

Pre-Columbian Mathematics: Countless Reasons to Be Proud of Our Heritage

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INTRODUCTION

Mathematics is around us everywhere we go. We open our eyes and look at our alarm clocks, heat our coffee in the microwave, and put gas in our cars to go to work; mathematics rules our surroundings, and yet many students view so much mathematical reasoning as abstract and disconnected. Young children usually have an especially hard time making these connections given their lack of experience. It's our duty to open their eyes to discover how meaningful mathematical reasoning is and how they can relate everything they learn to their real lives. Further, it is important that they know that the math impulse may be seen time and time again throughout history, including in the ancestral peoples of many of my students.

This is a second grade mathematics and social studies unit to be explored with a bilingual class during Hispanic Heritage Month, in a school where 73% of the students are in the bilingual program. The purpose for this unit is to present students with an opportunity to explore numbers in a whole new way.

Mathematics is an exact science with provable truths—theorems and formulas—and exact methods of analysis and proof. On the other hand, the teaching of mathematics is a very inexact human endeavor involving a variety of interpersonal skills and a good intuition about human nature. (Tucker)

Making mathematics a part of history is an effective way to explore its relationship with basic human tendencies as a complement to its exact provable nature. Ancient mathematics often begins from very simple premises that show the student a universal rationality behind mathematics. It also humanizes the mathematical odyssey by showing how intelligent ancient people grappled with math problems, not unlike those of the student. Because of the similar, understandable solutions reached by ancient peoples, the student can see the human nature of math and further the valuing of what many of my students view as their ancestral culture.

Students will discover how their Mexican and Central American heritage goes beyond their knowledge. By integrating mathematics and social studies they will learn about how ancient people from Mexico and Central America were curious about mathematics in their surroundings and how they used it in their daily lives. All these concepts will be presented and compared to our systems today to show similarities and differences between them. This comparative method will not only show the student that the ancestors were important mathematicians but also help them see the structure of certain fundamental mathematical operations.

The phase transition mentioned above involves many partial shifts of focus—from core mathematics toward applications and toward interdisciplinary work with the natural and social sciences, from academic to industrial and laboratory settings, from individual self-directed work to collaborative and multidisciplinary effort, from technical communication with co-specialists to translational communication across disciplinary and cultural boundaries. (Bass)

OBJECTIVES

This unit will provide activities to teach the following HISD objectives in Mathematics and Social Studies, as well as the TEKS that follow the second grade curriculum provided by TEA.

Mathematics

- (2.1) - Number, operation, and quantitative reasoning. The student understands how place value is used to represent whole numbers. The student is expected to:
- (A) - use concrete models of hundreds, tens, and ones to represent a given whole number (up to 999) in various ways;
 - (B) - use place value to read, write, and describe the value of whole numbers to 999; and
 - (C) - use place value to compare and order whole numbers to 999 and record the comparisons using numbers and symbols (<, =, >).
- (2.5) - Patterns, relationships, and algebraic thinking. The student uses patterns in numbers and operations. The student is expected to:
- (A) - find patterns in numbers such as in a 100s chart;
 - B) - use patterns in place value to compare and order whole numbers through 999; and
 - (C) - identify, describe, and extend repeating and additive patterns to make predictions and solve problems.
- (2.13) - Underlying processes and mathematical tools. The student communicates about Grade 2 mathematics using informal language.
- (B) - relate informal language to mathematical language and symbols.
- (2.12) - Underlying processes and mathematical tools. The student applies Grade 2 mathematics to solve problems connected to everyday experiences and activities in and outside of school. The student is expected to:
- (A) - identify the mathematics in everyday situations.

Social Studies

- (2) - History. The student understands the concepts of time and chronology. The student is expected to:
- (A) - describe the order of events by using designations of time periods such as ancient times and modern times;
 - (B) -use vocabulary related to chronology, including past, present, and future;
 - (C) - create and interpret timelines; and
 - (D) - describe and measure calendar time by days, weeks, months, and years.
- (17) - Social studies skills. The student applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology. The student is expected to:
- (D) - sequence and categorize information;
 - (E) - interpret oral, visual, and print material by identifying the main idea, predicting, and comparing and contrasting.

(18) - Social studies skills. The student communicates in written, oral, and visual forms. The student is expected to:

(B) - create written and visual material such as stories, poems, maps, and graphic organizers to express ideas.

RATIONALE

Learning about this topic is relevant because it shows another angle of the students' culture and where they come from. During Hispanic Heritage Month, thousands of students explore their heritage by doing the same thing over and over again: listening to Hispanic music, learning the same dances, reading about famous Hispanics, or exploring a specific Hispanic country. These are common ideas, and, in my opinion, they only scratch the surface of what Hispanic heritage is all about. Children need to feel proud of their past and be able to learn about it to share it with their families and, someday, their own children. Learning about their past and their strong personalities and characteristics builds on their self-esteem as Hispanics and helps them understand their position in society. Integrating Mathematics and Social Studies adds another angle to classroom discussion and gives them another subject to integrate into their experiences.

Number concept is a very important strand in our curriculum that provides our children with the foundation to use numbers for all the other strands. Seeing this strand through a different approach gives children the opportunity to see it in a new context, understand why it is important, and make it more meaningful. Learning how their ancestors counted, used patterns, and kept track of time, will give students background information on which to anchor their new experiences in the second grade curriculum and give them a sense of pride that will last the rest of their lives.

UNIT BACKGROUND

I will teach this topic by using this unit as a complement to my previous unit: *Ancient Mexico: A Treasure to Find and Explore*, written in 2005 in the seminar "Latin America Before the Spanish: Pre-Columbian Art, History and Culture". In this unit, *The Legend of Lord Eight Deer*, a Mixtec epic, based on the *Codex Nuttall*, opens children's eyes and imaginations to how the process of writing was done in ancient Mesoamerica and how important written communication is.

In this unit, the focus will be to use the same piece of literature paying specific attention to the mathematical concepts in the story, provided by the use of the calendar, showing us a broader image of what the ancient Mesoamerican culture was. Students will be introduced to the Mixtec calendar in detail. The students will learn how the Mixtecs used it to plan and name their children and how they related the days to people's personalities and duties in society. They will observe and analyze patterns in this calendar to be able to make predictions. In this unit I will design hands-on activities around the *Legend of Lord Eight Deer* in the *Codex Nuttall*, to provide students with firsthand experiences to explore the different aspects of Pre-Columbian Mathematics. For example, students will see the different base number system and how the ancient peoples worked their computations. All this will be done in comparison to our number system today, providing the opportunity to present mathematical concepts in an interdisciplinary way. Making all these connections will result in a more interesting way to teach mathematical concepts that might be difficult for the children to grasp, as well as a more fun and meaningful way for the children to learn.

Mesoamerica

The historical and cultural background for this unit will come from the concept of Mesoamerica. This has been defined as a cultural zone from Mexico to Central America, where people spoke as many as sixty different languages but were united by their history, a part of which the calendar was a very important component. Even though Mesoamerica had a population

that lived in the areas where Mexico, Guatemala, Honduras, Belize and El Salvador are today, they shared traits that made them unique. Learning that cultures have many different aspects to them but share similarities as well is a key element when teaching this unit. The students will be able to see the calendar they shared, by studying more closely how the Mixtec used it.

(APPENDIX D)

The Mixtecs called themselves Ñuudzahui or “People of the Rain” in their own language. They rose to power in southern México between A.D. 950-1521. Formulating alliances with the Tolteca-Chichimeca to the north together with the Zapotecs to the east, Mixtec kings and queens used royal marriage to extend their influence over much of what are today the Mexican states of Oaxaca and Puebla. By the time of the Spanish invasion, the highest ranked royal Mixtec dynasty resided at Tilantongo, Oaxaca. The Mixtecs were formidable enemies of the Aztecs whose capital was Tenochtitlán located in the Valley of México and they fought many wars against Aztec imperial armies throughout the fifteenth century. There are over a quarter million Mixtec people still living in Oaxaca today and many thousands have immigrated to the United States. Most Mixtecs in Oaxaca subsist by farming. (Pohl)

The 260-Day Calendar

Many archaeologists agree that the Amerindians in Mesoamerica were alive through farming and agriculture. With domesticated grains they had enough food to be stored for a long time. The weather was also something that made them worry and be extremely careful when planning. Crops would grow their best when planted at the right time. This would provide abundant growth. They couldn’t risk their crops being a couple of weeks off their dates for prosperity. If not done during or on these dates, an entire year of food would be lost. For these reasons having complete mastery of the weather patterns was vital for survival. The Amerindians noticed that by observing the moon’s cycle, they could predict events and check for accuracy. They noticed that fertility cycles were also related to the length of the lunar cycle. Movements of the sun and the moon were very important for the Amerindians.

The 260-day calendar did not have anything to do with the seasons, so it had no agricultural purpose. It consists of 20 named days. These were days that had names, just like today, and had a constant place of relationship with the others. The place of these days was kept consistently through Mesoamerica even though the names were different. It was one more element shared by these all various cultures. They named the days differently, but there were always 20 named days and 13 dates. These twenty days are repeated thirteen times in the 260-day calendar. The names of the days started with Alligator and after twenty 13 day cycles, Alligator comes up again.

(APPENDICES E, F, G)

A divinatory calendar of 20 x 13 days (tonalpohualli), calculated together with a solar calendar of 365 days, is widely regarded as being more accurate than those of many other ancient civilizations throughout the world. (Pohl)

Alligator	Serpent	Water	Reed	Earthquake
Wind	Death	Dog	Ocelot	Knife
House	Deer	Monkey	Eagle	Rain
Lizard	Rabbit	Grass	Vulture	Flower

In Mesoamerica the rhythms of the days were considered sacred and powerful by people like the Maya. Being born on a particular date was very important because the day would stamp

specific characteristics on the newborn that would seal its fate in life. Finally, people who today still use the calendar say that it represents the length of human gestation. Conception and birth would occur on the same date in the calendar, only 260 days apart.

The 13 day period, or *trecena*, would be the equivalent of our seven days week. Starting off would be 1 Alligator, until 12 Reed to go back to 1 Ocelot and start over again. After 52 years, each year-bearer would have occurred 13 times. Then, a major calendar adjustment had to be made. The New Fire Ceremony indicated a New Era would begin. It involved extinguishing the fires and lights in the city and lighting a new one at midnight after a human sacrifice, from which all the city's lights were relit.

Mixtec Writing

In Mesoamerica documenting events that were important for them and that they wanted to perpetuate for the future generations to see was done in books like the *Codex Nuttall*, one of eight examples of ancient manuscripts written in the Pre-Colombian times.

These books are some of the very few examples of Ancient Mexican writing left to us today. After the conquest of the Aztec Empire in 1521, a few learned Spaniards began to collect pictographic books and sent them back to Europe. There are eight pre-Conquest style codices attributed to the Mixtec-speaking people of Oaxaca. They were made of animal hide and covered with a gesso-like foundation upon which figures were painted and then folded so that they could either be stored compactly or opened to reveal all of the pages on one side. The fact that the Mixtecs painted scenes from codices on drinking goblets is a testament to the role the recitation of the sagas played at royal banquets. (Pohl)

Mixtecs, in this particular case, documented the life of Lord Eight Deer and included dates and names using the Mixtec calendar. The Mixtec group codices were not meant to be read simply as books; they also served as scripts for the celebration and re-enactment of historical events. The codices could be displayed as “storyboards.” A poet recited the text from the codex to musical accompaniment, while actors performed parts of the saga in costume. Observing these dates in the book and using tables and the Mixtec calendar to calculate dates, students will be able to track the storyline and real timeline of these events.

Codex Nuttall

The Nuttall Codex is a Pre-Hispanic pictorial manuscript, painted by Mixtec scribes before the arrival of the Spaniards. It is also called the Zouche-Nuttall Codex. The codex was made of tanned deer skin, which was covered with a fine stucco layer. It is folded in an accordion-like fashion, containing 47 plates, painted on both sides.

The Nuttall Codex contains two sections which are clearly identifiable. One tells the story of some of the most important kings of the Mixtecs in the present day state of Oaxaca over a period of some 500 years of history (from 890 to 1382AD), such as the chronicles of the dynasties of Tilantongo, Teozacualco-Zaachila and Tututepec. The entire reverse side of the Nuttall Codex is dedicated to the life of the most celebrated ruler of the Mixtecs: a legendary king named Eight Deer, also known as Jaguar Claw (1063 – 1115). This great sovereign, compared even to Quetzalcoatl, was the only Mixtec ruler who during his reign achieved the unification of the three Mixtec empires: the Upper, Lower and Coastal, but not without great exertion, marriages, alliances, wars, and bloodshed.

A picture manuscript can be found edited by Zelia Nuttall, and in this copy the replica allows you to follow the story the way the Mixtec wrote it. It is meant to be read from right to left

following a serpent movement from top to bottom, following the red lines on the pages. The pictures represent the dates, characters, and places where the events took place.

LESSON PLANS

Lesson One: Introduction to Mixtec Calendar 1

Objectives

Students will describe and measure calendar time by days, weeks, months, and years. Students will compare and contrast Mixtec/our calendar. SS 2.A, B, C, D.

Materials Needed

Mesoamerica, Mixtecs, Day Signs Pictures, Calendar Pattern, Paper Plates (APPENDICES E, F)

Vocabulary

calendar, signs, rhythm, nature, characteristics, trecena

Activities

1. Students will talk about calendars and how they use them every day. Then, they will discuss the vocabulary. They will define the word characteristic as a trait of their personality.
2. They will be introduced to the Mixtec calendar and how Mixtecs believed that the day they were born had influence over their personal characteristics according to the day sign. Then they will be presented with pictures of the day signs.
3. Students will identify day signs and match them with their names.
4. Students will create a calendar wheel using pattern to illustrate how it works.
5. Students will practice day sequences and make predictions of which day will be in each sign.
6. Students will visit <http://www.azteccalendar.com/> to search for their birth date and see which sign is their day sign.

Assessment

After listening to the *Legend of Lord Eight Deer*, the students will find dates and names of characters using the *Codex Nuttall*. The students will work in small groups and will use a copy of different pages from the *Codex Nuttall*. They will identify the characters and dates on the pages, cut and paste them in columns that display the categories. The work will be assessed by using a rubric that awards points for accuracy of the symbols and their placement in the chart, and elaboration of the explanation of the events portrayed.

Lesson Two: Mixtec Calendar 2

Objectives

Students will find patterns in numbers such as in a 100s chart. MATH 2.5A,B,C.

Materials Needed

Hundred Chart, individual hundred charts mats/ copies unifix cubes. Mixtec Calendar Chart (APPENDIX G)

Vocabulary

Patterns, dates, cycles, trecena

Activities

1. Students will explore finding patterns in hundred chart using unifix cubes to place in the skip counting patterns: by 2's, 3's, 4's, 5's, 6's, 7's, 8's, 9's, 10's, 11's, 12's.

2. Students will comment on the patterns they see and will color them on their individual hundred charts.
3. Students will review Mixtec calendar day signs and will chant the sequence of days. They will see these patterns in the Mixtec Calendar Table.
4. Students will start brainstorming and finding patterns in the table.

Assessment

1. Given a problem solving situation, students will find specific numbers in the Hundred Chart with the game Arrow Math. (Students are given a starting number and a series of arrows to move within the hundred chart. At the end, they should reveal the number they ended at after following the arrows).
2. Students will answer questions about dates in the Mixtec Calendar Table, predicting and finding dates on the chart the same way they did with the Arrow Math. The questions will be given as a written test and they will find the answers and record their findings. Questions:
 - List the mane dates where the patterns between columns grow by adding 7.
 - List the name dates where the patterns between columns diminish by subtracting 6.
 - If you start on Serpent 5, how many days pass until Lizard 7?
 - If you count backwards from Jaguar 10, how many days until Rabbit 9?
 - Explain how you used patterns to find your answers.

Lesson Three: Scavenger Hunt at the Museum of Fine Arts

Objectives

Students will interpret oral, visual, and print material by identifying the main idea, predicting, and comparing and contrasting SS17.E, and create written and visual material such as stories, poems, maps, and graphic organizers to express ideas SS18.B.

Materials Needed

Visit to the Pre-Columbian Art Exhibit at the Houston Museum of Fine Arts

Vocabulary

Museum, exhibit, objects, record

Activities

1. Students will visit the Pre-Columbian Art exhibit at the Houston Museum of Fine Arts.
2. Students will observe and record with illustrations and words the places where they can see the numerical representations in the art pieces.

Assessment

Students will record the numerical representations found in the art pieces on a table provided. They will explain their findings in short sentences, describing the piece and the use of the date on it. They will be evaluated on accuracy of the numbers found and creativity of their explanations using a rubric.

Draw the number you found.....	Explain what your number means.....
Draw the number you found.....	Explain what your number means.....
Draw the number you found.....	Explain what your number means.....

Lesson Four: Mayan Math

Objectives

Students will relate informal language to mathematical language and symbols and will use concrete models of hundreds, tens, and ones to represent a given whole number in various ways. MATH 2.1A,B,C.

Materials

Popsicle sticks, beans, const. paper mats, unifix cubes (APPENDICES A, B, C)

Vocabulary

Maya, regrouping

Activities

1. Students will be presented with a game: Secret Number “5” (Roll number generator and place amount of ones on the mat. Roll again, and if higher than the magic number, they must create a group of that number and move to the next column. Continue and if they go beyond 5 in the second column, they do the same again. This game can be played with any magic number below 10. The purpose is to teach students to regroup in other base numbers to prepare them to regroup with the tens.)
2. The students will practice regrouping with other magic numbers.
3. Students will be presented with a similar form of math: Mayan Math (They will be presented with the method and then will use sticks and beans to illustrate how Mayan Math was performed).

Mayan numbers were represented with dots, bars and the zero was shaped like a shell. They were read from bottom up and when added they were to be placed in columns using a vigesimal system, meaning that our “ones” column instead of being 0-9 goes up to 19, to then, regroup. The same with our “tens” would be twenties in this system. Every five dots is regrouped into a bar; every five bars is regrouped again. Simple addition, moves from left to right and using manipulatives, every five beans changes into a popsicle stick. This will represent dots and bars. Students are not required to translate to Arabic numbers unless ready.

4. Students will represent numbers using the manipulatives and will draw the pictorial representation. If the class practices and is ready, simple addition problems will be performed.

Assessment

The students will be tested on representing numbers in the Mayan system using manipulatives first and then with a pictorial representation. If the class is ready, then they will solve simple addition problems using the Mayan system, first with manipulatives, and then showing their answers using a pictorial representation. They will be evaluated in accuracy of their answers.

Use the manipulatives to represent the following numbers in the Mayan system. Then, illustrate your number with a pictorial representation:
15
25
40
100
Use the manipulatives to add the following numbers in the Mayan system. Then, illustrate your number with a pictorial representation:
$39 + 18$
$22 + 56$

ANNOTATED BIBLIOGRAPHY

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Houston Independent School District. *Project CLEAR Curriculum: Mathematics Grade 2*. Houston, TX Houston Independent School District, 2006-2007. <<http://clear.houstonisd.org>>. Houston Independent School District Curriculum.

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Pohl, John M.D. *Ancient Books: Mixtec Group Codices*. Foundation for the Advancement of Mesoamerican Studies, Inc., 1993. <<http://www.famsi.org/research/pohl/jpcodices/index.html>>. Resource with information about Mesoamerica and Mixtec culture.

Tucker, Alan. "Differing Viewpoints on the Teaching of Mathematics." *Notices of the American Mathematical Society*. 44.1, (1997). <<http://www.ams.org/notices/199612/page2.pdf>>.

This is an article about being open to new approaches to teaching mathematics.

Supplemental Resources

Byland, Bruce & John M.D. Pohl. *In the Realm of Eight Deer*. Norman, Oklahoma: University of Oklahoma, 1994.

This book provides information about the process of interpretation of the codices and provides evidence that the codices retell real events

Carmack, Robert, Janine Gasco, and Garry H. Gossen. *The Legacy of Mesoamerica History and Culture of a Native American Civilization*. Upper Saddle River, New Jersey: Prentice Hall, 1996.

This book provides an overview of origins and development of Mesoamerican culture as well as the development of language and languages in Mesoamerica and also indigenous literature.

Coe, Michael and Rex Koontz. *Mexico from the Olmecs to the Aztecs*. New York: Thames and Hudson, 2002.

This book provides information about the Ancient Mexican cultures with a standard overview of Ancient Mexican history.

Cohelo, Elizabeth. *Adding English*. Toronto, Canada: Pippin Publishing Corporation, 2004.

This book has ideas about how to create an appropriate environment in a classroom by promoting multiculturalism as the right atmosphere for a second language acquisition.

Edmonson, Munro S. *The Book of the Year*. Salt Lake City, Utah: University of Utah Press, 1988.

This book is about the Mixtec calendar in detail.

Nuttall, Zelia. *The Codex Nuttall: A Picture Manuscript from Ancient Mexico*. New York: Dover Publications, 1975.

This book is a reproduction of the Ancient Mexican manuscript that provides full color illustrations showing the codices.

Scofield, Bruce. *Day-Signs: Native American Astrology from Ancient Mexico*. Amherst, MA: One Reed Publications, 1997.

This book explains the 260 day calendar and the meaning of the day signs.

Web Resources for Teachers

<<http://www.azteccalendar.com>>.

Website where the students can find their birth date in the Aztec calendar signs.

<<http://clear.houstonisd.org>>.

Website with the Houston Independent School District CLEAR Curriculum.

Books for Students

Forbes, Claire. *Pueblos del Pasado*. Minnetonka, MN: Two-Can Publishing LLC, 2002.

This is an expository children's book that illustrates and gives information about ancient cultures including the Maya culture which can bring pictorial examples and useful information when talking about how symbols illustrate real life objects.

Pohl, John M.D. *The Legend of Lord Eight Deer: An Epic of Ancient Mexico*. Oxford: Oxford University Press, 2002.

This book was written for students from nine to twelve years old and is a retelling of the most important Mexican historical epic.

Thus, during the Pre-Columbian and Columbian periods we pay our attention to literature about Amerindians of the ethnological kind, written mostly by Europeans. Had history taken a different turn, the United States easily could have been a part of the great Spanish or French overseas empires. Its present inhabitants might speak Spanish and form one nation with Mexico, or speak French and be joined with Canadian Francophone Quebec and Montreal.Â Being a sea-going people from Scandinavia in northern Europe, the Vikings were proud of their warriors and explorers and told stories called "œsagas" about them. The saga of Leif Ericson tells how he sailed from Greenland to the eastern coast of North America in about the years AD 1000. Next (Pre-Raphaelite Brotherhood). The term pre-Columbian is used to refer to the cultures of the Americas in the time before significant European influence. While technically referring to the era before Christopher Columbus, in practice the term usually includes indigenous cultures as they continued to develop until they were conquered or significantly influenced by Europeans, even if this happened decades or even centuries after Columbus first landed, in 1492. Pre-Columbian civilizations, the aboriginal American Indian cultures that evolved in Mesoamerica (part of Mexico and Central America) and the Andean region (western South America) prior to Spanish exploration and conquest in the 16th century. Learn more about pre-Columbian civilizations in this article.Â The domestication of successful food plants proved to be a long, slow process, and it was not until much later that a condition of permanent village farming life was achieved in the tropical latitudes of the two continents. Sedentary village farming in Mesoamerica came into being by about 1500 bce . Corn (maize), beans , squashes , chili peppers , and cotton were the most important crops.