LESSON PLAN TITLE: *Plan the Perfect Chinese Palace Using a Magnetic Compass* Grades: 2-3

TIME REQUIRED: 2-3 class periods

CONCEPT STATEMENT: This activity explores how the observation of the earth, sky, and natural cycles led to the early development of a calendar and the magnetic compass in China. Students will also learn about the meanings that the ancient Chinese associated with the cardinal directions and manipulate a magnetic compass to determine directions.

OBJECTIVES:

Students will:

1. Practice locating north, south, east, and west using the position of the sun as a guideline;
2. Learn about the Chinese invention of the magnetic compass;
3. Practice using a compass to find north, south, east, and west; and
4. Create guardians for an auspicious imperial palace.

STANDARDS OF LEARNING CORRELATIONS:

History: 2.1, 2.4.a-b

Science: 2.1, 2.2, 3.8.a

Visual Arts: 2.3, 2.4, 2.11, 3.4, 3.5, 3.6, 3.13

MATERIALS:

a large open space

Per Group (for outside activities)
a compass
large piece of rectangular poster board and pencil or marker

Per Student (for writing and art activity)
drawing paper and colored markers or pencils
scissors for cutting out seated emperors and guardian figures
glue or glue sticks for attaching the figures to the poster board

**Prerequisite Skills and Knowledge**

Students should have a basic understanding of magnetic attraction and repulsion, magnetic fields, and map directions before beginning this activity. They should also know that the ends of a magnet are called "north" and "south."

VOCABULARY:

**astrology –** The study of the movements and relative positions of celestial bodies interpreted as having an influence on human affairs and the natural world.

**astronomy –** The branch of science that deals with celestial objects, space, and the physical universe as a whole.

**attract –** To pull forward or draw near with a force.

**attraction** – The ability or force possessed by something to draw something else towards it.

**auspicious** – promising success; advantageous; opportune; favorable.

**calendar** – Any of various systems of reckoning time in which the beginning, length, and divisions of a year are defined.

**magnet** – Any piece of iron, steel, nickel, or magnetite (lodestone) that has the property of attracting iron or steel (or nickel). This property may be present or artificially induced. (Cobalt is also magnetic, but is rarely used to make magnets).

**lodestone –** A naturally occurring magnet composed of magnetite.

**magnetism** – The force exerted by a magnetic field.

**magnetic field** – A region of space in which a magnetic force acts.

**repel** – To push back or away with a force.

**repulsion** – The ability or force possessed by something to push something else away from it.

OVERVIEW FOR PRELIMINARY ACTIVITY:

Use the background information provided below to develop an age-appropriate introduction to the ideas that ancient Chinese people developed about the directions of east, south, west, and north by observing the natural cycles of the sun, moon, and stars.

**East, South, West, and North in Ancient China:** Like many early people, the ancient Chinese thought that there were connections between what they saw in the sky and events on earth. This idea makes sense when you think about the things they could directly observe about the sky. The rain falling from the sky made it possible to grow crops. The sun rose in the east and set in the west to mark the beginning and end of each day. The phases of the moon followed a distinct pattern that helped them plant seeds at the best times. Over many centuries, the waxing and waning of the moon also gave the ancient Chinese the idea to group days into months, while the changing seasons gave them the idea to group months into years.

It took a long time for the Chinese to figure out how to make these cycles work together. Careful observations of the positions of the sun, moon, stars, and planets eventually allowed them to understand the timing of the spring and autumn equinoxes and the summer and winter solstices. The calendar that developed out of their observations uses the monthly cycles of the moon—AND the yearly cycle of the sun—to accurately track the passage of time. The ancient Chinese figured out how to combine the two cycles by inserting seven extra months (leap months) into each 19-year calendar cycle. The calendar that resulted is the longest unbroken time measurement system in history!

Many of these developments took place even before the time of the Xia dynasty, which is traditionally viewed as the first ruling dynasty in China, (ca. 2100–1600 BCE). One of the first Chinese written sources that mentions the Chinese calendar is the *Shiji* (*Records of the Grand Historian)*, which wasn't composed until around the 2nd century BCE. The accounts in the *Shiji* about the first Chinese emperors and sovereigns are based on legends and tales—so scholars have relied heavily on archeological evidence as they have studied early Chinese calendar systems.

The *Shiji* gives the credit for developing the first Chinese calendar to Ta Nao, a court official who was given the task by Hungdi, the legendary Yellow Emperor. Because the emperor was responsible for ruling well, an accurate calendar was important so that he could accurately predict the Earth's natural cycles. Many beliefs about astrological connections between celestial events, such as comets and eclipses, and earthly events such as drought, war, and catastrophes, developed alongside these early observations and systems. Because of these beliefs, the ancient Chinese developed various rituals (ceremonies with a sequence of steps of actions) that were performed to ensure good fortune for the Chinese people.

Over time the sky was divided into five sections, known as *gong* (palaces). These palaces were associated with the directions of north, south, east, and west—and the middle. The middle or center region contained the star patterns that they believed were connected with the emperor and his court. The star patterns (or constellations) in the rest of the night sky were connected with one of the four directions—and with an animal and a color.

Today in America, we usually list the directions in the order of north, south, east, and west. The ancient Chinese, however, listed them in a different order. They started with the east because the sun rises in the east. After east, they listed the other directions in their circular order of appearance. So they would list the directions as east, south, west, and north.

The connections between the directions and specific animals are described in an ancient Chinese book called the *I Ching*, or *The Book of Changes*, which was based on various ancient records relating to divination (knowledge or prediction of the future).

> North is associated with the Black Tortoise, winter, water, longevity—and sometimes with a snake.
>
> East is associated with the Blue Dragon, spring, good will and auspiciousness (good luck) and wood.
>
> South is associated with the Red Bird, summer, and fire.
>
> West is associated with the White Tiger, autumn, and metal.

Heaven and earth were also symbolized by shapes. The sphere of heaven was represented by a circle. The square (or rectangle) represented the earth within the sphere of heaven. Beginning in very ancient times, these directions and symbols were often thought about as Chinese tombs, palaces, and the settlements around them were designed. For example, an early ruler of the Western Zhou dynasty (1046–771 BCE) founded a permanent capital at Fenghao (present-day Xian), which had a square or rectangular design with a roughly north/south central axis.

The capital also had special places for ritual ceremonies connected with natural cycles. This design for a capital became the prototype for future Chinese capital cities and imperial palaces, including the Forbidden City in present-day Beijing.

East, south, west, and north correspond to the movement of the sun. It's likely that early palaces faced south because the south offered the warmth and light of the sun during most of the daylight hours. Because cold winds came from the north, the most important people were seated with their backs to the north. From the Western Zhou dynasty onward, the thrones (dragon chairs) of kings and emperors faced south within the squared-off walls of their palaces. To the ruler's left, on the east, which was associated with morning, spring and life, were the places for court officials of highest rank or importance. Lesser officials were placed on the ruler's right, to the west, which was associated with evening, autumn, and death.

PRELIMINARY ACTIVITY DIRECTIONS

If possible, take the class outside for this exercise, which will provide a review of north, south, east, and west—and how these directions relate to the movement of the sun.

Divide the class into small groups of 4 to 5 students. Give each group a large rectangular piece of poster board and a pencil. Ask each group to decide on the directions of east, south, west, and north using their observations and memories of where the sun is positioned in the sky at various times of the day.

Ask them to mark the poster board with the letters E, S, W, and N at the right, bottom, left, and top edges of the paper. Once they have finished, ask them to place their poster board on the ground so that the letters are linked with the directions they have decided on.

Once they have committed to the four directions, ask them if they think their directions are all the same. (Each group could point directly east to help with this determination. It's likely that they not be pointing in exactly the same directions.)

Ask them how they might check their poster board positions for accuracy. If they have learned about compasses, they should come up with the idea of using a compass to check their directions. Tell them that compasses were invented in China—and that they will learn about the invention of compasses and how to use them in the next class period. (Save the poster boards for the follow-up activity.)

OVERVIEW FOR MAIN ACTIVITY

**How and when was the compass invented in China?** Since directions had such important symbolic meanings in ancient China, it makes perfect sense that the ancient Chinese would be fascinated by lodestones, which are naturally occurring magnets. At first, lodestones were used for divination (foretelling the future), but later the Chinese found ways to use them in navigation and direction finding.

No one knows exactly when compasses first appeared in China, but it was many centuries before they were used in Europe. In a fourth-century BCE text called *The Book of the Devil Valley Master*, there is a reference to a "south-pointer," which—in addition to its usual purpose—was used by jade hunters to keep them from getting lost. (The usual purpose seems to have been to help them achieve order and harmony through divination.)

According to another Chinese account, Emperor Wang Mang (who ruled briefly from 9 to 23 CE, between the Western and Eastern Han dynasties) had a spoon-shaped "Ladle of Majesty" that pointed south. The device was probably shaped like a spoon to echo the shape of the star pattern called the Big Dipper. The handle of the celestial dipper always points toward the south in the sky. The Ladle of Majesty was carved out of a lodestone. The ladle sat on a square bronze plate, which represented the Earth. A circle within the square represented heaven. Markings on the base also indicated compass directions. The ladle was carved so that the handle of the lodestone dipper would point to the south. The emperor probably used his ladle to make sure that he faced south, the luckiest direction, as he gave his ruled the land.

The first complete description of a magnetic compass that has survived dates from 1044 CE (Northern Song dynasty). This work, the *Wujing Zongyao* (*Collection of the Most Important Military Techniques*) describes a magnetic iron fish that floated on water to indicate direction.

**How did it work?** A thin layer of molten iron was cast in the shape of a fish. As the iron cooled, the fish was placed so that its head pointed toward the south and the tail toward the north. (In China, lodestone ladles and fish compasses were said to point to the south because south was considered the most important direction. Of course, the other end of the compass pointed north.) This placement caused the magnetic domains within the iron to align themselves with the Earth's magnetic field, and the resulting fish became a magnet. The fish was then placed in a bowl filled with water.
The fish was allowed to move freely on the water's surface until its head pointed south. The description ends with a reminder that the information about how the fish was made and used was to remain a secret.

The *Meng Xi Bi Tan* (*Meng Ch'i Pi T'an*) or "Dream Pool Essays" written by Shen Gua around 1088, gives another description of the making of a compass. Shen Gua was an astronomer, mathematician, and high official who wrote "Magicians rub the point of a needle with the lodestone; then it is able to point to the south."

Another early reference to a Chinese compass comes from the *Shih Lin Kuang Chi*, an encyclopedia compiled between 1100 and 1250 and first printed in 1325. This work describes a wooden turtle into which a lodestone was placed. The turtle was balanced on a pivot so that it could spin freely. The tail of the turtle, which was a magnetic needle, always turned to point south.

The first known reference to the use of the compass in Chinese navigation dates to about 1111 CE (Song dynasty). The *Pingzhou Ketan*, which means *Pingzhou Table Talks*, by Zhu Yu describes events from about 1086 forward and contains a variety of nautical information. The work says that at night ship pilots steer by the stars and in the day by the sun. However in "dark weather," they look at the south-pointing needle.

**The Compass in the West:** The magnetic compass was first mentioned in European sources by the English monk Alexander Neckham in 1187. In his book *On the Nature of Things*, he describes a device in which a magnet "… whirls around in a circle until, when its motion ceases, its point looks direct to the north."

No one knows exactly how Neckham learned about the compass, but over the next two hundred years, the compass is mentioned in many other European publications and sources. Silk Road travelers, including Marco Polo, may well have brought the first magnetic compasses to Europe. Early compasses were made of thin pieces of lodestone (naturally occurring magnets composed of magnetite) that floated on water. Since the lodestones always pointed in the same direction, travelers were able to navigate even when it was cloudy and they couldn't see the stars. By 1300, the compass was in fairly common use by European navigators.

**Make the Art Connection:**

Many ancient Chinese palaces, tombs, and cities had special symbols for protection that were connected with specific directions. For example, as Buddhism became known in China through the Silk Road trade routes that flourished during the Han and Tang dynasties, Buddhist deities such as the Heavenly Guardians of the East, South, West and North became a part of China's cultural and artistic heritage.

***Heavenly Guardian (Lokapala)***
7th century, Chinese, Tang dynasty (618–907)
earthenware with pigment
Floyd D. and Elisabeth S. Gottwald Fund, 90.219 a-b

This heavenly guardian statue, which you can see in the East Asian galleries of the Virginia Museum of Fine Arts, was made to protect the tomb of a prominent person during the Tang dynasty. His armor features dragon wings and reptilian scales. His arms are protected by gauntlets and his shins by greaves. A plumed phoenix decorates his helmet. He is stomping on a demon and glaring at any threat to those he protects. His raised hand originally held a spear, which is now lost. He was also decorated with gilding (thin applications of gold) and painted in bright colors.

After viewing and talking about the figure of *Lokapala*, ask the students to make a list of adjectives that might describe a fierce guardian of an imperial palace. (Ask them to save these lists to use during their final art activity.)

ACTIVITY DIRECTIONS (This part of the activity should definitely be done outside. The metal support structures and electrical components of buildings can affect the accuracy of compasses that are used inside them.)

Take the class outside and explain that they will be working in the same groups as in the previous activity for this outdoor adventure. (They should take their poster boards and pencils with them.) Distribute a compass to each group and give them the following directions:

- Each group will determine the proper direction for each of the four sides of their very own imperial palace! The ancient Chinese probably used many different sightings of the sun and stars to make sure that their palaces faced toward the south, but today, you're going to use a magnetic compass to accurately find east, south, west, and north for your very own imperial palace.

- Let's begin by reviewing how a compass works. A compass needle is a magnet. The needle always has one end marked with a special color or symbol. In today's world, this end is called the north end of the compass needle. The north end of the needle in modern compasses always points north (in the direction of the Earth's geographic north).

- How is that different from the ancient Chinese devices?
  (Ancient Chinese devices pointed toward the south.)

- To find the correct position of all four directions using the compass, turn the base of the compass until the north end of the compass needle lines up with the north marking on the face of the compass. Once that's done, all the other directions will be correct.

As they work, visit each group to make sure they understand how the compass works. Many adults have trouble with this skill! Next, ask each group to use the compass to help them place their poster board so that the north and south ends are pointed in the correct directions. Once the poster board is properly placed, ask each group to sketch in the outer walls of their imperial palace on the poster board. Once all the groups have their outlines finished, continue with these directions:

- Sketch in a door, or gate, for each wall. (They should take turns drawing.)

- Once your doors are in place, draw in the emperor's throne and place an arrow showing which direction he will face when he sits on his throne. Ask students to face in the same direction as the emperor.

  Is east to his right or left? (East is on his right.)
  Is west to his right or left? (West is on his left.)

- Each group should now name your imperial palace. Write the name on the poster board above the south wall.

- When we return to the classroom, each group will produce 5 drawings connected with their imperial palace. One picture should be of the emperor on his throne. The other 4 should be of Heavenly Guardian figures who will protect the group's palace on the east, south, west, and north!

- Decide, within your groups, who will draw each figure. Each student should put his or her initials by the direction (east, south, west, north, or center for the emperor) of the figure he or she will draw. Be sure to bring your poser boards back to the classroom with you.

Take the class back inside for the related art activity that follows.

**The Art Connection Acivity:**
For this activity, each student should have a piece of drawing paper and colored markers or crayons. You may need to remind them of which figure they decided to draw. They should begin by labeling their drawings with the direction they have been assigned (east, south, west, north, or center for the emperor).

Before beginning the guardian drawings, ask them to review the adjectives they listed to describe fierce guardians of an imperial palace. You may also want to remind them of the symbols associated with the various directions if they need further inspiration.

> North is associated with the Black Tortoise, winter, water, longevity—and sometimes with a snake.
>
> East is associated with the Blue Dragon, spring, good will and auspiciousness (good luck) and wood.
>
> South is associated with the Red Bird, summer, and fire.
>
> West is associated with the White Tiger, autumn, and metal.

When they have finished their pictures, they should cut out the figures and glue them onto the poster boards in the correct places. Each group should present their finished imperial palace to the group.

ADDITIONAL RESOURCES AND SOURCES:

The website links listed below have been developed by the Magnetism Group in the Physics Department at Trinity College Dublin. The web addresses below take you to information and many pictures and illustrations that relate to Chinese magnets and compasses.
https://www.tcd.ie/Physics/Magnetism/Guide/mythsorgins.php
https://www.tcd.ie/Physics/Magnetism/Guide/compass.php

National High Magnetic Field Laborartory:
http://www.magnet.fsu.edu/education/tutorials/museum/chinesecompass.html

Cultural China: Kaleidoscope: Science and Invention:
http://kaleidoscope.cultural-china.com/en/136Kaleidoscope2.html

The International Dunhuang Project: The Silk Road Online
http://idp.bl.uk/4DCGI/education/astronomy/history.html
http://idp.bl.uk/4DCGI/education/astronomy/sky.html

The Mathematics of the Chinese Calendar by Helmer Aslaksen, Department of Mathematics, National University of Singapore:
http://www.math.nus.edu.sg/aslaksen/calendar/chinese.shtml

**Books for Children:**

Beshore, George. *Science in Ancient China*. Franklin Watts, (Division of Grolier Publishing). 1998.

Harvey, Miles. *Look What Came From China.* Franklin Watts, New York. 1998.

**Books for Adults:**

Aczel, Amir D., Ph. D. *The Riddle of the Compass*. Harcourt Inc. 2001.

Needham, Joseph. *The Shorter Science and Civilisation in China*, (abridged by Colin A. Ronan). Cambridge University Press, 1995.

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