PICTURE IT:
VISUAL-SPATIAL TEACHING
TO IMPROVE SCIENCE LEARNING

by

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In presenting this professional paper in partial fulfillment of the requirements for a master’s degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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July 2012
LIST OF TABLES

1. Data Triangulation Matrix ...........................................................................................................22
2. Fall 2011 Fourth Grade Classroom Visual-Spatial Identifier Self Report ..................26
3. Fall 2011 Classroom Visual-Spatial Identifier Identifying Responses Sorted by Student .................................................................................................................................29
4. Fall 2011 Student Response to Visual-Spatial Identifier Key Indicator Questions ....30
6. Spring 2011 Student Response to Visual-Spatial Identifier Question .........................34
7. Fall 2011 Fourth Grade Classroom Pre-Test Results .................................................................36
8. Winter 2012 Fourth Grade Classroom Post-Test Results .......................................................38
9. Spring 2012 Fourth Grade Classroom Post-Test Results .......................................................42
LIST OF FIGURES

1. 2011-2012 Fourth Grade American Indian Student Test Results ....................................47
2. 2011-2012 Fourth Grade Non-American Indian Student Test Results ..........................54
All students do not learn by the same means, but rather, each student has their own way of learning. They may incorporate more than one learning style to best suit their needs, but prefer one style instead of another. The purpose of this study was to evaluate whether integrating a visual-spatial teaching style would improve student test scores in the classroom and if they would retain the new content. Visual-spatial activities were incorporated into the lessons on a daily basis to support the learning of vocabulary. The research also allowed for the identification of students who preferred this learning style rather than other styles of learning. Assessments and student interviews were used to determine whether this style of learning was effective in the classroom. A comparison of the data showed an increase in test scores from the pre-test to the post-tests. Student interviews reported that they preferred learning with the visual-spatial strategies.
INTRODUCTION AND BACKGROUND

Background

Hardin Intermediate School is located in Hardin, Montana, 45 miles southeast from the largest city in the state. Hardin Intermediate consists of 312 students in third through fifth grades. It provides services to Crow and Northern Cheyenne tribal members as well as residents of the town, including the farming and ranching area. The school consists of five third-grade classrooms with one intervention room, five fourth-grade classrooms with one intervention room, and five fifth-grade classrooms with one intervention room. The school employs 25 certified staff members, including music and physical education, and ten paraprofessionals.

I have been teaching 4th grade at Hardin Intermediate School in Hardin, Montana for 10 years. My classroom consists of 23 students with 10 girls and 13 boys. Nine students leave the classroom for math and/or reading intervention, a supplemental program for students who test at the beginning of the school year below the current grade level. Three students leave at different times during the day for extra reading intervention to prepare them for the lesson for the next day. One student receives services in the special education classroom for Math and Language Arts. Approximately half of my class is eligible for free or reduced lunch. My classroom consists of 70% Native American, 36% Caucasian, and 4% Hispanic students representing a diverse community of cultural groups (PowerSchool, 2012).
Focus of Study

The overarching purpose of the study was to improve my teaching skills and improve my students' content scores. I wanted to know if the students were able to remember the content learned from using visual-spatial oriented science activities in the classroom. More specifically, the purpose was to examine whether students gained knowledge in the content area by implementing a visual-spatial learner based approach, and whether the gains, if any, were the same for all students or greater for the groups specified in my action research. This research gave me the necessary data to tell whether I should continue this approach in my classroom.

I have been incorporating several of these techniques in my classroom throughout the year during instruction for different content areas. “Spatial representations, when used well, support learning in reading, mathematics, and science.” (Sawyer, 2006, p. 283). One example is during Language Arts. I introduce that week’s vocabulary using a power-point slideshow that incorporates a picture with the definition representing the new word. To reinforce this technique, the students have to draw a picture representing the word and write a sentence that explains the picture using that vocabulary word. As a class, we follow up these techniques by reviewing the words and definitions each day.

In the fall before the treatment began, the Visual-Spatial Identifier (Appendix A) was administered to the students in my classroom by reading the questions aloud to accommodate students who needed assistance. The identifier had the students rank themselves from one (not true) to five (very true) using statements in relation to key characteristics that identify visual-spatial learners. One example is “I solve problems in
unusual ways” (Golon, 2008, p. 32). With this in mind, I was able to incorporate those teaching techniques into my lessons during the treatment period. Visual-spatial teaching techniques included the use of drawing pictures or diagrams and creating 3-D representations to present the concept.

**Focus Questions**

From using these different techniques in the other content areas, it interested me to see how my students’ science test scores would improve if I designed my lessons around these teaching strategies. More specifically, the purpose was to examine whether students gained knowledge in the content areas by implementing a visual-spatial learner based approach, and whether the gains, if any, were the same for all students or greater for certain groups.

Focus questions:

1. Will my students’ science knowledge improve by implementing a visual-spatial learner based approach?

2. Will the gains of all students be the same or will they vary by students’ learning styles compared to this new teaching style?

3. Do American Indian students show more gains on their science assessments compared to Non-American Indian students using the visual-spatial learning techniques?

4. Will the students retain the learned science content after an extended amount of time has lapsed?
CONCEPTUAL FRAMEWORK

Introduction

Students have been using different styles of learning to adapt to their needs for many years. This action research focuses on the visual-spatial learning style, how students use it to learn, and what techniques are available for teachers to incorporate in their classrooms. “Forming mental images is the capacity to picture things inside your head” (Lazear, 2000, p. 21). Thomas Gardner (1983) explains that

Spatial intelligence entails a number of loosely related capacities: the ability to recognize transformation of one element into another; the capacity to conjure up mental imagery and then to transform that imagery; the capacity to produce a graphic likeness of spatial information; and the like. (p. 176)

Gardner (1983) also states that

central to spatial intelligence are the capacities to perceive the visual world accurately, to perform transformations and modifications upon one’s initial perceptions, and to be able to re-create aspects of one’s visual experience, even in the absence of relevant physical stimuli. (p. 173)

Throughout time, higher thinking individuals such as Albert Einstein, Charles Darwin, and Sigmund Freud, developed their theories using visual images (Armstrong, 1993). “These images represent cognitive schemas or “mental maps” that helped guide the development of thought in these geniuses over a period of years” (Armstrong, 1993, p. 56).
Theory

The theory of multiple intelligences, developed in 1983 by Howard Gardner, reflects what teachers already know about their students: that they have different styles of learning that make them intelligent (Stepanek, 1999). He supports the existence of these multiple intelligences by describing that some people are quite skilled in one area, while they have average abilities in other areas (Ormrod, 2006). In 1983, Gardner identified eight different intelligences: logical-mathematical, linguistic, visual-spatial, body-kinesthetic, musical, interpersonal, intrapersonal, and naturalistic. Of the different intelligences, the realms of the logical-mathematical and linguistic intelligences are usually concentrated on by schools. They are reinforced by the measure of these intelligences with IQ tests and standardized tests. As times are changing, teachers are becoming more interested in Gardner’s theory and beginning to incorporate the eight intelligences into their teaching. As Gardner (1999) states,

A species-wide definition represents one essential claim about human intelligences; the existence of individual differences in the profile of intelligences marks the other. Although we all receive these intelligences as part of our birthright, no two people have exactly the same intelligences in the same combinations and that we each have a unique blend of intelligences. After all, intelligences arise from the combination of a person’s genetic heritage and life conditions in a given culture and era. (p. 45)
In today’s classrooms, one-third of the students are visual-spatial (Golon, 2004). To reach these students, teachers simply need to incorporate more visuals with the new information that is being introduced (Golon, 2004).

**Brain Related**

Stimulating the brain with adequate difficulty levels promotes learning. Each person uses both brain hemispheres in different measures. Brain research continuously overturns established ideas about how the brain influences observed differences in student learning styles or intelligences. Research is not yet conclusive in this area of study. Silverman states, “Individuals who have enhanced right hemispheric development, perceive and organize information in a different manner from those who have greater left-hemispheric development” (Silverman, 2002, p.16). Visual-spatial intelligence might focus on the right hemisphere of the brain. The right hemisphere enables us to see the “big picture” as our mental video camera. “Right hemispheric strengths include: art, geometry, thinking in multiple dimensions, music, creativity, empathy, design and invention, and the sheer joy of creating something wonderful out of the trash you nearly threw away” (Golon, 2004, p. 6).

Visual-spatial learners think in images instead of words (Golon, 2008; Gregory, 2005). Visual-spatial learners are able to synthesize (creating a whole by melding the parts). They are capable of developing perception through experiences (Silverman, 2002). Visual-spatial learners communicate in images rather than language. Non-visual-spatial learners are sequential, breaking down information into parts, use verbal language, and rationalize (Silverman, 2002). Engagement is true for visual-spatial learners as well
as all learners. Dr. Jerre Levy stated, “Unless the right hemisphere is activated and engaged, attention is low and learning is poor” (Silverman, 2002, p. 15). Every student in the classroom can benefit from activating the right hemisphere by posing challenging tasks that stimulate both hemispheres (Silverman, 2002). According to Gardner (1983), “The right hemisphere proves more important for the solution of problems than does the left” (p. 183).

**Culture**

Learning styles can be influenced by culture, though some students’ learning preferences are not always shared through a cultural background (Jarrett & Stepanek, 1997). Cultures from different areas developed types of spatial intelligence conducive to their lifestyles. Gardner states, “Eskimos have developed a high degree of spatial ability, possibly because of the difficulty of finding their way around their environment” (Gardner, 1983, p. 201). “Highly developed spatial abilities are also found amongst a radically different population—the Puluwat people of the Caroline Islands in the South Seas in which they have highly developed skills of navigation” (Gardner, 1983, p. 202). The Visual-Spatial Resource Access Team studied the preferred learning styles of the predominately Navajo students in the Page, AZ school district. Of the 530 students, 390 of the Navajo students in the district were visual-spatial learners (Golon, 2008, p.5).

American Indian students may have a different learning environment in the home than at an educational facility. Typically, a school environment restricts freedom of movement in the classroom and limits learning through exploration and hands-on activities. This is the opposite in an American Indian household. These environments
emphasize visual, spatial, and kinesthetic orientations, while classrooms emphasize verbal, mathematical, and logical orientations. American Indian students have tendencies to learn using visual perception and memory along with a preference for movement and activity while learning (Cajete, 1999).

**Visual-Spatial Learners**

Individuals who think in images are visual-spatial learners. They learn from the whole picture rather than step-by-step seeing from many perspectives (Golon, 2008). “These students can create images from visual input, create images from touch, form images based on sound and language, and create images in the absence of any immediate input” (Sawyer, 2006, p. 287). Visual-spatial learners exhibit several different qualities: “intuition, originality, and the ability to synthesize information from a variety of sources” (Silverman, 2002, p. 337). Visual learners learn best by examination. “They are able to see detail and appreciate graphs, charts, and representations to make sense of and develop an understanding of concepts and ideas” (Gregory, 2005, p. 62). To know it, they need to see it (Fliess, 2006). Visual-spatial learners are at a disadvantage on class and state achievement tests that are timed tests requiring them to show their work. Silverman states, “Being required to show their work is nearly impossible for some visual-spatial children, because they see it all at once, rather than arriving at answers through traditional steps. They just know. They don’t know how they know and they can’t explain to anyone else the route they took to the knowing—they just see it” (Silverman, 2002, p. 94). Alexandra Golon compares a visual-spatial child to a computer. She states
Streams of text can be downloaded and recalled almost instantly on a computer. Images, however, can take considerably longer. For the visual-spatial child, the image is readily there, but downloading the translation of that image into something that can be communicated—the actual words to describe that picture—can be a time-consuming struggle for them. (Golon, 2004, p. 6)

Howard Gardner (1983) states, “while these images are typically seen as helpful aids to thinking, some commentators have gone much farther, deeming visual and spatial imagery as a primary source of thought” (p. 177). He further states,

Linguistic and spatial intelligences provide the principal sources of storage and solution. Confronted by an item in a standardized test, individuals appear to use words or spatial images to approach the problem and to encode it and exploit the resources of language and/or imagery to solve the problem. (Gardner, 1983, p. 177)

Research

A multidisciplinary team developed the Visual-Spatial Identifier over a ten-year period to conduct studies to identify visual-spatial learners. The team studied 750 students, fourth through sixth graders, in two urban and rural school districts to make their determinations (Silverman, 2002). The identifier has students rank themselves from one (not true) to five (very true) using statements relating key characteristics that identify visual-spatial learners. One example is “I solve problems in unusual ways”. According to the Visual-Spatial Learner: Characteristics Comparison, students who developed their own method of problem solving are recognized as visual-spatial learners (Jarrett et al.,
Therefore, if a student ranks himself as a five, he has one characteristic of a visual-spatial learner. Depending on the responses on the identifier and the learning characteristics according to the comparison, students can be identified into the visual-spatial learner category.

In a study done by Standing (1973), it was found that people have an open expanse of memories for pictures (Sawyer, 2006). In his research, ten people were shown thousands of pictures over a five-day period. A rate of 83% recognition of the pictures was discovered with vivid pictures being recognized more frequently (Sawyer, 2006, p. 284). Although he may have exaggerated the trend, “Standing extrapolated that if people saw a million vivid images, they would retain 986,300 in the near term, and would recognize 731,400 after a year,” stated Sawyer (2006, p. 284).

**Retention and Recall**

The visual-spatial intelligence correlates significantly with working memory capacity. “For new information to truly be learned, it must transfer, and assimilate, into our long-term memory” (Connell, 2005, p. 107). The way information is processed and stored in the brain is important (Hindal et al., 2009). Visual-spatial learners are encouraged to create mental images for recall and comprehension (Golon, 2008). Incorporating images by drawing, using a diagram, or mentally creating an image into new material being learned will increase the likelihood students will retain new information permanently (Golon, 2008). Webs and concept maps are effective teaching tools due to the fact that they implement visual chunking to process and remember information (Connell, 2005). “Usama (2002) notes that cognitive characteristics relate to
the way in which people tend to perceive, remember, think, solve problems, organize and represent information in their minds. This offers a useful picture” (Hindal et al., 2009, p. 188). Students who are able to separate relevant material from its context do not overload their working memory. In the context of science, visual-spatial learners are able to select what is important and disregard what is not (Hindal et al. 2009). Hindal and collaborators state “Baddeley (1986) found evidence showing that the working memory had some kind of separate ‘loops’ for visual material and auditory-verbal material while those with higher abilities in the visual-spatial were found to be better at recalling ” (Hindal et al., 2009, p. 190). Having visual-spatial abilities correlates as a measure of being divergent, the ability to generate links between long-term memory, and the ability to store information in the form of pictures, diagrams or spatial relationships (Hindal et al., 2009).

Visuals are an excellent way to help students remember and retain information. “Retention refers to the process whereby long-term memory preserves a learning in such a way that it can locate, identify, and retrieve it accurately in the future,” (Sousa, 2006, p. 86). When a student creates a visual scene, the chances of retrieval doubles (Sawyer, 2006). According to Sousa, the retention rate for a student after a 24-hour period is 20% using visual spatial strategies (Sousa, 2006). Gregory defines the retention rate for visual students as 30% using the research from the National Training Labs in Bethel, Maine (Gregory, 2005, p. 115). Being able to retain content for later retrieval depends on how we learned the information in the first place (Dixon, 1983). Visual-spatial learners especially need instruction in meaningful and connected ways of learning (Dixon, 1983). When students are able to manipulate symbolic structural components, they are able to
solidify their understanding of the content, whereas, pictures facilitate understanding (Dixon, 1983, p. 218). “Successful teachers use a variety of methods, keeping in mind that students are more likely to retain and achieve whenever they are actively engaged in the learning” (Sousa, 2006, p. 95).

**Teaching Strategies**

Educators use a variety of methods to reach visual-spatial learners. Providing students with the opportunity to draw or paint, allows them to use their spatial intelligence (Armstrong, 2000). Visual-spatial learners thrive when the right hemisphere is activated through color, humor, imagery and visualization, and hands-on activities (Golon, 2004). Verbal instruction is enhanced by visual aids, such as pictures, models, drawings, and objects (Jarrett et al., 1997).

The implications for the sciences of the visual-spatial characteristic are immense, with the extensive use of diagrams, graphs, models, and visual representations: circuit diagrams and geometrical optics in physics, the various visual representations of electrolysis and diagrams to show atomic and molecular structures in chemistry, models of biological structures and various life cycles in biology. (Hindal et al., 2009, p. 189)

By incorporating strategies that engage visual-spatial learners, all the students in the classroom are more effectively reached and benefit (Golon, 2008). Alexandra Golon states,

As educators, we can no longer ignore the importance of visual-spatial skills for current and future generations of students. We must nurture them in those
students who were born with them and cultivate them in the others. We no longer can afford to teach just the basics of reading, writing, and arithmetic; today’s students will face a job market completely foreign to us. (Golon, 2008, p. 14)

With guidance from compassionate teachers, visual-spatial learners can have an advantage in school (Golon, 2008).

A Hawaiian nonprofit organization, Pacific Resources for Education and Learning (PREL), is using the visual environment to enhance science literacy for the children in their area (Phillips, 2011). This K-12 instructional approach is based on integrating science instruction with art, language structure, technology, and writing. Picturing Science consists of three elements: 1) increasing vocabulary knowledge; 2) applying word knowledge; and 3) writing purposefully in cognitively rich contexts (Phillips, 2011, p. 3). Through the use of observational drawing, photography, symbols, and gestures, students increase vocabulary knowledge by labeling and collecting vocabulary relevant to the content being studied. Students use the collected knowledge to apply it to their own surroundings. Using visualization techniques, students describe, analyze, and interpret images using the vocabulary and apply it to real life surroundings (Phillips, 2011). The third element has students develop descriptive writing relevant to their observations. “These teaching techniques can also help diverse learners acquire vocabulary and concepts by connecting images to words in the real world” (Phillips, 2011, p. 4).

Obstacles for Visual-Spatial learners

Visual-spatial learners have many obstacles in their learning. Their three-dimensional minds have a difficult time grasping two-dimensional experiences. They
live in a world of moving dynamic shapes. One obstacle for these students is the teacher. “Traditional lecturing and teacher-centered instruction in the classroom is the preference showing that there is reluctance to take risks to engage students in open-ended kinds of projects or to use a range of intelligences” (Gardner, 2004, p. 215). Instructors may lack confidence or intellectual strength and select projects or activities that have little aptitude or flair. Students may also enjoy doing these types of assignments making teachers feel that they are not complex enough to challenge students (Gardner, 2004, p. 215).

Math facts are another issue for visual-spatial learners. Rote memorization is a challenge for these students. Being natural mathematicians and scientists and excellent pattern-finders, memorizing facts is difficult for them. They use visual images in their minds to understand a concept. Timing them on math facts poses an obstacle for the visual-spatial learner since they don’t have sufficient time to convert the pictures they have stored in their minds into words or numbers (Silverman, 2002). The left side of the brain originates our sense of time. School is run by time. Students are required to complete assignments on time, arrive on time, change subjects at certain times, and take timed tests. All left-brained hemisphere attributes inconclusive in current research (Silverman, 2002).

Testing itself is a challenge for visual-spatial learners. Many tests do not include visual images hindering these learners’ understanding of the questions (Silverman, 2002). These learners are also under additional pressure to retrieve pictures from their stores making it more difficult for them. Because some visual-spatial learners are dyslexic, highly gifted, or divergent thinkers, they have difficulties grasping exactly what the test question is asking. This causes them to see possibilities under different circumstances for
several of the answers to be correct (Silverman, 2002). Visual-spatial learners are poor at rote memorization, while many “tests require regurgitation of memorized information” (Silverman, 2002, p. 336). Because visual-spatial learners do not have strong sequential skills, it is difficult for them to organize their thoughts to write essays. Along with this, math tests that require visual-spatial learners to show their work are difficult for them because they arrive at answers unconsciously or by using pictures (Silverman, 2002). National, state, and local mandated tests also are causing issues for VS learners. The time that is dedicated in classrooms to prepare students for these assessments leaves little or no time for even the most ingenious practitioners to devote much time to visual-spatial activities (Gardner, 2004, p. 215).

Our civilization has developed over the last thousand years by being educated (Silverman, 2002). More attention needs to be given in schools to the development of visual-spatial abilities as the movement of the future leans toward technology. The transformation of our culture began with books, movies, then television, and now computers. Through the use of computers, visual-spatial learners are engaged through visual representations of information, graphic displays, icons, the mouse, the keyboard, and the de-emphasis on time (Silverman, 2002). “The beneficial aspects of visual-spatial reasoning will become more prized in this century as technology continues to advance” (Silverman, 2002, p. 356).
METHODOLOGY

During an eight-week treatment period, visual-spatial instructional strategies were integrated into science lessons to teach science concepts to a fourth grade classroom consisting of 23 students at Hardin Intermediate School. After the treatment began, one student moved changing the demographics of my classroom to 68% American Indian, 27% Caucasian, and 5% Hispanic. This student was identified as a high visual-spatial learner. The research methodology for this project received an exemption by Montana State University’s Institutional Review Board and compliance for working with human subjects was maintained. Visual-spatial learners learn by transforming the content into images in their minds or by developing the content into two- or three-dimensional forms (Armstrong, 2000). The Visual-Spatial Identifier was administered to each student before the lessons began to identify which students tended to use this learning style. The lessons used visual-spatial teaching strategies to determine improvement in student learning. Several of the activities that I incorporated followed suggestions in 7 Kinds of Smart to develop spatial intelligence. Armstrong suggested in his book “purchasing a visual dictionary” (Armstrong, 1999, p. 61). I had the students create a visual dictionary using drawings or printed images. He also suggested to “make three-dimensional models” (Armstrong, 1999, 61). Several of the activities were using three-dimensional imagery. One other suggestion that he makes is “incorporating drawings and diagrams into presentations” (Armstrong, 1999, 61). I incorporated these in two ways: by having the students draw, and by using the diagrams in the presentations and on the assessments. Teacher observations along with formal assessments were used to collect data to
investigate if only the visual-spatial learners improved or if all students in the classroom showed improvement.

Pre-Assessment

The week before the treatment, the *Visual-Spatial Identifier* (Appendix A) was administered to the students in my classroom. To ensure that all students were interpreting the question in the same manner, I read each question. I then gave my interpretation of the question so that everyone involved understood it in the same way. As previously mentioned in the paper, the identifier was used to help me to discover which students tend to use this style of learning. After I analyzed the data, I had a small group of students that were identified as high visual-spatial to track during the treatment. This also allowed me to track the progress of the other students to see if they also benefited from this teaching style.

When the treatment began in the fall, the students began a unit about the solar system with a pre-test (Appendix B). The test included vocabulary and diagrams of the solar system. Students were required to label the planets with the correct name in the correct order. The vocabulary section was matching the descriptions of the planets and other celestial bodies with the definition. They also had a word bank box in which they chose words to fill in the blanks in appropriate sentences or to match diagrams. The unit was taught in three different lessons over a period of eight weeks: Lesson 1 on Moon and Sun, lesson 2 on planets, and lesson 3 on stars, constellations, comets, and asteroids.
Treatment

To reinforce the vocabulary throughout the unit, the students drew a picture to represent the word and wrote the definition next to the picture. I created a power-point slideshow that incorporated a picture with the definition representing the new word. As a class, we followed up these visual-spatial techniques by reviewing the words and definitions each day. As a review for the vocabulary before the test, the students created memory games, matching images and text. Once they had the words with a picture on one set of cards and the definitions on the other set of cards, they turned them over and took turns matching the pairs. When all the matches were made, the player with the most matches won.

Before beginning the lessons, the students were also required to draw a picture representing everything they knew about the solar system. This served two purposes: it allowed me to measure the students’ background knowledge and allowed me to see their representations in relation to each other in their drawings. For instance, did they draw the moon in the correct position and proportion in comparison with the Earth and the Sun?

In the first lesson I used a visual-spatial activity that models how the Sun heats the Earth’s surface. Students were given a chart with the appropriate headings to record their observations (Appendix D). The students worked in small groups. Each group was given a container with sand, a container with soil, and a container with water. They were also given a thermometer for each container and a heat lamp. Students recorded the beginning temperatures after the thermometer was in the containers for two minutes. Before placing the containers under the heat lamps, the students made predictions. Next,
they placed the containers under the heat lamp and waited for approximately fifteen minutes and recorded the new temperature. The class discussed their results and conclusions. The students should have come to the conclusion that the Earth is heated differently by the Sun depending on its composition.

To begin the next lesson, I administered the Moonlight probe (Keeley, 2009) (Appendix E). The purpose of this probe was to discover student misconceptions about light and the Moon. I wanted to know if students knew whether the moon has its own light source or if it received it from a different source. It was also an introduction to the moon phases. I also administered the Going Through a Phase probe (Keeley, 2005) (Appendix F). This probe tied in with the other probe in that it also pertains to the reflection of light on the Moon from the Sun. I was also able to ascertain whether students knew that the phases changed due to the position of the Moon in relation to the Earth and Sun. To help the students learn the phases of the moon, they participated in two different activities. First, they tried to recreate the phases of the moon by using a flashlight to represent the Sun, a small bouncy ball to represent the Moon, and a larger styro-foam ball to represent the Earth. They worked in groups to rotate the ball around the “Earth” to recreate the different phases of the moon. By doing this, they created a picture in their minds to refer back to when they were learning more or doing the post-test. Also, as part of this lesson, the students used Oreo cookies to make a representation of the moon phases. In order to do this, they twisted the cookies apart and used both sides of the cookie. They scraped off or added the frosting to make it match one of the moon phases. After they made representations for all of the phases, they glued the cookie to a piece of construction paper in the correct order of the phases. Once that was done,
they labeled each phase with the appropriate name. This activity provided them with a picture that they could recreate in their minds when they needed to recall the information. I also showed the students a moon calendar located on the Internet. To follow up this activity, I gave each student a calendar that they could use to record their observations of the moon each night. The students also listened to a Crow story called “Sun and Moon”. It tells how the Crow people used the phases of the moon in their daily lives when they were nomadic.

As an introduction to the next lesson, I had the students do the Outer Planets investigation in our science textbook (Appendix G). The students drew circles and labeled them with the planet name to represent the outer planets using the metric measurements provided. After cutting out the circles, the students filled out the chart (Appendix H) using their “planets” as models. This activity allowed students to visualize size comparisons between the outer planets and to determine that the size of the planet gets smaller the farther away from the Sun it is located. They also used this activity to learn the order of the planets. Next, the students did an activity referred to as Adopt a Planet using the teacher created questions (Appendix I). The students were organized into groups and each group drew out of a bag which planet they would adopt. They discussed amongst themselves who would be responsible for finding which information and how they would create and organize their posters. The students did research using books from the library, their science textbooks, and the Internet websites that were provided for them. Students were given four days of class time to research and create their final project. They were to create a visually appealing poster integrating color, font size, and appropriate science content. The groups displayed their posters around the
classroom. Each group rotated to a different poster making observations of differences and likenesses between their planets.

The next lesson in my unit consisted of the stars and constellations. The students created star clocks (Appendix L). This activity introduced the students to the position of the Big Dipper in the night sky during the different seasons. The objective of this activity was for students to discover that the North Star does not change position. They also discovered that people could use the Big Dipper to tell time during the night. The students then listened to a Crow story called “The Seven Stars.” The story represents their version of how the Big Dipper was created. The students also read the section of their science textbook that pertained to constellations.

For the next lesson, the class viewed pictures of other celestial bodies in the solar system. They also viewed BrainPop videos about asteroids and comets.

Post Assessment

The students used their posters and vocabulary memory games to review for the post-test. The post-test (Appendix M) was administered. After a two-month period the post-post-test was administered to gage the students’ retention of the content learned.

At the end of the unit, several students were interviewed using the teacher created interview questions (Appendix C). The purpose for the interviews with my students was to gain their personal thoughts pertaining to how they think when applying the information they have learned. I also questioned them about the visual-spatial activities that they participated in and if and how they helped them to learn. I questioned them as to which vocabulary approach they preferred and which helped them to learn the best.
During the treatment period, visual-spatial teaching strategies were implemented in my classroom. Through these activities I was able to determine whether these strategies improved my students’ learning through the use of rubrics and the post-tests. I was also able to collect the necessary data to apply it to the research questions in Table 1 shown below.

Table 1
*Data Triangulation Matrix*

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Collection Tools I</th>
<th>Data Collection Tools II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will my students’ science knowledge improve by implementing a visual-spatial learner based approach?</td>
<td>Teacher developed pre-test and post-test</td>
<td>Teacher observation sheet Student Rubrics</td>
</tr>
<tr>
<td>Will the gains of all students be the same or will they vary by students’ learning styles compared to this new teaching style?</td>
<td>Student engagement/Likert scale survey: Visual-Spatial Identifier Fall 2011</td>
<td>Teacher developed interview questions</td>
</tr>
</tbody>
</table>
| Do American Indian students show more gains on their science assessments compared to Non-American Indian students using the visual-spatial learning techniques? | Individual student test results
Student engagement/Likert scale survey: Visual-Spatial Identifier Fall 2011 | Teacher developed post-test given after two months |
| Will the students retain the learned content after an extended amount of time has lapsed? | Teacher developed post-test                    | Teacher developed post-test                    |
DATA AND ANALYSIS

Throughout my treatment, I implemented different tools to collect data. I was then able to sort and analyze the data to answer my focus questions and to determine if the treatment had a positive outcome. I first implemented the *Visual-Spatial Identifier* to identify which students were high visual-spatial learners, blended visual-spatial learners, or low visual-spatial learners. Next, I used a teacher-developed pre-test to discover background knowledge and to establish a basis for student learning. Throughout the treatment, I used formal and informal assessments to monitor student progress and understanding. At the end of the unit, I implemented a teacher-developed post-test to determine student learning from the visual-spatial teaching model. This same post-test was given two months later to ascertain student retention. Using all of the assessments, I was able to monitor American Indian students’ learning and to determine if this teaching style was beneficial for this particular group of students or if it was beneficial to all the students in the classroom.

**Visual Spatial Identifier**

The Visual-Spatial Identifier was used during the treatment period as a resource for identifying students as VS learners. VS learners learn best by using pictures or images to create visuals in their minds that they use to recall information. The data presented which students exhibited characteristics of learning visual-spatially. Using this data, I was able to compare the students that were identified as visual-spatial learners to students who were not.
The results of the *Visual-Spatial Identifier* indicated that 35% of the students in my classroom were identified as high visual-spatial learners, answering five or more identifier questions appropriately, as indicated in Table 2. I also identified 26% of my students as blended visual-spatial learners for answering three or four identifier questions appropriately. These students use a combination of different learning styles to benefit their learning. Thirty-nine percent of the students in the class, who responded with two or fewer appropriate identifier responses were labeled as low visual-spatial learners.

Survey question 2, “I think mainly in pictures instead of words,” was one of the questions used to make this determination. Two key points that identify visual-spatial learners are seeing the big picture and visualizing spelling words in order to spell them. Of the 23 students that participated in the survey, six answered very true. Six students responded in the middle with mostly true, while 11 students answered not true or somewhat true. Therefore, six students have one question that identifies them as visual-spatial.

Another question that was used to make this determination was question 6, “I don’t do well on tests with time limits.” Only six students responded with very true while one student replied with true. Therefore, seven students have one question that identifies them as visual-spatial. Seven students selected not true, while six students were in the middle with mostly true. Visual-spatial learners have difficulty with timed tests. Instead, they permanently learn the concepts using extended time periods instead of learning through drill and practice.
The third question used to make the identification was question 7, “I have neat handwriting.” Research shows (Silverman, 2002) that visual-spatial students are able to type on a keyboard more accurately than they are able to do handwriting. “The keyboard allows an individual to access both hemispheres, so a visual-spatial learner’s powerful right hemisphere can assist his weaker left hemisphere” states Silverman (Silverman, 2002, p. 91). The “not true” was selected by six students, while four more students chose “somewhat true” as their response. Therefore, ten students have one question that identifies them as visual-spatial.

The last survey question that I felt was one of the key determining factors was question 11, “I solve problems in unusual ways.” This question relates to several key points in identifying visual-spatial learners. The key characteristics revolve around the student’s ability to solve and create unusual solutions to problems. Very true was chosen by six students and three students selected true. Eleven students chose not true and somewhat true, while three students selected mostly true. Therefore, nine students have one question that identifies them as visual-spatial.
Table 2
Fall 2011 Fourth Grade Classroom Visual-Spatial Identifier Self Report (N=23)

<table>
<thead>
<tr>
<th>Question</th>
<th>1= not true</th>
<th>2 = Somewhat true</th>
<th>3 = mostly true</th>
<th>4 = true</th>
<th>5 = very true</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1 - I hate speaking in front of a group.</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Question 2 - I think mainly in pictures instead of words. *</td>
<td>7</td>
<td>4</td>
<td>6</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Question 3 - I am good at spelling. *</td>
<td>4</td>
<td>1</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Question 4 - I often lose track of time. *</td>
<td>11</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Question 5 - I know more than others think I know.</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Question 6 - I don't do well on tests with time limits. *</td>
<td>7</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Question 7 - I have neat handwriting. *</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Question 8 - I have a wild imagination. *</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Question 9 - I like to take things apart to find out how they work. *</td>
<td>9</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Question 10 - I hate writing assignments.</td>
<td>9</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Question 11 - I solve problems in unusual ways. *</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Question 12 - It's much easier for me to tell you about things than to write about them.</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Question 13 - I have a hard time explaining how I come up with my answers.</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Question 14 - I am well organized. *</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Question 15 - It was easy for me to memorize my math facts.</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

* Represents high visual-spatial response questions.
Question 14, “I am well organized” was a question that related to a key point. Of the 23 students, only 6 students chose not true, while 10 students selected very true. The key point for this identifier uses the statement, “creates unique methods of organization” (Silverman, 2006). To me, this key point is open for discussion and does not clearly identify the students as visual-spatial learners. I feel that if they create their own method of organization and they are organized, it doesn’t matter if it is a unique way of doing it.

The last question on the survey, “It was easy for me to memorize my math facts” was difficult to use as a determining factor. Students not identified as visual-spatial learners, are good at rote memorization. Fifty-seven percent of the students responded with mostly true or very true. Yet, as I work with the students during math classes, I can see that many of them do not know their facts since they are still using other methods to figure the answer. Of the five students who responded with not true or somewhat true, only two were included in the group I labeled as visual-spatial learners. As I stated previously, it is difficult to determine whether or not this survey gives me definitive results. Surveys of this nature provide useful information, although the participants may have misconceptions about themselves. Using this survey along with other data resources, such as teacher observation, provided me with more accurate results.

I was also unsure of the results for question 11. The data shows that each response was chosen by almost the same number of students. This could be a result of the influence of the math program that my school adopted last year. It teaches the students to solve problems in unique and unusual ways instead of the traditional methods. It makes me think that many of the students were responding based on this math experience.
In Table 3, I broke down the data based on the nine questions that identified certain students as visual spatial learners based upon their individual answers. I determined which questions needed a response of very true compared to not true for other questions since not all the questions would require the same response. For example, question 2 would require a response of true or very true to label the student as visual-spatial. Whereas question 15 would require a response of not true or somewhat true. The response varied by question depending on the identifying criteria explained previously. I looked for the repetition of assigned student numbers to determine which students would be “labeled” as visual-spatial learners. I also presented this same data in Table 4 to show the data by student response using only the questions that were the basis of identification. This data was used to determine which students would be labeled as high visual-spatial learners (five or more appropriate responses), blended visual-spatial learners (three or four appropriate responses), and low visual-spatial learners (two or less appropriate responses).
Table 3
*Fall 2011 Classroom Visual-Spatial Identifier Identifying Responses Sorted by Student (N=23)*

<table>
<thead>
<tr>
<th>Visual Spatial Identifier Question</th>
<th>Assigned Student Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not True</td>
</tr>
<tr>
<td>2</td>
<td>2* 5 6 7 12 20 23</td>
</tr>
<tr>
<td>3</td>
<td>3 13 14 18</td>
</tr>
<tr>
<td>4</td>
<td>2 3 4 5 7 8 13 16 17 19 23</td>
</tr>
<tr>
<td>6</td>
<td>2 3 10 14 18 21 23</td>
</tr>
<tr>
<td>7</td>
<td>1 4 10 17 18 21</td>
</tr>
<tr>
<td>8</td>
<td>1 13 21 23</td>
</tr>
<tr>
<td>9</td>
<td>2 6 8 10 13 14 20 21 22</td>
</tr>
<tr>
<td>11</td>
<td>2 6 13 18 21 22</td>
</tr>
<tr>
<td>14</td>
<td>6 7 9 10 16 18</td>
</tr>
</tbody>
</table>

* Represents student number.
Table 4  
*Fall 2011 Student Response to Visual-Spatial Identifier Key Indicator Questions (N=23)*

<table>
<thead>
<tr>
<th>Student Number</th>
<th>VS Identifier Question Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student 1</td>
<td>2, 6, 7, 9, 11</td>
</tr>
<tr>
<td>Student 2</td>
<td>8</td>
</tr>
<tr>
<td>Student 3</td>
<td>3, 7, 9</td>
</tr>
<tr>
<td>Student 4</td>
<td>2, 6, 7, 8, 9, 14</td>
</tr>
<tr>
<td>Student 5</td>
<td>8, 9</td>
</tr>
<tr>
<td>Student 6</td>
<td>8, 14</td>
</tr>
<tr>
<td>Student 7</td>
<td>3, 6, 8, 14</td>
</tr>
<tr>
<td>Student 8</td>
<td>6, 8, 11</td>
</tr>
<tr>
<td>Student 9</td>
<td>7, 8, 9, 11, 14</td>
</tr>
<tr>
<td>Student 10</td>
<td>2, 4, 7, 8, 11, 14</td>
</tr>
<tr>
<td>Student 11</td>
<td>2, 4, 6, 8, 9 11, 15</td>
</tr>
<tr>
<td>Student 12</td>
<td>4, 8</td>
</tr>
<tr>
<td>Student 13</td>
<td>3, 7, 15</td>
</tr>
<tr>
<td>Student 14</td>
<td>2, 3, 8, 11</td>
</tr>
<tr>
<td>Student 15</td>
<td>8</td>
</tr>
<tr>
<td>Student 16</td>
<td>7, 8, 9, 11, 14, 15</td>
</tr>
<tr>
<td>Student 17</td>
<td>7, 8, 9, 11, 15</td>
</tr>
<tr>
<td>Student 18</td>
<td>3, 4, 7, 8, 14</td>
</tr>
<tr>
<td>Student 19</td>
<td>6, 9</td>
</tr>
<tr>
<td>Student 20</td>
<td></td>
</tr>
<tr>
<td>Student 21</td>
<td>2, 7, 15</td>
</tr>
<tr>
<td>Student 22</td>
<td>6, 8</td>
</tr>
<tr>
<td>Student 23</td>
<td>11</td>
</tr>
</tbody>
</table>
Based on the data in Table 3 and 4, I labeled eight students as high visual-spatial learners. These students answered five or more identifier questions with responses that are labeled as identifying characteristics of a visual spatial learner. These students were identified based on the fact that the same questions were answered with the same response. All eight of the students either answered the following questions, 7 and 8, 7 and 9, 8 and 9, or a combination of all three, with the identifying response. Those same students also answered questions 11, 14, or 15 or a combination of the questions with the same response.

The six students that responded to three or four identifier questions with characteristics of a visual spatial learner were labeled as blended visual-spatial learners. In other words, they use a combination of learning styles. This group responded differently with varying questions. The most common question that was answered by this group was question 3. Three students out of the six were identified using this question. Questions 7 and 15 were also questions that were answered by three or more students in this response group to identify them as blended visual-spatial learners.

The remaining nine students were identified as low visual-spatial learners due to the fact that they answered two or fewer of the identifying questions. The majority of these students responded with varying answers, yet six responded to question 8 with true or very true.

As a precursor for my action research, I administered the Visual-Spatial Identifier in the spring to my 2010-2011 students. I was able to compare the students from my last year’s class to the treatment group. The data results are presented in Table 5 and 6. The
data from the treatment period showed that eight students were identified as high visual-spatial learners. In the data from the spring 2011 classroom, only one student responded to the necessary amount of five or more questions with appropriate responses to be identified as a high visual-spatial learner. Only four students were identified as blended visual-spatial learners, while twelve students were identified as low visual-spatial learners.
<table>
<thead>
<tr>
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<th>1= not true</th>
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<td></td>
<td></td>
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<td>Question 3 - I am good at spelling.  *</td>
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<td>Question 4 - I often lose track of time.  *</td>
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<tr>
<td>Question 5 - I know more than others think I know.</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 6 - I don't do well on tests with time limits.  *</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 7 - I have neat handwriting.  *</td>
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<td></td>
<td></td>
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<tr>
<td>Question 8 - I have a wild imagination.  *</td>
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<td>Question 9 - I like to take things apart to find out how they work.  *</td>
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<tr>
<td>Question 10 - I hate writing assignments.</td>
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<tr>
<td>Question 11 - I solve problems in unusual ways.  *</td>
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<td></td>
<td></td>
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<tr>
<td>Question 12 - It's much easier for me to tell you about things than to write about them.</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 13 - I have a hard time explaining how I come up with my answers.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 14 - I am well organized.  *</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 15 - It was easy for me to memorize my math facts.</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

* Represents high visual-spatial response questions.
Table 6
Spring 2011 Student Response to Visual-Spatial Identifier Questions (N=17)

<table>
<thead>
<tr>
<th>Student Number</th>
<th>VS Identifier Question Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student 1</td>
<td>3, 7, 15</td>
</tr>
<tr>
<td>Student 2</td>
<td>14</td>
</tr>
<tr>
<td>Student 3</td>
<td>3, 4, 9, 15</td>
</tr>
<tr>
<td>Student 4</td>
<td>2, 3, 4, 8, 14</td>
</tr>
<tr>
<td>Student 5</td>
<td>4, 6</td>
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<tr>
<td>Student 6</td>
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</tr>
<tr>
<td>Student 7</td>
<td></td>
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<tr>
<td>Student 8</td>
<td>7</td>
</tr>
<tr>
<td>Student 9</td>
<td>8</td>
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<tr>
<td>Student 10</td>
<td></td>
</tr>
<tr>
<td>Student 11</td>
<td>8, 9, 11</td>
</tr>
<tr>
<td>Student 12</td>
<td>3, 7, 14</td>
</tr>
<tr>
<td>Student 13</td>
<td>8</td>
</tr>
<tr>
<td>Student 14</td>
<td>7</td>
</tr>
<tr>
<td>Student 15</td>
<td>6</td>
</tr>
<tr>
<td>Student 16</td>
<td>4</td>
</tr>
<tr>
<td>Student 17</td>
<td>11, 15</td>
</tr>
</tbody>
</table>

Compared to the data from the treatment period, the responses for the students in the spring 2011 data were quite different. Only one student was labeled as a high visual-spatial learner. The questions that this student answered that were similar to the fall 2011 students were questions 8 and 14.
The number of students that were identified as blended visual-spatial learners was similar for both groups. The spring 2011 group had 29% of the students identified compared to 26% for the fall 2011 classroom. The spring 2011 students were consistent with the fall 2011 students as to which questions they responded the same. Those questions were 3, 7, and 15 and were answered appropriately by 3 out of the 4 students that were identified.

The spring 2011 classroom had the highest number of students in the low visual-spatial learners group, 71%. The students were random in which questions they responded to appropriately and three of the students didn’t answer any of the identifier questions with an appropriate response. Overall, the blended visual-spatial learners were the most consistent with the number of students who were identified.

**Findings From Pre-Test Measures**

The 23 students in the 2011 fall classroom completed the pre-test prior to the lessons taught for the astronomy unit. One student identified as blended visual-spatial was absent that day and did not take the test, lowering the number of blended VS students to five. This test allowed for a baseline to be established as a comparison with the post-test that was completed at the conclusion of the astronomy unit. Table 7 below reports the results of the pre-test showing the number correct compared to the number of incorrect answers concentrating on the vocabulary sections of the test for a total of 15 items. It also reports the number of correct answers given by each visual-spatial group.
Table 7
Fall 2011 Fourth Grade Classroom Pre-Test Results (N=22)

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Whole Class Number Correct</th>
<th>Whole Class Number Wrong</th>
<th>Number Correct</th>
<th>High VSI (8)</th>
<th>Blended VSI (5)</th>
<th>Low VSI (9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td></td>
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<tr>
<td>2</td>
<td>9</td>
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<td>6</td>
<td>6</td>
<td>16</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>7</td>
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<tr>
<td>13</td>
<td>2</td>
<td>20</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>20</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td></td>
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<tr>
<td>16</td>
<td>5</td>
<td>17</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>7</td>
<td>15</td>
<td>2</td>
<td>2</td>
<td>3</td>
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<tr>
<td>18</td>
<td>9</td>
<td>13</td>
<td>4</td>
<td>1</td>
<td>4</td>
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<td>20</td>
<td>3</td>
<td>19</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>15</td>
<td>105</td>
<td>225</td>
<td>37</td>
<td>14</td>
<td>54</td>
</tr>
</tbody>
</table>

The students answered twice as many questions incorrectly as correctly on the pre-test. Item numbers 13, 14, and 15 received the most incorrect responses, 20 out of 22, by the students. Questions 19 and 20 received the second highest incorrect responses with 19 out of 22. One high visual-spatial student and one low visual-spatial student
responded to questions 13 and 14 correctly. Only 2 low visual-spatial students answered question 15 correctly. The 5 blended visual-spatial students answered the least number of questions, 14, correctly for an average of 2.8 of 15 items correct. The 8 high visual-spatial students answered 37 correctly, for an average of 4.63 correct, while the 9 low visual-spatial students responded to 54 questions correctly, averaging 6 items correct.

No matter which category the students fell in, the test results had a high number of incorrect responses. Some of the content material was new to the students and I didn’t expect correct responses to these questions. Very few students had background knowledge in this content area beyond the names of the planets. Most of the content was new material for them.

**Findings From Post-Test Measures**

At the completion of the unit, the post-test was administered to 22 students in the winter of 2012. One student who was identified as high VS moved before the unit was completed dropping the total number of students in the classroom from 23 to 22. The results of the post-test are recorded in Table 8 below. With this information, I was able to compare the students’ responses with the pre-test to measure learning from the visual-spatial teaching style. I was able to compare the responses of the different groups of visual-spatial learners, whether learning took place, and if any particular group of students improved more than another.
### Table 8
*Winter 2011 Fourth Grade Classroom Post-Test Results (N=22)*

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Whole Class Number Correct</th>
<th>Whole Class Number Wrong</th>
<th>Number Correct</th>
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<tbody>
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<td>High VSI (7)</td>
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<td>Blended VSI (6)</td>
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<td>Low VSI (9)</td>
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<td>76</td>
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After analyzing the data, the results of the post-test showed improvement among the students. Five questions that had the least number of correct responses in the pre-test showed the most improvement in the results of the post-test. Question 13 only had 2
correct responses in the pre-test compared to 19 in the post-test. Only one high visual-spatial learner responded correctly to this question in the pre-test compared to six in the post-test. While five blended visual-spatial learners and eight low visual-spatial learners answered correctly on the post-test compared to zero blended and one low visual-spatial learner on the pre-test.

The post-test showed that question 14 also had a significant improvement in correct responses. The data shows two correct responses in the pre-test compared to eight correct responses in the post-test. The high VS students and the low VS students both had three students who responded with correct answers compared to one correct response for each in the pre-test. The blended VS students had no correct responses on the pre-test compared to two on the post-test.

Question 15 also showed an increase in the amount of correct responses on the post-test. The post-test had ten correct responses compared to two correct responses on the pre-test. No high or blended VS learners responded with correct responses on the pre-test, while four high and two blended students answered correctly on the post-test. The data shows an increase of two correct responses for the low VS students from the pre-test to the post-test.

An increase in the number of correct responses was also shown for question 19. The pre-test had three correct responses with an increase to seven correct responses on the post-test. The data increased from zero responses by the high VS learners to three correct responses. The blended VS students increased from zero correct responses to one
correct response. The low VS learners showed no increase or decrease of responses, but stayed at three correct responses.

Question 20 also showed an increase in the correct number of responses from the pre-test to the post-test. The pre-test only had 3 correct responses while the post-test increased to 11 correct responses. The high VS learners went from 1 correct response to five, while the low VS students went from 2 correct responses to 5 correct responses. The blended VS learners only had an increase of 1 correct response starting at 0 correct responses on the pre-test.

Overall, the students of all visual-spatial groups showed improvement from the pre-test to the post-test. However, the size of the improvement varied. The average number of correct responses attained by the 7 high VS students increased from 4.63 (out of 15 items) on the pretest to 8.43 on the post-test for an average gain of 3.8 correct items. The 6 blended VS students showed the greatest improvement, with an average score of 2.8 correct items on the pretest and an average of 6 correct on the posttest, for an average gain of 4.2 items correct. The 9 low VS students showed the smallest gain with an average pretest score of 6 compared to an average posttest score of 8.44 or a gain of 2.44.

Two students in the blended VS group made significant gains from the pretest to the posttest. Student 3 had zero correct responses for the vocabulary section of the pretest compared to 13 correct responses on the posttest. Student 13 had four correct responses on the pretest compared to ten correct responses on the posttest. None of the other blended VS students made the significant gains that these two students achieved.
Only one student in the high VS group made considerable gains from the pretest to the posttest. Student 4 had 7 correct responses on the pretest increasing to 14 correct responses on the posttest, doubling his number of correct responses. The low VS students only showed one student making substantial gains from the pretest to the posttest. Student 20 went from 2 correct responses to 7 correct responses making a gain of 5 correct responses.

A post-post-test was implemented two months after the first post-test was given to gage the retention of the information from the students. With the absence of 1 blended VS student and the transfer of 1 high VS student, the total number of students for the post-post-test results was 21. I was then able to use the data, Table 9 below, from this post-post-test to answer my fourth focus question: Will the students retain the learned content after an extended amount of time has lapsed?
Table 9
Spring 2012 Fourth Grade Classroom Post-Post-Test Results (N=21)

<table>
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<tr>
<th>Item Number</th>
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<th>Whole Class</th>
<th>Number Correct</th>
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<th>Blended VSI (5)</th>
<th>Low VSI (9)</th>
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</thead>
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<tr>
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<tr>
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<td>145</td>
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<td>85</td>
</tr>
</tbody>
</table>

The results of the spring post-post-test remained very similar to the results of the winter post-test. The winter post-test showed 173 total correct responses while the spring post-test showed 170 total correct responses. The majority of the questions showed either
an increase or the same number of correct responses in the data for the spring post-post-test. Only questions 2, 6, 12, 13, and 17 showed a decrease in the number of correct responses on the spring post-post-test. Question 2 decreased from 9 correct answers to 7 correct answers. There was a decrease from 9 correct responses to 6 correct responses for question 6. Question 12 had a decrease of 4 responses, 16 to 12, while question 13 decreased by 5 responses, 19 to 14. The last question that showed a decrease, question 17, lowered from 11 correct responses to 8 correct responses. One student, a blended VS learner, was absent on the day of the spring post-test showing a decrease of one response for the blended VS responses.

The results for question 13 dropped slightly from the winter post-test to the spring post-post-test. The total correct responses on the winter post-test were 19 correct responses, while there were only 14 correct responses on the spring post-post-test. The blended VS students showed the most number of decreased responses, from five correct answers to two correct answers. The high VS learners decreased by one, six correct responses on the winter post-test to five on the spring post-test. While the low VS students also decreased by one, eight correct to seven correct responses.

Question 14 showed an increase in correct responses from the winter post-test to the spring post-post-test. The winter post-test had 8 correct responses while the spring post-post-test had 13 correct responses. The low VS students showed the most increase in correct responses for this question, three correct to seven correct. The high VS students increased by one correct response, while the blended VS students remained the same number. Either the students remembered the content better the second time they took the test or they were better guessers the second time.
One question, 15, had the same results for both tests. The results showed ten correct responses for both tests. The high VS learners decreased by one, while the blended VS learners increased by one correct response. The number of correct responses by the low VS learners remained the same.

There was also an increase in the number of correct responses for question 19. The winter post-test had seven correct answers while the spring post-post-test had nine correct answers. The increase showed in the responses by the low VS students. That group went from three correct responses to five correct responses, while the other two groups remained the same.

The last question, 20, also showed an increase from the winter to the spring. The low VS students increased from five correct responses to seven correct responses. The high VS students increased from five correct responses to six correct responses. The blended VS students remained the same at one correct response.

Overall, the students were able to retain the majority of the content after a two-month period. The group that showed the most overall improvement was the blended VS learners. That group had eight questions that had no correct responses on the pre-test. Eight of the questions had the same number or an increase in number of correct responses after the spring post-post-test. Seven of those questions were answered with no correct responses on the pre-test.

The low VS learners also showed improvement from test to test. Of the nine students identified for this group, half of them consistently answered the questions correctly on both post-tests. This group of students consists of six of the top students in
my classroom. They are able to retain the content taught in the classroom in whatever way that it is presented to them. They are the students that receive the highest scores on assignments and tests in all content areas.

The high visual-spatial learners also showed increases in correct answers from the pre-test to the post-tests. This group of students was able to improve the number of correct responses for the vocabulary sections of the tests except on four questions. They did not show improvement on questions 1, 2, 4, and 6. The high VS students showed the most improvement on questions 13, 16, and 20. They only had 1 correct response on the pre-test and increased to 6 correct responses on the winter post-test, while maintaining 5 correct answers on the spring post-post-test for question 13. Question 16 had similar results, 1 correct response on the pre-test, increasing to 6 correct responses on the winter post-test, but dropping to 4 correct responses on the spring post-post-test. The high VS students also improved on question 20. They started with one correct response on the pre-test, increased to five correct responses on the winter post-test, and again increasing to six correct responses on the spring post-post-test.

Looking at retention from the winter post-test to the spring post-post-test in terms of the average number of correct responses per student, I found that the seven high VS students retained the most content knowledge. Their average winter post-test score was 8.43 items correct, compared to 8.29 on the post-post-test. The six students in the blended VS group who completed the post-test attained an average of 6 items correct, and the five who completed the post-post-test attained an average of 5.4 items correct. The nine students in the low VS earned an average of 8.44 items correct on the post-test, compared to 9.44 correct on the post-post-test.
As a result of teaching my students using a visual-spatial approach, the majority of the students made gains on the post-tests. The use of visuals in the classroom and on the assessments reinforced the content and allowed the students to remember the vocabulary. Sawyer states,

It leads to the belief that “spatial” students should receive special instruction that emphasizes imagery, but that non-spatial students should receive some other form of instruction. It may be a mistake to assume that only students with high imagery abilities should be presented with visual information. Additionally, there is evidence that spatial visualization ability develops with experience, suggesting that denying low-spatial individuals the chance to work with visual information may limit their development. The learning sciences should focus on learning rather than assumptions about ability, and it should examine how to design visual environments that will benefit all learners. (Sawyer, 2006, p. 295)

All three assessments were used to establish if using a visual-spatial teaching style would benefit American Indian students. The results of the individual American Indian students are shown below in Figure 1. The table compares the number of correct responses from each assessment for each of these students in my classroom. Student 7 was absent for the pre-test, while student 14 was absent for the spring post-post-test.
Figure 1. 2011-2012 Fourth Grade American Indian Student Test Results, (N=15).
All of the 15 American Indian students, except one, showed improvement from the pre-test to the post-tests. Of these students, six were identified as high visual-spatial students, five were identified as blended visual-spatial students, and four were identified as low visual-spatial students.

Student 3 and student 23 both responded with 0 correct responses on the pre-test. Student 3, identified as a blended visual-spatial learner, improved to 13 correct answers on the winter post-test, while receiving 9 correct responses on the spring post-post-test. This student is identified with a learning disability and had assistance reading the tests, but no assistance selecting the answers. Student 23, identified as a low visual-spatial learner, also improved on the post-tests. He maintained a score of five correct responses on both post-tests increasing from zero on the pre-test. This student also has difficulties in the classroom, but is not identified with special needs.

Student 12 earned 9 correct responses on the pre-test, dropped to 8 correct responses on the winter post-test, and increased back to 9 correct responses on the spring post-post-test. This student is one of my top students in the classroom and is in the low visual-spatial learner group. He was inconsistent with which answers he responded to correctly on all three assessments, answering with the correct response for one test, but selecting a different answer for the next.

Another of the American Indian students, identified as a blended visual-spatial learner, made gains on the post-tests. Student 13 answered 4 questions correctly on the pre-test. She doubled her score on both post-tests, ten on the winter post-test and nine on the spring post-post-test. This student is in an intervention classroom for both Language
Arts and Math but does not have a learning disability. The other three American Indian students who were identified as blended visual-spatial learners did not make significant gains from the pre-test to the post-tests, improving by only one question or making no change in scores. Student 14 was absent for the pre-test, but answered three questions correctly on both post-tests. Student 7 and 21 both increased by one correct response from the pre-test to the post-test. Student 21 decreased by one correct response from the winter post-test to the spring post-post-test, while student 7 was absent for the spring post-post-test. These three students do not take learning seriously and have a tendency to make guesses when doing assignments rather than using the information that had been taught. I did not expect to see gains by these students based on previous experience with these students.

Overall, the American Indian students in my classroom made gains with learning the content from a visual-spatial learning style. The visuals that were used in the classroom and on the assessments to reinforce the content helped their learning. The data also shows the students were able to retain the information after a two month period with little decrease in their scores, and in some cases an increase from the first post-test.

**Interview Data**

The results of the identifier indicated that 26% of the students in my classroom use visualizing pictures instead of words most of the time. One student explained his reasoning as “I can see the pictures in my mind. I can see the pictures with the words.” Another student had a similar response “I look back in my head for the pictures.” A third student stated, “I closed my eyes and looked for the words with the pictures.”
majority of the class, 74% that answered the identifier, like to learn the new information using step-by-step techniques instead of visualizing pictures or the whole picture. One student responded, “When I learn it step-by-step, it is easier for me. It is hard for me to think of it at all at one time.” Another student said “When I learn it step-by-step, I can go back to the beginning if I get stuck in the middle and look at what I did before.” “If I do it step-by-step while the teacher is doing it, it is easier to understand,” stated another student.

When several students were asked which visual-spatial learning technique they liked using the best, one responded with “I liked drawing the pictures because I like seeing the pictures.” Another student stated, “I like it when the pictures are with the vocabulary words in the slideshow. It helps me to see what the word is and I don’t have to visualize it myself.” Other students stated they liked doing the hands on activities. “I like doing things with my hands, so I liked cutting out the circles to make the planets and being able to move them around. I like to touch and feel what things are like.”

Several students were questioned whether they used these techniques when they did the assessments. One student responded, “Sometimes I visualize the words without closing my eyes and it helps me.” One boy stated, “I can see all the words when I do that. I do it with math problems, too.” “When I take tests, I don’t close my eyes to see the words, I just know them or I memorized them,” stated another student. Several students responded differently. “I didn’t close my eyes to remember the words, I just knew them.” One student said, “I learned it from reading books and using my background knowledge.”
When they were asked if they used other techniques rather than closing their eyes to visualize, they had a variety of responses. One student stated, “I repeat the words and definitions over and over until I know them.” Another student said, “I remember the meanings from reading the definitions. I look for the key words that were highlighted on my study guide.” One girl stated, “I study with my mom. She gives me the definition and I tell her the word.” Yet another student responded, “I can see the page that the words were on. When I see the page, I remember what it said.”

Some of the students in my classroom seemed to prefer using the visual-spatial techniques to learn the new content information. Others preferred to continue learning step-by-step or by memorizing the information. Either way they preferred to learn, they were able to learn and retain some of the new content information.

Summary of Findings

Overall, the students improved from the pre-test to the post-tests using a visual-spatial learning approach. Providing them with different visuals to learn the material helped them to understand what they were learning and helped them to better retain the information. I also believe by using visuals on the post-tests made a difference for many of the students. The American Indian students benefited from the visual-spatial learning style showing improvement from the pre-test, 51 correct responses, to 110 correct responses on the post-test and 104 correct responses on the post-post-test. The increase in correct responses on the winter and spring post-tests confirms this.
INTERPRETATION AND CONCLUSION

Visual-spatial teaching techniques were incorporated into a fourth grade classroom to determine the benefits of this learning style for students. The overall effect was positive for the learning environment. The students made gains from the pre-test to the post-tests showing that the content was learned. The data also shows the information was retained by the majority of the students.

After determining, by using the *Visual-Spatial Identifier*, whether the students had a tendency to learn using the visual-spatial learning style, I was able to determine if the students learned the content. The students were exposed to the new content by the use of different forms of visual aids. Whether the students were drawing a picture to go with a vocabulary word, using hands on activities with models, or watching a slideshow with pictures, they were exposed to the material as a visual-spatial approach. My first two focus questions go hand-in-hand with each other. I wanted to discover if the students’ science knowledge would improve by implementing a visual-spatial learner based approach. I also wanted to know if the gains of all the students would be the same or if there would be a variance between the different learning styles.

Twenty-two students took the pre-test in the fall of 2011. Of the 330 total questions answered by the students, only 105 questions were answered correctly. The low visual-spatial learners received the most correct responses with 54 out of the 105. Most of these students are the top students in my class and receive A’s and B’s on assignments and tests. They have the most background knowledge of the students in my classroom. They are also the better readers and are in my top reading group. This group
improved from the pre-test to the winter post-test. The number of correct responses on
the winter post-test improved from 54 to 76. Their scores also improved from the winter
post-test to the spring post-post-test, 76 to 85.

The blended visual-spatial learners also improved from the pre-test to the post-
test. These six students scored low, 14 correct responses, on the pre-test, but improved
for the winter post-test, 36 correct responses. This group of students represents mixed
abilities in the classroom. One student is identified as special needs and leaves the
classroom for instruction in reading and math. Three of the students attend intervention
classes for Language Arts and Math, while the other two stay in the classroom for
Language Arts instruction. The blended visual-spatial students improved for the winter
post-test, but declined on the spring post-post-test, 36 correct responses to 27 correct
responses.

The high visual-spatial learners also made improvements from the pre-test to the
post-tests. This group of students also represents mixed abilities in the classroom. Two
of the students attend Language Arts intervention, while the rest of the group stays in the
regular classroom. These students improved from 37 correct responses on the pre-test to
59 correct responses on the winter post-test. The high visual-spatial learners maintained
a high score on the spring post-post-test scoring 58 correct responses.

Therefore, the use of visual aids in the classroom improved student learning for
all students. Each group increased by 22 correct responses from the pre-test to the winter
post-test. The blended VS learners showed the most gains per average, an increase of
4.2, from the pre-test to the winter post-test. While both the high and blended VS
learners decreased the average number of correct responses per student from the winter post-test to the spring post-post-test, the low VS learners had an increase of an average of one correct response per student.

![Figure 2](image)

*Figure 2. 2011-2012 Fourth Grade Non-American Indian Student Test Results, (N=7).*

One comparison I wanted to make was whether this teaching style would benefit the American Indian students more than non-American Indian students. Figure 2, above, showed the results of non-American Indian students in my classroom. Comparing these results with Figure 1, I see significant differences between the two groups. The pre-test showed 57% of the non-American Indian students answered five or more correct
responses while 29% of the American Indian students answered five or more correct responses.

The winter post-test also showed differences between the two groups. The American Indian students improved their scores of five or more correct responses to 80% compared to 86% for the non-American Indian students. The non-American Indian students improved their percentage by 29, while the American Indian students improved by 51. That number is a significant increase showing that visual-spatial teaching increases American Indian students’ knowledge.

The spring post-test showed both an increase and a decrease for both groups of students. The highest decrease was four responses, while the highest increase was also four responses. All the non-American Indian students except one either maintained their score or improved it. The one student whose score decreased, only dropped by one incorrect response. The students whose scores improved increased by two correct responses. The American Indian students showed that six students’ scores decreased by one or two incorrect responses. Yet, eight students either maintained their previous score or increased it. The data shows that visual-spatial teaching improves student learning. It also shows that fourteen out of the twenty-two students were able to retain the content to maintain or increase their assessment scores from the winter post-test to the spring post-post-test. The visual-spatial teaching style is beneficial to many students regardless of their learning style or culture.
The implementation of the visual-spatial teaching strategies in my classroom was a benefit to my students and myself. I enjoyed integrating the diverse visual-spatial techniques to provide a different way of learning for the students. The activities allowed me to create a variance to the type of lessons that I taught, while maintaining the importance of the content. I also benefited from these activities by keeping the students more engaged and manageable while they were learning. I will definitely be incorporating more visual-spatial activities in my classroom in the years to come.

The visual-spatial teaching style also had a positive impact on the students. They seemed to enjoy doing the various activities. They were more engaged while participating in the hands on activities. It allowed them to visualize the vocabulary words while they were learning the definitions. The students also learned the content well, as shown on the results of the post-tests, and were able to retain what they learned two months previously. The students were also allowed to work in cooperative groups or with partners. It provided more sharing of ideas and cooperation amongst the students.

The impact that my action research had in my classroom conveys to me that more teachers should be incorporating visual-spatial activities in their classrooms. Since Hardin Intermediate School has a high population of American Indian students, visual-spatial teaching should be integrated in classrooms every day. Preparing the activities was not time consuming and it kept the students more engaged during the lessons.

The principal at Hardin Intermediate School would also agree with the findings of my action research. Our school received a new literacy grant that is promoting
engagement in the classrooms. He would encourage the other teachers in my school to incorporate this teaching style into their lessons to promote engagement among the students. He realizes that our students have a diverse style of learning and would encourage incorporating different styles to make the most impact on all our students.

I intend to continue integrating the visual-spatial teaching style in my classroom. I will also encourage and share activities with fellow teachers to help benefit all the students in our school.

The fundamental challenge for the learning sciences is not to determine whether students use imagery or whether imagery is educationally valuable in some vague, universal way. Rather the challenge is more precise – when and how can teachers use which function of imagery to support learning, creativity, and reasoning?

(Sawyer, 2006, p. 296)
REFERENCES CITED


APPENDICES
APPENDIX A

THE VISUAL-SPATIAL IDENTIFIER
(SELF REPORT)
The Visual-Spatial Identifier
(Self Report)
http://www.gifteddevelopment.com/

Name ________________________             Age ______              Gender ____________

Please indicate the degree to which the following descriptors apply:
1 = not true   2 = somewhat true   3 = mostly true   4 = true   5 = very true

1. I hate speaking in front of a group.      1 2 3 4 5

2. I think mainly in pictures instead of words. 1 2 3 4 5

3. I am good at spelling. 1 2 3 4 5

4. I often lose track of time. 1 2 3 4 5

5. I know more than others think I know. 1 2 3 4 5

6. I don’t do well on tests with time limits. 1 2 3 4 5

7. I have neat handwriting. 1 2 3 4 5

8. I have a wild imagination. 1 2 3 4 5

9. I like to take things apart to find out how they work. 1 2 3 4 5

10. I hate writing assignments. 1 2 3 4 5

11. I solve problems in unusual ways. 1 2 3 4 5

12. It’s much easier for me to tell you about things than to write about them. 1 2 3 4 5

13. I have a hard time explaining how I come up with my answers. 1 2 3 4 5

14. I am well organized. 1 2 3 4 5

15. It was easy for me to memorize my math facts. 1 2 3 4 5
APPENDIX B

ASTRONOMY PRE-TEST
Read each definition. Then write the letter of the word that matches.

1. the path Earth takes as it travels around the Sun  
   a. planet

2. a large body made of rock or gas that moves around a star  
   b. orbit

3. occurs when the Moon passes into Earth’s shadow  
   c. solar system

4. is made up of the Sun, nine planets, and other smaller bodies that orbit the Sun  
   d. phases of the Moon

5. the largest planets in the solar system that are made up mostly of gases  
   e. lunar eclipse

6. The changes in the amount of the lighted side of the Moon that are visible from Earth  
   f. gas giants

Write answers to the questions on the lines below.

7. Why does the Moon look bright from Earth?
   ____________________________________________________________
   ____________________________________________________________

8. What makes up the solar system?
   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

9. Stars appear to move because
   ____________________________________________________________
   ____________________________________________________________
10. Four ways that stars can be classified are
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________

11. How does gravity affect objects on Earth?
_______________________________________________________________________________
_______________________________________________________________________________
_______________________________________________________________________________

**Fill in the blanks with words from the box below.**

<table>
<thead>
<tr>
<th>comet</th>
<th>asteroids</th>
<th>universe</th>
</tr>
</thead>
<tbody>
<tr>
<td>galaxy</td>
<td>red giant</td>
<td>constellation</td>
</tr>
<tr>
<td>star</td>
<td>revolution</td>
<td>moon</td>
</tr>
</tbody>
</table>

12. The __________________ is made up of all the matter and energy there is, including
the galaxies and their stars, planets, and moons.

13. A ______________________ is a group of stars that forms a pattern in the night sky.

14. Each _______________________, or trip around the Sun, is a year.

15. A huge system, or group, of stars held together by gravity is a ____________________.

16. A huge ball of very hot gases that gives off light, heat, and other kinds of energy is a
__________________.

17. Small, icy bodies with very long tails that orbit the sun are ____________________.

18. A __________________ is a body that orbits a planet.

19. A __________________ is a very large, bright, cool star.

20. Rocky or metallic objects that orbit the Sun between Mars and Jupiter are
______________________.
Label the solar system with the appropriate names.
APPENDIX C

INTERVIEW QUESTIONS
INTERVIEW QUESTIONS

1. When you learn new information is it easier for you to learn by seeing the whole picture or step-by-step? Can you explain to me how it helps you?

2. Which technique, ex: drawing a picture, using the hands-on activities did you like using the best? Will you explain why?

3. When you did the assessment, did you close your eyes and see the picture of what the final outcome of the diagram would be? If you did, did you visualize all the words to label them on the diagram or did you use a different way to remember them? Please explain how you did this.

4. If you didn’t use the mental picture, which other techniques do you use to remember information for assessments?

5. What technique did you use to remember the vocabulary words?
APPENDIX D

SUN EFFECTS INVESTIGATION
**Sun Effects**

**Procedure**

1. **Collaborate** Work in a small group. In your *Science Notebook*, make a chart like the one shown.


3. **Measure** Place a thermometer in each bowl. The bulb of each thermometer should be covered the same amount. Wait 2 minutes. Then check and record the temperature in each bowl.

4. **Predict** Place the three bowls close together under a lamp. The light should hit all three bowls equally. Predict how the temperature of each material will change after 30 minutes. **Safety**: Do not touch the light bulb. It may be very hot.

5. **Measure** After 30 minutes, read the thermometers. Record in your chart the temperature of each material.

**Conclusion**

1. **Compare** Which material is warmest after 30 minutes? How did your results compare with your predictions?

2. **Infer** Would a light-colored or a dark-colored material heat faster in sunlight?

3. **Use Models** What can you infer from your model about how the Sun affects sand, water, and soil on Earth?

**Materials**
- 3 shallow bowls
- sand
- soil
- water
- 3 thermometers
- lamp with 100-watt bulb
- clock or watch
- goggles
APPENDIX E

MOONLIGHT PROBE
Moonlight

Five friends noticed they could see better at night when there was a full Moon. They wondered where the moonlight came from. This is what they said:

Curtis: "The Moon reflects the light from the Earth."

Chet: "The light from the Sun bounces off the Moon."

Clarence: "The Moon gets its light from distant stars."

Fallon: "The Moon absorbs light from the Sun during the day."

Deirdre: "There is light inside of the Moon that makes it shine."

Which person do you most agree with? Explain your thinking about moonlight.
APPENDIX F

GOING THROUGH A PHASE PROBE
Mrs. Timmons asked her class to share their ideas about what causes the different phases of the Moon. This is what some of her students said:

Mona: The Moon lights up in different parts at different times of the month.
Jared: The phases of the Moon change according to the season of the year.
Sofia: Parts of the Moon reflect light depending on the position of the Earth in relation to the Sun and Moon.
Drew: The Earth casts a shadow that causes a monthly pattern in how much of the Moon we can see from Earth.
Trey: Different planets cast a shadow on the Moon as they revolve around the Sun.
Oofra: The shadow of the Sun blocks part of the Moon each night causing a pattern of different Moon phases.
Natasha: The clouds cover the parts of the Moon that we can't see.
Raj: The Moon grows a little bit bigger each day until it is full and then it gets smaller again. It repeats this cycle every month.

Which student do you agree with and why? Explain your thinking.
APPENDIX G

OUTER PLANETS INVESTIGATION
Investigate

Outer Planets

Procedure

1. In your Science Notebook, make a chart like the one shown.

2. Measure For each measurement below, use a metric ruler to draw a line of that length on construction paper. Draw another line perpendicular to the first line. Connect the lines to make a circle. Label each circle with the name of the planet it represents.

   Jupiter 23 cm
   Saturn 19 cm
   Uranus 8.2 cm
   Neptune 7.6 cm
   Pluto 0.4 cm (4 mm)

3. Use a Model Cut out and label each planet. Put the model planets in the order they are in the solar system, as listed. Record this data in your chart.

4. Compare Put your model planets in order from smallest to largest. Record the data. Put your model planets in order from largest to smallest. Record the data.

Conclusion

1. Analyze Data Compare your data. Which two sets of data are similar?

2. Infer Refer to the data about planet size on D57. What can you infer about the general relationship between planet size and distance from the Sun?

Materials

- 2 large sheets of construction paper
- metric ruler
- pencil
- scissors
APPENDIX H

ADOPT A PLANET RESEARCH QUESTIONS
Adopt a Planet Research Questions

1. What is the name of your planet?

2. How far away from the Sun is your planet?

3. How many days does it take for your planet to orbit around the Sun?

4. What is the diameter of your planet?

5. What is your planet made of?

6. How many moons does your planet have?

7. What other interesting facts did you find about your planet?
APPENDIX I

PLANET RESEARCH STUDENT RUBRIC
### Planet Research Student Rubric

<table>
<thead>
<tr>
<th></th>
<th>3 points</th>
<th>2 points</th>
<th>1 point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you create your</td>
<td>I used 4 or more colors in my text and content.</td>
<td>I used 2 or 3 colors in my text and content.</td>
<td>I used one color in my text and content.</td>
</tr>
<tr>
<td>poster using visually</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>appealing colors?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the representation</td>
<td>I used accurate colors for the representation and included texture</td>
<td>I used accurate colors for the representation but did not include</td>
<td>I used colors that were not accurate for my planet.</td>
</tr>
<tr>
<td>of your planet show it</td>
<td>that shows details of the face of the planet.</td>
<td>texture that shows details of the landforms.</td>
<td></td>
</tr>
<tr>
<td>true to life?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Was your poster</td>
<td>I put the planet in the middle of the poster with the text on the sides.</td>
<td>I put the planet in the middle of the poster with the text on the sides.</td>
<td>I put the planet on the side of the poster and the text in the middle.</td>
</tr>
<tr>
<td>organized in a way to</td>
<td>I used large text that was easy to read.</td>
<td>I used small text that was not easy to read.</td>
<td></td>
</tr>
<tr>
<td>draw the attention to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>the details?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX J

PLANET RESEARCH TEACHER RUBRIC
## Planet Research Teacher Rubric

<table>
<thead>
<tr>
<th></th>
<th>3 points</th>
<th>2 points</th>
<th>1 point</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Was the poster created using visually appealing colors?</strong></td>
<td>4 or more colors were used in the text and content.</td>
<td>2 or 3 colors were in the text and content.</td>
<td>Only 1 color was used in the text and content.</td>
</tr>
<tr>
<td><strong>Did the students show appropriate answers to the questions on their posters?</strong></td>
<td>All seven questions were represented on their poster.</td>
<td>6 or 5 questions were represented on their posters.</td>
<td>4 or less questions were represented on their posters.</td>
</tr>
<tr>
<td><strong>Did the students work appropriately in their groups and were cooperative with their partners?</strong></td>
<td>All partners in the group shared responsibility in finding answers to the questions and participated in the creation of the poster.</td>
<td>Only 1 partner in the group shared responsibility in finding answers to the questions and participated in the creation of the poster.</td>
<td>The partners in the group were acting inappropriately while working and did not work cooperatively.</td>
</tr>
<tr>
<td><strong>Did the poster represent the science content appropriately?</strong></td>
<td>The planet was displayed with the correct number of moons or rings and was proportionately displayed.</td>
<td>The planet was displayed with an incorrect number of moons or rings but was proportionate.</td>
<td>The planet was displayed with no moons or rings and was disproportionate.</td>
</tr>
</tbody>
</table>
APPENDIX K

STAR CLOCK INVESTIGATION
**Investigate**

**Star Clock**

**Procedure**

1. In your Science Notebook, make a chart like the one shown.

2. Cut out the Star Clock base and the Star Clock wheel. Place the wheel on top of the base. Attach the two parts by pushing a paper fastener through the center of each. **Safety**: Be careful. The paper fastener is sharp.

3. **Collaborate** Work with a partner. Discuss the times given on the base of the clock. Note how this is different from a time clock.

4. **Use Models** Turn the wheel so that the Big Dipper is at the left. Find March and read and record the time for mid-March. That is the time when the Big Dipper will be in that position in the sky.

5. **Record Data** Turn the wheel so the Big Dipper is at the top, to the right, and then to the bottom. For each position, read and record the times for mid-March.

6. Follow steps 4 and 5 to complete your chart for the other three months.

**Conclusion**

1. **Observe** How does the position of the North Star change during the night?

2. **Infer** How could people use the pattern of the Big Dipper's movement to tell time?

**Materials**

- star clock Activity Support Master
- scissors
- paper fastener
APPENDIX L

ASTRONOMY POST-TEST
Astronomy Post-test

Read each definition. Then write the letter of the word that matches.

____ 1. the path Earth takes as it travels around the Sun
____ 2. a large body made of rock or gas that moves around a star
____ 3. occurs when the Moon passes into Earth’s shadow
____ 4. is made up of the Sun, nine planets, and other smaller bodies that orbit the Sun
____ 5. the largest planets in the solar system that are made up mostly of gases
____ 6. The changes in the amount of the lighted side of the Moon that are visible from Earth.

a. planet
b. orbit
c. solar system
d. phases of the Moon
e. lunar eclipse
f. gas giants
Fill in the blanks with words from the box below.

<table>
<thead>
<tr>
<th>Comet</th>
<th>Asteroids</th>
<th>Universe</th>
</tr>
</thead>
<tbody>
<tr>
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<td><img src="image2.png" alt="Asteroids" /></td>
<td><img src="image3.png" alt="Universe" /></td>
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<tr>
<td>Galaxy</td>
<td>Red giant</td>
<td>Constellation</td>
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<tr>
<td><img src="image4.png" alt="Galaxy" /></td>
<td><img src="image5.png" alt="Red giant" /></td>
<td><img src="image6.png" alt="Constellation" /></td>
</tr>
<tr>
<td>Star</td>
<td>Revolution</td>
<td>Moon</td>
</tr>
<tr>
<td><img src="image7.png" alt="Star" /></td>
<td><img src="image8.png" alt="Revolution" /></td>
<td><img src="image9.png" alt="Moon" /></td>
</tr>
</tbody>
</table>

12. The ____________ is made up of all the matter and energy there is, including the galaxies and their stars, planets, and moons.

13. A ________________ is a group of stars that forms a pattern in the night sky.

14. Each ________________, or trip around the Sun, is a year.

15. A huge system, or group, of stars held together by gravity is a ________________.

16. A huge ball of very hot gases that gives off light, heat, and other kinds of energy is a ____________.

17. Small, icy bodies with very long tails that orbit the sun are ________________.

18. A ________________ is a body that orbits a planet.

19. A ________________ is a very large, bright, cool star.
20. Rocky or metallic objects that orbit the Sun between Mars and Jupiter are _____________________.

Label the names of the moon phases with the appropriate letter.

___1. Full Moon  ___2. Waxing Crescent  ___3. Waning Gibbous
___4. First Quarter  ___5. Waxing Gibbous  ___6. Last Quarter
___7. Waning Crescent  ___8. New Moon

Label the solar system with the appropriate names.
APPENDIX M

VISUAL-SPATIAL ACTIVITY PICTURES
Oreo Cookie Moon Phases
Planet Research Posters

**PLUTO**

- Pluto is 3,658 miles from the Sun.
- Pluto takes 248 days to go around the Sun.
- The diameter of Pluto is 2340 mi.
- Pluto is an oval.
- Pluto has 1 moon.
- Pluto is made of gas.
- Pluto is no longer a planet.

**VENUS**

- Diameter: Venus diameter 8,153 mi long.
- Made of: Venus is made of rock.
- Means: Venus has no moons.
- A day on Venus: 243 days on Earth.
- A year on Venus: 225 days.

**Other facts**

- Venus is Rapid for they cannot go fast once they are out of Earth.
Saturn

How many days it takes around the sun?

It takes 30 days.

What is it made of?

It is made of rocks.

An interesting fact is that Saturn has the White Titans, the Black Titans, and sisters of the God Saturn. It also has 60 moons orbiting around it and also has rings to its planet.

Mars

Mars is the 4th planet.

Diameter: 11,192 miles

251 million km

Day discovered: 24 May

What Mars is made of: Rock and dust

687 Earth days

Days to orbit: 1 year

Mars has 2 moons: Phobos and Deimos.
APPENDIX N

MEMORY CARD GAME
Asteroids are rocky fragments left over from the formation of the solar system about 4.6 billion years ago.

A solar system is a system of planets and other objects orbiting the Sun.

A comet is a small, frozen mass of dust and gas revolving around the sun.

A meteor is a shooting star, observed when a particle of dust enters into the Earth’s atmosphere.
A constellation is a group of stars that forms a pattern in the night sky.

A galaxy is a group of stars, gas and dust held together by gravity.

A gibbous moon is when it is more than half full, but not completely full.

A meteorite is an object from Outer Space, such as a rock, that falls into the Earth and lands on it’s surface.

The Milky Way Galaxy is the spiraled-shaped galaxy that contains our solar system.

An orbit is the path one object takes around another.
Changes in the lighted side of the Moon that you can see from Earth are the phases of the Moon.

A planet is an object moving around a star.

A revolution is when a planet or other object is moving around another object.

A star is a huge ball of very hot gases that gives off light, heat, and other kinds of energy.
The universe is made up of all the matter and energy there is, including the galaxies and their stars, planets, and moons.

The phase when no light from the Moon is seen is the new moon.