's motion and continue to do it until she faces the students again and does a different motion. Use the following series of motions:

Rub your hands together Snap your fingers Clap your hands Slap your hands on your legs (At this time one student could flick the lights on and off to simulate lightning, while another student beats on a drum to simulate thunder.) Stomp your feet. Slap your hands on legs and stomp your feet (represents height of storm) Stomp your feet Slap your hands on your legs. Clap your hands Snap your fingers Rub your hands together Open palms (quiet)

## **B.** Explore (interpersonal, bodily-kinesthetic, spatial)

We just made it sound like a thunderstorm. It rains a lot during a storm. There is always moisture in the air and clouds, but it does not always fall. Let's find out why.

- 1. In pairs, students will fill a dropper with water and squeeze out several drops onto the inside of the plastic lid.
- 2. One student quickly turns the lid over and holds it, while the other student uses the tip of the pencil to drag the drops together. The drops will leap together.
- 3. When the drops are large enough, they will fall like rain (Padilla et al., 2000).

## C. Explain (linguistic, spatial, bodily-kinesthetic)

Clouds are made of water droplets. When wind and gravity move them around, they bump into one another and make larger drops. Just like in the activity, they must be large drops in order to fall to the ground.

Rain falls when the temperature is above 0 °C, and the droplets are larger than 0.5 mm in diameter. Cumulonimbus, altocumulus, altostratus, stratus, and nimbostratus clouds can produce rain.

Droplets smaller than 0.5 mm are called mist or drizzle. They usually fall from nimbostratus clouds.

These types of precipitation occur when the temperature is below  $0 \, ^{\circ}C$ .

Freezing rain occurs when the drops fall through cold air near the ground but do not have enough time to freeze. Instead they freeze when they hit a cold object on the ground.

*Sleet forms when rain falls through layers of air that are below 0 °C and the drops freeze.* 

(Draw a picture of cumulonimbus cloud on the chalkboard to use as you talk.) Hail, round ice pellets that are larger than 5 mm in diameter, are only formed inside cumulonimbus clouds. They are made when ice pellets are carried up and down inside the cloud by strong updrafts. Each time the pellet goes through a cold layer in the cloud another layer of ice forms. This continues until the updraft can no longer support the pellet's weight, and it falls to the ground. Snow occurs when water vapor from a cloud turns directly into ice crystals. All snowflakes have 6 sides or branches.

### **D. Extend (bodily-kinesthetic, spatial)**

If time permits, have students cut six sided snowflakes. Start with a square piece of white paper. Fold the opposite corners together to form a triangle. Next, fold the triangle into three equal triangles. Finally, cut intricate crystal structures on the folds.

### E. Evaluation (linguistic, musical)

Write an acrostic poem. Each line of the poem should start with a letter in the word PRECIPITATION.

# Performance-Based Assessment: Factors That Influence the Weather

Directions: Choose one of the following activities. Prepare it alone or with one other person. It will be used as a test grade to assess your knowledge of factors that influence the weather.

## 1. A Day in the Life of a Water Drop

Perform a skit, write a creative essay, or give a speech about what it would be like to be a drop of water for a day. You must include information on the water cycle, types of heat, and weather (clouds, precipitation, etc.)

### 2. The Weather Rap

Write a poem or song that discusses types of heat, winds, water cycle, clouds, and precipitation. It must be read or performed in front of the class. (If sung, you may ask 2-3 people to be back-up singers/dancers)

### 3. Precipitation Poster

Create a poster that shows pictures, diagrams, etc of weather related information learned in this unit. A brief oral presentation of your poster is required.

## 4. An Exciting Experiment

Find a weather related experiment from a book that was not performed or discussed in class. Perform a demonstration for the class. Explain how it works and why it is important information to know.

### 5. Wonderful Weather Forecast

Use the Internet to show current weather maps. Give a weather report for our area. Discuss the formation of winds (local and global) and precipitation.

## 6. The Weather Weekly

(For group of 3-4) Create an issue of The Weather Weekly newspaper. Each group member must write a factual weather article with an illustration for the front page. Each member must also compose one of the following weather-related newspaper parts: Advertisements, editorials, weather forecast, political cartoon, sports page, or other approved newspaper section.

### 7. Create Your Own Project

Create a weather related project of your own. Please get teacher approval before work begins.