Seminar Title: Understanding our World through Geometric Reasoning

Curriculum Unit: Cultural Geometry Implementation for Second Grade

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Introduction to Geometrical Thought

In the past few weeks, I have heard numerous people lay a thought out on the table for me to consider. Oddly enough, it has been the same basic idea and it has not been connected to the geometry curriculum I am working on. Interestingly, it is the idea of life taking on circular patterns rather than the commonly held European idea of life in a linear pattern with certain expected life events occurring as markers on that line. The linear concept can seem somewhat reassuring because it makes clear what we expect from our lives. It can be compared to the idea of a timeline, but without the dates provided in advance. Even if you make a mistake on the linear movement, you move on to the next stage. This linear concept of life is an Anglo view brought across the oceans to the Americas in times past, but one that still quietly remains an accepted truth in the minds of many of European descent. However, the people who spoke to me about their perception of life patterns do not see life as being so clearly directed and linear in movement. They see life as more of a continuum of circles where each life circle becomes a piece of the entirety of life, with what was learned previously influencing the next circle. It is a cycling of lessons learned and wisdom gained more than of the linear passing of time.

The Native American concept of life in interlacing circles is that of each new circle providing a natural opportunity in which hozho, or the life balance referred to as "walking in beauty," can be moved toward and experienced. The life experiences and choices made in each cycle can bring one closer to or move them further from the harmony that humans are meant to walk in with all living entities.

In continuation of that cycling thought, the shape of a Navajo female hogan, or family home, represents multiple circular themes that complement each other and that are united. For Instance, a newborn child symbolically begins the circle of their life from the east doorway where the sun rises, progresses in life clockwise to the south as a toddler, west to adolescence, north to adulthood, and then exits the circle in the north as an elderly person. The life cycle has been fully traveled. In the Navajo world, there are also circular progressions of specific stages of learning represented in the clockwise travel through the hogan. They are thinking to the east, planning to the south, implementing to the west, and reflecting to the north.

Geometry and numeration have specific meanings to specific cultures. Shapes tell stories. Numbers are built into belief systems. Symmetry and rotations have functions that are not accidently devised. Children have a natural attraction to geometry. Not only does geometry develop childhood reasoning skills and further brain development, but a child's recognition of geometric patterns and shapes in their communities helps them understand their connections to their families and their background culture. It develops a cherished sense of belonging and inner knowledge of who they are and what their story is.

All of the shaped pieces of our lives that brought us to where we are, are parts of a larger design. That design carries beauty and order. A person could imprint a piece of that design on pottery to show others something important. They could weave a design section into a rug as an inspired part of a specific understanding that they want to represent, or they could work it into a beadwork design to represent the environment of their people. Different cultures represent their

understanding in different designs. This curriculum will work to include Native American culture within the exploration of geometry for second grade students.

Who

Flagstaff is a mountain city in Arizona with a population estimated by the US Census Bureau at 76,000 (US Census Bureau, 2022). Despite the larger population, it has a small city feeling and is nested at the base of the San Francisco Peaks. These peaks are sacred to numerous Native American tribes in the region. Their history on these lands precedes those of the current populace by thousands of years, and their presence is felt across the area. Flagstaff is near the borders of both the Navajo and Hopi Nations, with other tribes also in the surrounding areas.

Flagstaff Unified School District has ten elementary schools, one of which is Thomas Elementary school. The students at this school are overall 44 percent Hispanic, 28 percent Native American and 22 percent white. However, in three specific grade levels the percentage of Native American students reaches over 30 percent. These percentages are reported by the State of Arizona for the 2021 – 2022 school year on their Report Cards website. Using their statistics for demographics, it is also notable to see that, although the population demographics of the school have remained fairly steady over the four years prior to the 2021-2022 school year, moving into the 2021-2022 school year from the one previous, there was over a five percent increase in Native American students and a 4 percent decrease in white students while the Hispanic population held steady (Arizona School Report Cards 2022). According to our district transportation director, out of 411 students enrolled at Thomas Elementary, 195 are from outside of our school's stated boundaries (P. Fleming, personal communication, June 16, 2023). These 195 students are enrolled by choice from families outside of the immediate neighborhood. Thomas Elementary's low socioeconomic status, plus low state test scores for both Hispanic and Native American student populations have placed the school in a special position within the district to receive additional Title I funding assistance for the next three years to raise those test scores. Several other schools in FUSD are also in the same position and will be receiving additional Title I funds. There has been a lot of consideration and planning within the school to decide and implement the most effective ways to accomplish assisting these students in excelling academically.

The specific students whom this curriculum is written for are three second grade classes at Thomas Elementary School. The lessons will be taught to the students one classroom at a time. These students are seven to eight years old and are still developing maturity. The Center for Disease Control, or CDC, indicates that children this age are rapidly developing mental skills. They are becoming more independent and learning how to work in groups or teams. This group is also learning responsibility and beginning to show persistence in academics, particularly when the goal is obtainable, and they are given encouragement while they work. They need movement built into class time. Interestingly enough, the CDC recommends limited screen time even at school. Structured, but simple teamwork along with supported independent work and using their bodies to learn are keys to learning at this age. (Centers for Disease Control , 2021)

Context/Rationale

I am one of the district's Native American Support teachers. I know from personal experience that when you tie into students' cultural background in their classrooms that they are more comfortable, experientially knowledgeable, and have a higher level of interest in participating and learning. The feeling of being respected and having their background culture honored in their own classroom creates a confidence in learning.

Many Native families still have hesitancies about education that stem from the considerably recent era of boarding school education. They are sometimes less supportive of their children's attendance and education than those populations that didn't have that experience. There are also some socio-economic factors and family responsibilities that lower attendance rates. This, compounded by the families' ethnicity not being closely represented by the teacher demographics, unintentionally results in some cultural misunderstandings. Part of my job is to bridge that gap to bring trust and understanding between families and the school. When we honor and understand our families' culture and respond to it respectfully, they are more comfortable with school attendance and support. When students and parents feel a greater connectedness to school, attendance increases, communication increases and student test scores go up. Think for a moment about the lengths Native families go to in order to honor their graduates. It is very expensive to buy cultural clothing and feed clan members and immediate family who attend the graduations. Obtaining and completing education is clearly highly valued and honored by our Native families. As teachers, we can partner with parents in helping students plan for and obtain their academic goals by carefully designing our classroom curriculum and experiences to welcome and support students of all cultures and by respecting and listening to their parents and guardians, even when their viewpoints vary from our own.

Some experts in the field of mathematics suggest that geometry is the foundational base upon which all other areas of mathematical thinking stand, excluding simple calculation. In that case, when geometric understanding increases, it results in corresponding higher levels of mathematical understanding in concepts across mathematical disciplines . It is noted that geometric comprehension particularly enhances mathematical reasoning skills (Clements & Sarama, 2011).

I propose that geometry is a natural construct of an inquisitive mind. Just as the original mathematicians analyzed, described the functions, developed rules, and decided upon the specific vocabulary of geometry, children develop their own intelligent geometric constructs through their own observations and experimentation. They use their own self-determined vocabulary extending from the range of their previous life experiences to explain these concepts until someone guides them into more precise vocabulary and descriptions (NCTM, 2000). Anyone observing children play can easily notice a child's intentional creation of patterns and shapes from a very young age. From my personal observation, some of those first experiences include running their fingers across spilled food on their highchair tray in lines and arcs or lining up like-item toys such as blocks or Hot Wheels cars in a row. As they age, they add to these basic self-discovered constructs, preparing them for a more formal presentation of geometry in primary grades (NCTM, 2000).

In addition to the exploration and self-construction of geometric thinking, children are also observant about the patterns around them within their homes and communities. All households are rich with geometric presentations seen in everything from floor coverings to kitchen dishes. Native American homes and communities have a unique set of favored geometric patterns. Not only are they aesthetically pleasing, but there is cultural meaning and relevancy behind the designs that adds to the understandings of individuals, which in turn strengthens community relationships and a sense of belonging. Not only are Native American designs unique in their connection to symbols of earth and nature, but they are also distinctively unique to the tribe and location that developed them, enabling students to identify strongly even to their own specific local tribal patterns. This sense of belonging and connection can be a drawing factor for Native American elementary students within a classroom to strongly engage them with geometry curriculum when their cultural background and their curiosity about other tribal entities is included in the structured mathematics setting (Moyer, 2001).

Although geometry can be a comfortable and natural fit for Native American students, geometry is one of the most limited or ignored branches of mathematics taught in schools in the United States. In elementary and middle schools, geometry is generally taught at the very end of the school year. Thus, if something gets left out of the teaching cycle due to time limits, geometry is the likely subject (Kilpatrick et al., 2003). This also occurs at the college level. Research has shown that, "Of all mathematics topics, geometry was the one prospective teachers claimed to have learned the least and believed they were least prepared to teach" (Clements & Sarama, 2011, p. 135). Considering its importance in understanding other disciplines of math, teacher comprehension of geometry needs to increase as well as that of the students.

Even though it is a vital foundational part of careers such as those involved in art, architecture, engineering, robotics, astronomy, GPS, biology and more, geometry is relegated a back seat in schools to other math concepts such as number facts. However, it is the very foundation for understanding many other areas of mathematics such as multiplication, fractions, and coordinate graphing as well as being the basis for mapping skills. Ideally, it should be integrated all year long in conjunction with other related academic areas (NCTM, 2000). Strengthening geometric education in schools results in the strengthening of many other areas of math and related subject areas.

Content Objectives

In this curriculum unit, students will begin by exploring lines, points, and planes and developing working definitions. Angles are a logical next step. With these concepts and vocabulary in place, students can progress to the exploration of two dimensional planar geometric shapes, using examples to deduce attributes and non-examples to clarify and solidify their thinking. The basic idea that dividing a shape produces a fractional part will be introduced after this. The last key element to experiment with is movement on a plane. This will prepare the students to look at Native American patterns and pottery designs and analyze the ways in which geometry was used to create those designs. As the students move forward, new vocabulary in both English and Navajo will be added to their knowledge base.

In considering this curriculum, note that one of the main content standards for second graders in the state of Arizona is to be able to identify and describe the attributes of shapes. Due to the students' academic readiness level, these geometric figures would begin with the most basic figures, moving toward some age-appropriate complexity. Second graders should be at a developmental stage able to process the attributes of circles, as well as four-sided figures such as squares, rectangles, rhombuses, trapezoids, and quadrilaterals. The basic concepts that pertain to the characteristics of five-sided pentagons and six-sided hexagons would also be within their zone of learning.

Although this curriculum does not venture that far, second graders are expected to be able to identify attributes of some three dimensional shapes and discussion of these should be embraced if they occur before being officially introduced (NCTM, 2000). According to Eureka Math, this would include cubes, simple rectangular prisms, cones, and cylinders (Watts-Lawton, 2018). The National Council of Teachers of Mathematics suggests using nets to help elementary students understand attributes of three dimensional figures (NCTM, 2000). These concepts would still need to be taught during the school year sometime following the presentation of this curriculum.

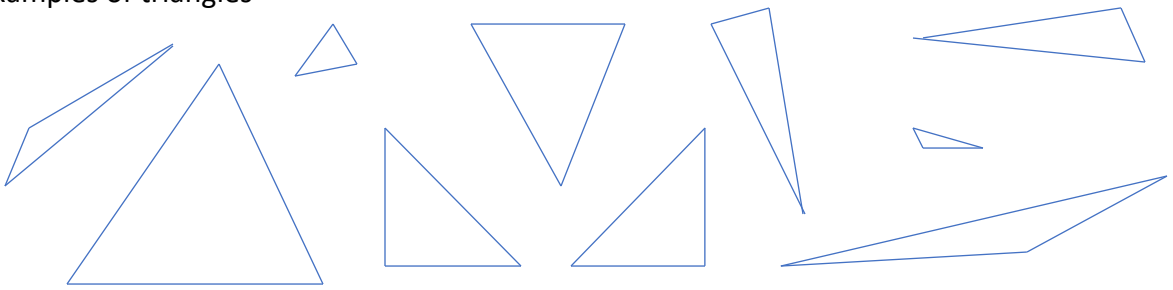
The first step for second grade is to set the foundation for learning the geometric attributes of two dimensional shapes and the concept of movement on a plane begins with acquiring a solid understanding of points, lines and planes. Without exploring and clarifying the properties of these foundational elements with an accurate vocabulary, it is difficult to move on to discussion of the attributes of shapes or define the movement that occurs during transformations.

Once the students understand points, lines and planes, they would next need to be able to put to use observation and reasoning to identify the attributes of geometric figures (Kilpatrick et al., 2003). Once those attributes are identified, conversely, they would then use that information to work the process in reverse. They would use logical thought to conclude which geometric figure(s) could be formed by a specified set of attributes (Van de Walle, et al., 2014). For instance, a second grader should understand that a triangle has three straight sides, three angles, three vertices and is a closed figure. If one attribute presented to them is that a figure has four angles, they should be able to reason that the figure could not be a triangle. In addition, they should be able to correctly draw a representation of a familiar geometric shape when given the specific attributes of that shape and be able to identify what shape it is.

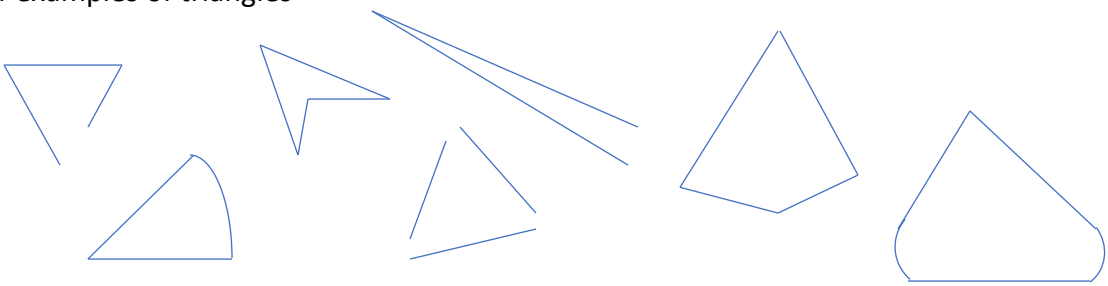
In order to strengthen their understanding of the attributes of geometric figures, students will need to have experience with non-examples of each figure and the opportunity to process why these are non-examples. The process of comparing and contrasting these visuals will increase their clarity of understanding. Students sometimes develop misconceptions while identifying accurate models that contain the attributes of shapes, and these misconceptions can adversely affect their identification of non-examples. One cause of this can be the limited number of examples shown during initial analysis. This is especially true when similar rather than highly varied examples are viewed by the students. (NCTM, 2000). The result is that any unfamiliar presentation, even of an accurate example, can be mistakenly viewed as a non-example. Two instances of this would be when either the size or orientation of a figure has not been experienced before and this lack of experience prompts confusion. While it may have all of the

previously confirmed attributes that make it a specific geometric figure, the new presentation causes the students to focus on trying to process what is new rather than analyzing based on the attributes they already know (Kilpatrick et al., 2003). They might think, “That cannot be a trapezoid. It’s too skinny on the bottom and too wide on the top, “ or in the case of a triangle they might think, “That can’t be a triangle. It is upside-down.”

Examples of triangles

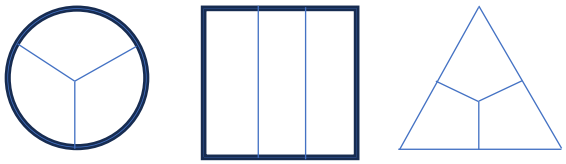


Non-examples of triangles



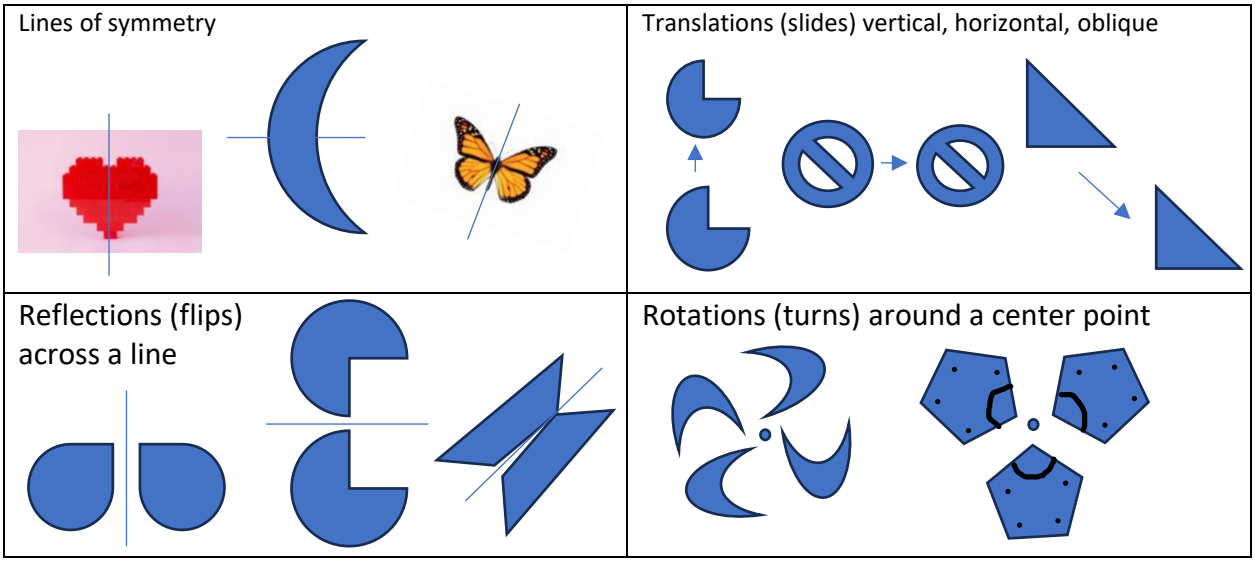
An additional consideration is that one of the Arizona state geometry standards for second grade is to divide circles and rectangles into halves, thirds and fourths and to be able to name corresponding fractions for the amounts designated. It is important for students to understand that fractional parts of a whole must be the same size, and that if there are 3 equal sized pieces that make up the whole, that 1 piece is 1/3 of the whole. Fractions are one of the more difficult geometric concepts for second graders although they have already had some experience with them in lower grades. Examples, non-examples and use of models such as pattern blocks or drawings on grid paper can provide ways for the students to visualize the concept (Van de Walle et al., 2014).

Examples of thirds



Non-examples of thirds

According to the National Council of Teachers of Mathematics, second graders should be able to explore movements of geometric figures on a plane. These are referred to as transformations and would include slides, flips and turns. They might do this exploration using a reflection tool such as a MIRA or by utilizing tracing paper that could be folded over a line of reflection or moved along a designated slide line called a vector. The NCTM also states that symmetry is an appropriate subject for all grade levels to investigate, including second grade (NCTM, 2000).



Symmetry is an intuitive idea even for very young children. Second graders can begin to transform those ideas into identifiable concepts. At this stage, it is easier for students to identify symmetry shown with a vertical line of symmetry rather than one that is horizontal or one that is oriented at a slant. The method of image drawing with the assistive use of tracing paper to create the second half of a symmetrical image can help the students with the experience needed to move toward identification of symmetry turned to other orientations (Kilpatrick et al., 2003).

Transformations are also an idea at the beginning stages for second graders. They can learn to identify the different types of transformations, but their ability to self-produce them is still at a manual rather than mental level. This means that they will need manipulatives and other tools to help them successfully accomplish producing these transformations on their own. As they spend some time doing hands-on experiential learning, they will gradually have a stronger mental sense of the transformative movements. Slides are the easiest transformation for students to conceptualize, so this is the best transformation to introduce first, and adequate practice should follow to well familiarize them with the idea. Flips and turns should follow the introduction of slides, with the teacher again providing multiple tools for student experimentation to support their thought processing (Kilpatrick et al., 2003).

There has been a tendency in mathematics practice in the United States to lean toward teaching geometry through teacher or textbook explanations. In this case, students rely more on memory rather than adequate experimentation and deductive reasoning to build geometric knowledge. However, experimentation with manipulatives and models is necessary to thoroughly understand geometry and to avoid forming misconceptions or to dispel ones already formed (Kilpatrick et

al., 2003). This could include the use of online technology tools as well as tactile tools. Student experience with manipulatives is an essential scaffold for students to learn to manipulate objects mentally (NCTM, 2000).

As students learn how to manipulate the movements both physically and mentally, they will tend to use their own self-determined words to explain what they have done. They may use words like turn, twist and push. These words are acceptable, especially at first, but they should be gently guided into using the more mathematically accurate vocabulary words slides, flips and rotations. These are words they can understand as they work with manipulatives and that can provide the class with a common language for class discussions. Teachers should consider the students' geometric language comprehension level. Gradually, they will learn the words transformations, translations and reflections, but that can wait for a later grade level instead of confusing them as second graders with words they can't spell, and many can't read.

As the Native American Support Teacher/Advisor in my school, one of my goals is to include cultural perspectives and information into the lessons. Through parental surveys, we have discerned that one of the high priorities of our Native American parents is for the children to have connections to and to learn some of their own Native language. The vast majority of our Native students are Navajo. This unit will include learning the Navajo words for some specific geometric shapes as well as learning to count to six in Diné Bizaad, meaning the Navajo language. The words in Navajo will be our main focus. Any other students knowing their own heritage language will be invited to count for us to demonstrate their own honored cultural knowledge. Many of our school's students, despite their identified specific heritage language, are familiar with and able to count to ten in Spanish already. Students may be interested to know that Arizona's Yaqui tribe speaks Spanish as their dominant language.

The Navajo Nation has produced a carefully thought out set of educational standards that are required to be taught on the Navajo Nation in addition to the resident state's educational standards. The Navajo refer to themselves as the Diné people. According to the original Diné Cultural Content Standards for Students produced by the Division of Diné Education and approved on June 23rd of 2000, the Diné have committed themselves to living life in accordance with ideals set at the beginning of time. However, current conditions of change and technology advances have pulled the people's connection to this belief system to a lower level. The Navajo Education Committee intentionally sought to preserve and revive the principles of cultural belief for Navajo youth while still maintaining, "excellence in education, a goal that will empower our people in westernized education while maintaining and retaining a strong bond to a unique ethnic culture" (Division of Diné Education, 2000, p. V). This is a goal that Native tribes and Nations across the United States aspire to for their children in education. These Native Nation educational standards are not required to be implemented off of the reservations, but they give teachers excellent guidance when working to be culturally responsive and culturally respectful to our Native families.

In order to integrate and strengthen language arts skills, the class will look at poetry written about shapes. They will come up with questions to clarify what is happening in the poem and be able to come up with visuals to show their comprehension. Part of the ability to comprehend is based on knowing what specific shapes look like and what physical movements it would be

possible for them to make under certain circumstances. This re-enforcing activity is designed to give additional practice with mentally processing the attributes of shapes.

One strong cultural connection to geometry lies in the geometric designs painted on Native Pottery. There are many shapes demonstrated in Navajo and other tribal pottery designs that the students will recognize as we progress in our geometric understanding. This unit will give them the opportunity to analyze what recognizable shapes and what transformative moves such as slides, flips and turns the artists chose to use in their designs. They will be able to look for examples of both symmetry and non-symmetry among other geometric design elements. I have spoken to Navajo pottery makers at length about the meaning of their designs and why they chose to use those designs and colors in their pottery. Then I purchased pottery from these artists for the students to use to consider both the geometrics and the cultural aspects of the designs. For the Native students, it will provide authenticity of the value of tribal identity and will allow them to be the knowledgeable experts sitting at the table . Students of other ethnicities will undergo a broadening of their understanding of Navajo culture and a new curiosity and higher level of comfort with the culture of others developed during conversational exchange.

Examining designs on pottery and connecting those to geometric figures as well as cultural meanings opens the door for students to explore these ideas further. In doing this, they will have the opportunity to further process the information that specific shapes are incorporated into designs that reflect the life of the artists, their beliefs, and their culture. They can stop to think about their own culture and geometric symbols and colors that could turn into designs to reflect their own life. The students will use the hands-on activity of making their own piece of pottery by planning the piece first. They will plan the simple shape, then decide upon the designs to adorn it with that have meaning to them. When they finish the pottery and it is ready, they will present their pottery to the class in a short presentation, explaining the geometric figures used, the meaning of their design and the colors chosen, and the choices they made in the design of its construction.

As an incentive to continue with excellence in their education, students will receive a certificate of excellence in Geometric and Cultural Design. At this point, they will graduate on to new areas of geometry and mathematics.

Teaching Strategies

Examples and Non-examples

Examples and non-examples are a way to bring clarity and depth of understanding into information students are learning. Human brains like to organize information and file it away. The more times an error is made, the harder it is to correct it because the brain develops groves that deepen each time we think the same way or think the same thing. It takes multiple events of thinking accurately to correct the misconception. It is better to gain clarity early on while learning than to try to correct those misconceptions later (Metropolitan State University of Denver, 2022).

The strategy of having students work with examples and non-examples is simple. Examples are often used to help identify the key attributes of a concept. When shown correct visual examples of a new concept, the teacher or student textbooks often provide limited representations. By not giving enough varied examples, it leaves room for what is not shown to provide insufficient processing. When presented with a new, correct example that looks different in some way than what has been experienced before, they may think it is an error and classify it as incorrect. Providing many variations builds stronger skills in the area of logical thinking used for analysis. Providing plenty of accurate examples from different viewpoints and many inaccurate examples, also known as non-examples, gives the students greater exposure and assists in the processing of difficult concepts. It helps the student identify the boundaries of the concept (Metropolitan State University of Denver, 2022).This practice translates into analytic skills that carry on into other math areas.

Vocabulary through Game Playing

Vocabulary is important for comprehension and the ability to participate in math class discussions. Simply trying to learn vocabulary by mental repetition is not motivating for students and lends itself to short-term memory. Turning learning into games, group work or positive social settings is helpful for improving long-term retention. The process of moving vocabulary into permanent memory occurs when vocabulary is put into practice. Some ways to provide that practice are through matching pictures to words, classifying items into groups, and memory games. There are five types of tasks that help students with processing words into long term memory. They are "…identifying, selecting, matching, sorting, ranking and sequencing" (Tuan, 2012). This unit will choose to use the methods matching two categories of cards, sorting into matching groups of cards, and placing cards in order, which could also be thought of as an arranging game.

Analysis of Native American Pottery

An artifact can be an item that is from times past, or it can be an item from current times. It is an object made by humans and is of interest for cultural or historical reasons. When chosen carefully, an artifact can meet content objectives in multiple subject areas and help make connections between content areas. In this case, the connections are between both geometrical shapes and transformations for math that connect with social studies standards on diverse culture and the geography of the area in which the people of the culture reside.

Traditional Navajo pottery did not have painted designs, so modern day painted Navajo pottery does not have a long history behind it. Originally, the pots were formed and then heated in a fire, which left dark marks on the outside of the reddish- brown pots. The art of painting pottery was probably picked up from watching other tribes who were already painting theirs. The modern pottery has some of the same designs on it as Navajo rugs do (Navajo art, 2018).

Students will be using pottery analysis in several rounds on separate days, each time looking for different geometric attributes in the designs on the pottery. On one day, the students

will look for design meanings. For accuracy, I checked with the artists who made the pots that I chose and that the students would examine. I asked the artists what the designs meant to them when they produced them. Sometimes more than one meaning was attached to the same design. On a separate day, the students will look at the pottery to identify symmetry, slides, and flips.

I have made a key for the designs on the pots that I obtained for this activity, which is attached to the end of the unit.

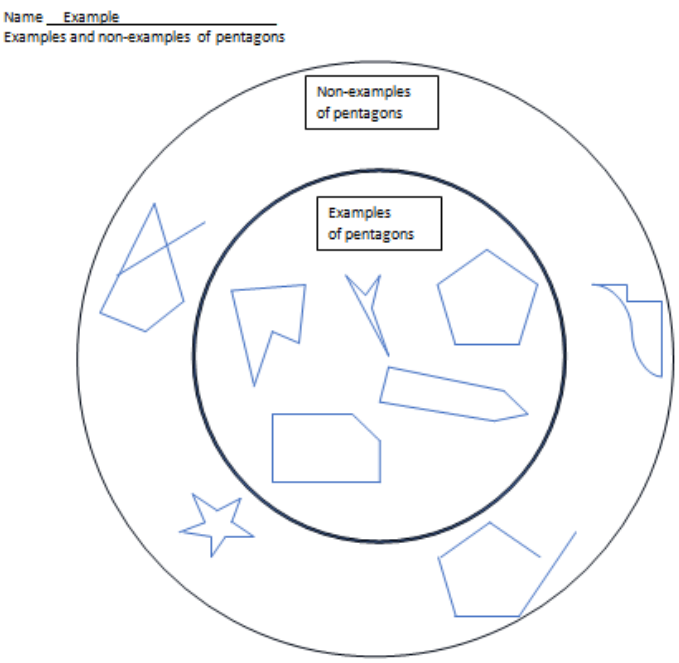
Student Activities

Attributes circles of examples and non-examples for polygons

Begin with concrete examples of polygons that are easy for the children to understand . Then begin to add more obvious abstract examples and move upward in complexity. However, these are second graders, so keep that development level in mind when choosing examples. Concrete examples would be those that the students have already had some experience with and that follow the same pattern. Then use some examples that are larger or smaller than the ones they are used to and some that are turned at a different orientation. Move into irregular shapes that have varied line lengths and unusual angles or a concave section but still have the attributes of the polygon. The idea is to use examples in which there is wide variation of the attributes. Next, expose the students to non- examples, such as lines that do not form a closed figure or shapes that have an arc instead of a line.

The next step is to provide the opportunity for the students to provide their own examples and non-examples. This is done in a team so that they can orally discuss their thinking. The team should be able to explain that thinking to the class or to each other by stating how their examples fit into the attributes of that shape and why the nonexamples do not illustrate the concept.

This activity will be set up with a drawing of two sets of circles, an inner circle for the examples and an outer circle. The space between the inner and outer circles will be where the non-examples are placed. This shows that the nonexamples are different from the examples and gives the students a place to collect their nonexample drawings.



Total physical response

The principal of total physical response is to have the students do an action with each vocabulary word that will help them remember it. If they are counting in Navajo, they can use sign language numbers with their hands as they speak the counting words. Alternately, if they have a number line on their desk, they could point to the correct numbers as they say the Navajo words with the class in unison.

Vocabulary Games

The students will learn the Navajo names for the polygons in this unit . Those polygons are the triangle (t1ago adeez'1), square (dik'3), rhombus (dį́į'go bídazniik'ą́), quadrilateral (dį́į́'go yistł'ah), pentagon (ashdlaji'go adeez'1), hexagon (hast32jigo adeez'1), and octagon (tseeb77'go adeez'1). They will also learn the Navajo names for the number words zero through eight. (0 - názbąs), (1 – t'ááłá'í), (2 – naaki), (3 – t áá'), (4 – dį́į́'), (5 – ashdla'), (6 – hastą́ą́), (7 – tsosts'id), (8 – tseebíí), (9 – náhást'éí), (10 – neeznáá).

The vocabulary practice will be acquired through using a card set. The card set is included with this curriculum. There are five categories of cards in the set. Simply print them two sided on heavy paper and they should come out correctly. The first set has the polygon pictures on the front and the polygon names in English and Navajo on the back. The second set has the English names for the polygons on the front and the Navajo names for the polygons on the back. If you

want to match the Navajo polygon words to the English polygon words, you could print a second set of this set. The third set has the names of the polygons on the front and the attributes of the polygons listed on the back. The fourth set has number words in English from zero to ten for identifying the number of sides the shape has, or alternately, for practicing matching to the Navajo words for the same numbers and to use to practice counting. On the back, they have the numbers. The fifth set has the numbers in the Navajo language, also for identifying the number of sides the shape has or simply for practice in counting and matching to the English number words. It has the numbers on the back.

The cards can be used in multiple ways. 1. One way is to hold up a card (by either the teacher or a student) for a whole group or a table group and to have the students name what the polygon is. 2. They could be shown either the attributes or the Navajo shape word and all students have a little wait time and then together draw the shape on the table with their finger. 3. They can be shown a card, then turn to their neighbor and say both the English and Navajo words or pass the card clockwise and each student say the word all the way around the table as they receive it. To end the circle, all students can say the word together out loud four times and clap once to signal the end.

A third way to use the cards are for matching. The Navajo number words will match very nicely with the Navajo shape words. Have the students notice that some of the shape words have the number word in them. Do they know why? Count the number of angles to see why. At this point, they can match the either the shapes or the attributes to the number cards. This will work because the attribute cards have the number of sides and angles listed. Be careful not to use the zero through 2 cards when doing this activity because there are no polygons with less than three sides. Keep in mind that a circle is not included in this activity because it is not a polygon. Instead, a circle is made up of points an equal distance from a center point, and therefore contains no lines or angles as a polygon does. Likewise, a point, line or angle are not classes of polygons. Points, lines and angles are foundational elements of geometry, but should be taught separately, not included in a polygon identification activity.

With enough practice, the whole class or small groups will be able to match the polygon cards to the polygon names in English and then additionally to the shape names in Navajo. They will be able to match and vocalize the numbers in English and the numbers in Navajo, then connect the attribute cards to the correct polygon cards.

These cards are in an attachment at the end of the curriculum unit.

Student analysis of Navajo pottery artifacts

Students will break into groups with a piece of Navajo pottery located on each group's table. They will be instructed about the fragility of pottery and each table will brainstorm ideas about how the pottery should be safely handled, offering up their one best idea to share with the group.

One of the analysis sessions will be over what polygons or geometric foundational elements they see on the pottery. This time they should include identifying circles, points, lines, arcs, angles, triangles, rectangles, squares). The students should use a worksheet with an illustration of these polygons and fundamental elements illustrated to assist them in recording the design in the

correct row or column. After they finish the first part of the activity, they will be given a key that shows the meanings of the artists' designs. They should work as a group to identify which of those designs they find. Why did the artists use these designs and meanings? How does it relate to the Navajo land, their beliefs, and their culture?

The second analysis of the pottery will occur after the students have experimented with symmetry and the transformations of flips, slides and turns. Their analysis will be done in groups again. This time the students will be looking at the same pottery for symmetry, slides, flips and turns.

Symmetry and Transformations Activities

A transformation is a slide, flip or turn. Symmetry and the transformations can be experimented with by using tracing paper. Students can draw the second half of a shape given to them already printed on paper using the tracing paper as a scaffold. They would draw the shape on the tracing paper and flip it over to connect to the original half. They can use manipulatives such as plastic or wooden shape pieces to rotate pieces manually to match a design or to create their own designs that slide, flip or turn. This can alternately be done on tracing paper by tracing from a printout of the shape while turning or sliding the tracing paper.

Poem Analysis

Shel Silverstein wrote the poem *Shapes.* It's characters are geometric shapes. This poem or poems like it can be analyzed for how the attributes of shapes affects their movement and abilities as characters. The students should think of the shapes with no additional body parts such as arms, legs, etc. extending beyond the shape. Why did the author choose the shape he did for each character? In what manner and from where did the triangle come? How did the attributes of the shapes affect what happened? Do they have any questions about the poem, for example, how can a circle pick up a square?

At the teacher's discretion, students can draw the poem as an illustrated cartoon or make an illustrated slide show to show their comprehension of what happened in the poem and why.

Student Assessment Plan

Formative using Card Sets

The teacher will observe students using the card sets during vocabulary games. By listening to student group table talk and visually observing how the students use the cards, the teacher will know whether the students understand the concepts or whether they need additional instructional support.

Formative using Attribute Circles

When the students work in groups to create attribute circles, observe their drawings in the circles. Are they accurate examples, and non-examples placed in the correct circle? Are their explanations about whether they are examples or non-examples detailed and complete? This

information will inform you whether they are ready to move on or whether there are still too many misconceptions that need to be clarified before moving on to the next activity.

Summative Pottery Making Project Assessment

Students will use pottery clay or self-drying clay substitute to make their own miniature piece of pottery. The process has steps.

1. The students will think about the landforms, the items in nature and their beliefs. They will draw geometric symbols or designs on paper until they arrive at a design that is meaningful to them. They will not include drawings of technology or drawings of modern items. If they want to represent those things, they will need to create a symbol for them. On the paper that holds their final design, they will write down what the pieces and colors of the design they created mean. They will explain these symbols to their tablemates for helpful feedback.

2. The students will be given clay to form into simple pottery items. They should make the pottery a simple style. The pottery will need to have some days to dry thoroughly. They will paint their design onto their pottery with acrylic paint after the self-drying pottery hardens. Acrylic paint washes out with water until it dries, then becomes water resistant and hard to remove. It washes out of brushes well if students keep the brushes wet. Students may need some protection for their clothing while they paint.

3. Students will prepare for a presentation. They will practice with a partner or a group of 3 taking turns showing their pottery and talking about their designs the colors they chose, and their meanings.

4. The students will make presentations to a group chosen by the students. It could be presentations to their own class, to a different class in the school, or their parents could be invited to visit as an audience.

Summative Assessment for Card Connections

After numerous practices with the card deck attribute cards matching them with picture cards of the correct shapes, and several experiences drawing shapes from attributes named orally, it is time to assess whether the students have successfully shown growth in geometric shape identification. First, have them draw pictures on paper of the shape that fits the attributes you describe for them. Next, make a three-column paper. In the first column, give them a list of the Navajo number words in order starting with three and going up to eight to use for reference. Make sure the list also has the Navajo number identified for them by writing the English number next to the word. Give them cut outs of the names of the shapes in Navajo and have them match them in the column next to the Navajo number words and glue them in the second column. Lastly, have them hand draw a picture of the matching geometric shape behind the words.

A sample Assessment for this is attached to the curriculum.

Alignment with Standards

Diné Standards

S4C R2. Understand the association and integration if mathematics, science, social studies, history and language arts into the study of Navajo fine arts, songs and hataal (healing chant)

Pre K-3rd Oral Diné Language Standards:
Concept 1.PO4. I will identify the vocabulary used in different contexts.

Pre K-3rd Diné Government Standards
Concept 4.PO2. I will follow directions.

Arizona Mathematics Standards 2nd Grade

2.G.A.1. Identify and describe specified attributes of two-dimensional and three-dimensional shapes, according to the number and shape of faces, number of angles, and the number of sides and/or vertices. Draw two-dimensional shapes based on the specified attributes.(e.g., triangles, quadrilaterals, pentagons, and hexagons).

2.G.A.3 Partition circles and rectangles into two, three, or four equal shares, describe the shares using the words halves, thirds, fourths, half of, third of, fourth of, and describe the whole as two halves, three thirds, or four fourths. Recognize that equal shares of identical wholes need not have the same shape.

Arizona History and Social Science Standards for 2nd Grade
2.G2.1 Explain how weather, climate, and other environmental characteristics affect people's lives in a place or region being studied.
2.G41 Identify different physical and cultural regions in the world.

Arizona English Language Arts Standards – 2nd Grade
2.RL.4 Describe how words and phrases supply rhythm (e.g., regular beats, alliteration, rhymes, repeated lines) and meaning in a story, poem, or song.
2.RL.5. Describe the overall structure of a story, including how the beginning introduces the story and the ending concludes the action.
2.RL.6 Acknowledge differences in the points of view of characters, including by speaking in a different voice for each character when reading dialogue aloud.
2. SL.5 Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings.

Teacher Resources

Daybreakwarrior. (2012, January 12). How to say numbers 0 to 10 in Navajo. YouTube. https://www.youtube.com/watch?v=X7XeCFNLgHQ

Summary: This video teaches adults how to count from zero to 10 in Navajo.

Daybreakwarrior. (2023, April 1). How to say words for shapes in the Navajo language. YouTube. https://www.youtube.com/watch?v=5RlsZhRC6_8

Summary: This video is very specific about what the Navajo words for specific shapes are. It is well researched and gives background. It is not for children. Look for the New Descriptive Names, or second section of the video.

Gold, Peter and Sonja Eder, directors. MUD - Native American Pottery, YouTube, 8 July 2022, https://www.youtube.com/watch?v=uXNO3ZcNWho. Accessed 11 May 2023.

Summary: Blackhorse Mitchell explains the Navajo ways of making pottery and the meanings of some of the symbols.

YouTube. (2020, December 27). How to count to 10 in Navajo language / Diné Bizaad. YouTube. https://www.youtube.com/watch?v=nin0FgQBhiw

Summary: Navajo Grandma teaches children how to count to ten in Navajo.

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