Studying Mayan Culture in the Elementary Classroom: Integrating Mathematics, Visual Arts and Technology through an Authentic Multi-leveled Curriculum

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Abstract

Across the United States, there are many elementary aged students whose parents or themselves are from Mexico, Guatemala, and Central America having Mayan heritage. In alignment with instructional concepts that build a positive classroom culture encouraging higher level learning for all students, the authors designed and implemented a curriculum that supported students who need multi-leveled and authentic instruction promoting collaboration and social interaction. Positive relationships were built between students who have varying abilities, including those with physical, cognitive, and language challenges, in order to scaffold learning through cultural awareness connected to mathematics concepts. In the 2015-2016 school year, this school's student population included 74% Hispanic students, most of whom identified with the Mayan culture. The study of ancient civilizations, such as the Maya, can employ historical contexts to introduce elementary level students to the evolution and logic of today's mathematics. As a practitioner focused article, the purpose is to describe an educational experience that was designed to connect students to their culture through interdisciplinary learning with mathematics, visual art, and technology. The goal of the featured lesson is to provide elementary educators with effective teaching strategies that support all students;' learning in mathematics and to engage students to demonstrate their understanding through multiple avenues of expression, including visual arts and through technology. The authors' impressions of how students responded to this interdisciplinary lesson are discussed along with future directions for integrating curriculum that assist teachers in designing culturally connected curriculum.

Keywords: Interdisciplinary teaching and learning, elementary mathematics, cultural connections

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Effectively teaching mathematics to elementary aged students, and particularly English Language Learners (ELLs) and students of varying mathematical ability levels, requires teachers to make interdisciplinary and cultural connections through a multi-leveled authentic curriculum, specialized content knowledge, and pedagogical content knowledge (Herrera et al., 2012; Mitchell, 2020). Mathematical notations may not share cultural uniformity, and for children from diverse backgrounds, these differences may present obstacles to learning (Diaz-Rico & Weed, 1995; Gupta, 2019; Moore, 1994; Prast et al., 2015). Exploring the historical and cultural variants in mathematics, such as concepts in Mayan history can help all students develop experiences and background knowledge linking mathematical ideas with different perspectives.

Standards for teaching mathematics developed by the National Council of Teachers of Mathematics (NCTM, 2000) and best practices suggested by Zemelman et al. (2012), emphasize the importance of relating mathematics to prior knowledge, background, real life situations, manipulatives, and technologies. In the United States, educational leaders emphasize that knowledge of mathematics and technology is necessary in order to compete in today's global society. Effective instruction includes special accommodations and strategies to meet all students' needs, especially students who are learning the English language and students of varying abilities (Jung & Schutte, 2018).

The study of the cultural and historical contexts of ancient civilizations can be an intriguing way to introduce students to the evolution and logic of today's mathematics (Bidwell, 1993; Mitchell, 2020). This practitioner focused article describes a lesson that was designed to .connect students to their culture by integrating mathematics, visual art and technology. Best

practices are shared with educators to infuse authentic multi-level strategies that enhance learning for all students in elementary mathematics using Mayan cultural concepts.

Understanding Context: Selected Population and School Demographics

Lake Worth, Florida, just south of West Palm Beach boasts one of the largest populations of Mayans outside of Mexico and Guatemala. This is evident in the local schools, including the elementary school which provided the focus of this article. A pseudonym of Sample Elementary School is used in this article. In the 2015-2016 school year, this school's student population included 74% Hispanic students, most of whom identified with the Mayan culture (National Center for Education Statistics, 2018). Another factor in the selection of this school site was that 43% of students, as designated by the Florida state assessments, were considered proficient in mathematics, compared to 54% of students across Florida. Other Florida state assessments rated 31% of students as proficient in Reading/Language Arts, as compared to 52% of students across the state (Public School Review, 2018). Fourth-grade students, some of whom had learning challenges including language barriers and varying cognitive abilities, completed lessons that integrated Mayan culture and history with mathematics, visual arts and technology (see Appendix A for sample lesson plan).

Literature Review

In schools where the majority of students are learning to speak English (ELLs), educators are striving to meet diverse needs in the elementary classroom (Mitchell, 2020). In integrated classrooms, where learners of all levels interact, high levels of engagement are necessary to encourage success for all students who have varying abilities (Jordan et al., 2009). Mixed ability,

collaborative groups of students, create a positive learning environment that supports all levels of understanding and allows students to demonstrate knowledge in a variety of ways (Jung & Schutte, 2018; Whole Schooling Consortium, 2005). Making cultural and interdisciplinary connections builds effective teaching in all disciplines, including mathematics (Pang et al., 2011). This approach to curriculum integration supports the National Council of Teachers of Mathematics (NCTM) (2000) principles and standards that state high expectations for all students are essential. "Mathematics can and must be learned by all students" (NCTM, 2000, p. 13).

Universal Design for Learning (UDL) (Center on Applied Special Technology [CAST], 2016) provides a framework for curriculum that meets the needs of diverse learners, such as students who are ELLs and those with varying abilities. UDL strategies focus on multiple means of student engagement (Why?), representation (What?), and action/expression (How?), while including all learners with varying abilities. Respecting students' voices and valuing all contributions supports a positive classroom environment. These concepts guide the design and implementation of curriculum focusing on the UDL approach (CAST, 2016). Students can scaffold their learning to reach higher levels of understanding using teaching and learning strategies that connect to school, home, and community (Jung & Schutte, 2018; Whole Schooling Consortium, 2005).

The importance of designing mathematics curriculum that engages all learners with cultural connections is a response to inequities that may befall historically marginalized students, such as students with varying abilities and Hispanic populations, including those students in this study (Gutiérrez, 2018). For this practitioner focused article, the literature review includes concepts for integrating mathematics, visual arts, and technology in culturally diverse and ability

rich classrooms. The background information concerning Mayan culture and approach to mathematics supports the authors' emphasis on implementing a curriculum that shares diverse views and varying expressions of knowledge for students.

Integrating Mathematics into Culturally Diverse Classrooms

Balancing multiple sources of information to illustrate different kinds of mathematical thinking strategies promotes learning, especially when similar mathematical concepts or processes are shared in a variety of contexts, formats, and problematic situations (NCTM, 2000). Mathematics teachers not only teach content area skills such as numbers and geometry, but they teach communication skills, including reading, writing, speaking, listening, and visually representing (Zemelman, et al., 2012). ELLs may be advanced in mathematical skills, but struggle with understanding the terminology used in the classroom or textbook, such as 'fractions' or 'division' (Gupta, 2019). Similarly, some students with varying abilities may struggle with language but comprehend mathematical concepts. Often students and teachers may become frustrated as language comprehension may inhibit mathematics success and lower students' confidence levels in mathematical ability (Furner & Marinas, 2013). Some best practices for teaching mathematics for all learners include the use of manipulatives (real objects), group work, dialogue, questioning, guidance through problem solving by teacher/peers, use of computers and other technology, and content integration (Zemelman et al., 2012).

The teaching and learning practice of content integration forms the foundation of this type of curriculum as an integral approach to teaching mathematics in an elementary classroom. Connecting to culture is effective for diverse students. In the described lessons, students explored the Mayan's contribution to mathematics, demonstrating the importance this particular culture

has on contemporary mathematical concepts. Also, students were allowed to demonstrate mathematical understanding through drawings and illustrations, which can alleviate some of the language frustrations, especially for ELLs. Teachers can then use students' drawings as a comprehension check or informal (in-progress) assessment (Furner, 2015). Multiple forms of knowledge representation provide an authentic way for students of varying abilities to demonstrate proficiency in the material taught in a lesson (Gardner, 1999). This notion is supported by the work of Herrera et al. (2012), who offered a framework for the academic development of culturally and linguistically diverse (CLD) students. In particular, they noted that authentic assessment in the form of, "student-created products provide the scaffolding CLD students need to best demonstrate their learning" (Herrera et al., 2012, p. 7).

Integrating Visual Arts into Culturally Diverse Classrooms

Utilizing visual art to encourage communication skills for all students is a key concept in this approach to curriculum integration. Kasten et al. (2005) describe the use of visual literacy as the impetus for including viewing and visually representing as an addition to the four original language arts (reading, writing, speaking, and listening). The creation of a visualization system, which is a network of images and experiences organized into schemata to link prior knowledge to new understandings, is activated when learning through the arts. Artmaking provides a foundation for a visualization system through active engagement using all the senses (sight, touch, smell, taste, and hearing). Diverse students, including ELLs benefit from learning through the arts as their proficiency in language is enriched through vocabulary use during artistic and cultural discussions (Craig & Paraiso, 2008).

Integrating visual arts into the curriculum provides valuable tools for all students by supporting creative expression and discussion (Towell et al., 2018). Engaging in dialogue about a cultural artwork can lead to connections between students that extend beyond the classroom into their lives and communities (Brown, 2013). Through arts integration, teachers provide students with opportunities to create, discuss, study, and consider new philosophical aspects through historical and cultural connections of visual art to other disciplines, such as mathematics. Teachers and students must be willing to experiment, explore, perform, and be open-minded to new concepts when utilizing an art integrated approach to teaching and learning (Furner, 2015).

Integrating Technology into Culturally Diverse Classrooms

The rapid pace of growth in technology in society has created new pathways for learning with digital tools (Collins & Halverson, 2018). Therefore, contemporary teachers must support their students' learning with digital technologies and do so in authentic contexts (Sheffield et al., 2018). Traditionally school technology resources have been shared in labs, libraries, and mobile carts, but in recent years there has been increased interest in one-to-one scenarios where all students have access to a computing device (Bebell & Burraston, 2014). According to Ok and Ratliffe (2018), "Mobile devices have become widely used in K-12 education settings for teaching diverse students" (p. 538).

Having access to 1:1 laptops can help transform learning for diverse learners by enabling teachers to differentiate instruction, as well as make accomodations for those with Limited English Proficiency (LEP) (Powers et al., 2020). Further, these tools support the integration of the principles of UDL into the diverse classroom because digital environments give teachers the means to represent information in varied ways (Rao, 2015). Through technology, students can

easily locate information, use a variety of apps, communicate with others, and collaborate on projects that can extend beyond the classroom.

Some of the benefits of incorporating technology into instruction in diverse classrooms include increasing student motivation and engagement (Billings & Mathison, 2012; Delacruz, 2014), improved time spent on task (Brown, 2016), and promoting active learning (Hur & Suh, 2012). In a study at a school with a high concentration of ELLs, Delacruz (2014) found that integrating the digital presentation tool, NearPod, into a guided reading lesson increased fourth-grade students' motivation to learn the presented content through the application. Another study found that the use of e-reader technology increased second-grade ELLs' time spent on reading as well as their enthusiasm for reading (Brown, 2016).

Research by Hur and Suh (2012) showed that the integration of interactive whiteboard (IWB), digital storytelling, and podcast technology into diverse classrooms helped teachers create active learning environments and assisted students in practicing language skills, resulting in higher test scores. The findings of a study by López (2010) indicated that a digital learning initiative that integrated IWB technology into 3rd and 5th-grade classrooms significantly improved performance parity for diverse students in both mathematics and reading. This line of research supports the notion that integrating technology can be an effective instructional strategy for teaching students of varying abilities.

The TESOL Technology Standards for Teachers

The Teachers of English to Speakers of Other Languages (TESOL) Technology Standards focus on how educators can and should use technology in and out of the classroom with second language learners in a wide range of contexts (Ioannou-Georgiou et al., 2008).

According to Ioannou-Georgiou et al. (2008), the standards "give prominence to technological issues, help educators realize the potential benefits of technology, and prompt educators to learn to use technology in their teaching" (p. 9). The TESOL Technology Standards include a section for language teachers that is guided by overarching goals:

1. Language teachers acquire and maintain foundational knowledge and skills in technology for professional purposes.
2. Language teachers integrate pedagogical knowledge and skills with technology to enhance language teaching and learning.
3. Language teachers apply technology in record-keeping, feedback, and assessment.
4. Language teachers use technology to improve communication, collaboration, and efficiency.

Ioannou-Georgiou et al. (2008) noted that it is hoped that the standards help minimize the digital divide that exists both between and within countries . In practice, these standards can help guide teachers of ELLs in using technology to effectively engage students in meaningful learning experiences. Further, the standards can support the notion that inclusive and equitable technology integration should support "learning that is broad, holistic, and promotes learning from diverse cultural perspectives" (de Alvarez & Dickson-Deane, 2018, p. 348). Educators should leverage technology to address the need to provide all students with authentic learning materials and perspectives (Roblyer & Hughes, 2019).

Background Information

When infusing historical and cultural study in the elementary curriculum, it is important for teachers to understand, share and discuss concepts with young children and allow for

application of new learning to promote deeper understanding for all students. Although the lesson featured in this article involved students of Mayan descent and, therefore, the mathematical concepts of Mayan culture, educators can integrate any culture that connects to a specific student group. According to Herrera et al. (2012), in order to achieve culturally responsive teaching, educators can integrate concepts that relate the culture of the students to the curriculum. Authentic multi-level learning includes concepts such as, multiple ways to express understanding, scaffolding to support students at different levels, and connections to the students' lives and community (Mitchell, 2020; Whole Schooling Consortium, 2005). This approach to teaching and learning also relates to Gardner's (1999) Theory of Multiple Intelligences in that students have opportunities to connect interpersonally, reflect intrapersonally, express knowledge visually/spatially and mathematically, and share ideas linguistically. Integrating visual art and technology with mathematical concepts infused with cultural understanding inspired this practitioner focused article. Background information about Mayan mathematics concepts provides a foundation for the shared lesson example and assists in understanding teaching practice that occurred at the school site.

Selected Concepts of the Mayan Mathematics System

Throughout the implementation of this specific learning experience, information about Mayan culture was infused into mathematics lessons. Some concepts that were shared with students are described in this section to assist with understanding how mathematical teaching and learning strategies can be applied in an elementary classroom. For example, students created colorful drawings using geometric shapes with different colors and designs while learning both mathematics and cultural history linked to their ancestors, as illustrated in Figure 1.

Figure 1

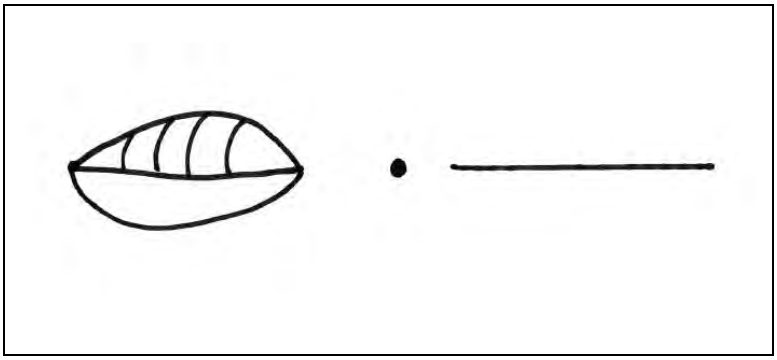
Student Circular Drawings to Illustrate Mathematical Concepts (photograph: Joseph Furner).

Historically while people in Europe were struggling with the Roman numeral system whose symbols lacked both representation for zero and a calculated correlation with the numbers they represented, the Mayans in Mesoamerica were developing a system which modern day scholars find to be sophisticated, beautiful, and logical (Kettunen & Helmke, 2020). The Mayans invented a counting system that could represent very large numbers by using only 3 symbols: a dot (1), a bar (5), and a shell symbol (0), as illustrated in Figure 2 (Kettunen & Helmke, 2020). It is a number system which shares similarities, such as place value, with the modern base-10,

Hindu-Arabic system; however, the place values were arranged vertically, and a base 20, vigesimal system, was used for calculating the shift in value (e.g., each shift represented a multiple of 20 instead of 10).

Figure 2

Mayan Mathematical Symbols.



The Mayan writing system contained approximately 1,000 symbols and phonetic and non-phonetic elements. For example, the Mayan calendar system is a complex system known as the Calendar Round of 52 years and was present among all the Mesoamericans in Mexico, Guatemala, and Belize (Coe, 1992). The calendar recognized both sacred and secular events with specific dates. The Maya defined each day with a four-fold index: the number of the day in the sacred calendar; the god of its day-sign, such as Tzolkin Month; the day's number in the year-calendar; and lastly, the god of the month, such as Haab Month, in which the day was positioned. The Mayan calendar in its final form probably dates from about the First Century, B.C.E., and may have originated with the Olmec civilization (Coe, 1992). It is extremely accurate, and the calculations of Mayan priests were so precise that their calendar correction is 10,000th of a day more exact than the standard calendar of the modern world. A parallel can be drawn between the Mayan calendar as an index of mathematics achievement of a pre-modern society and the

calendar notations of medieval Europe. The accuracy of the Mayan base-20 and sub-base 5, however, combined with the beautiful head symbols, have earned it recognition among historians and mathematicians for its accuracy and aesthetically pleasing sophistication (Coe, 1992).

By sharing selected concepts of the Mayan mathematical system, students may use a different perspective on applying mathematical strategies to tasks, such as counting, addition, and subtraction. Students may select diverse ways to represent mathematical understanding using symbols like the Mayan system or create their own visual representations for numbers or number groups. According to Herrera et al. (2012), "A culturally responsive perspective allows teachers to move beyond lists of culture-specific do's and don'ts that ignore within-group diversity" (p. 3). By changing perspectives, students can make informed choices on how best to represent their understanding of mathematical concepts.

Selected Teaching and Learning Strategies for Diverse Students

As students study mathematical concepts in the context of history and culture, it is important to utilize strategies that are effective for diverse students. One strategy involves learning vocabulary through demonstration and realia (real world objects) (Irby et al., 2018). Students can practice math skills of valuing in a similar fashion of the Mayan marketplace where people traded for items that they needed or desired such as, cacao beans, pottery, produce, farm animals, and honey (History on the Net, 2020). Manipulatives (objects used to illustrate concepts) can assist in understanding abstract ideas by making problems concrete (Bruner, 1966; McNeil & Jarvin, 2007) . Play printed money, buttons, blocks, and connecting base-ten blocks are examples of manipulatives that are effective at the elementary school level (Leong et al., 2015). Students can also explore creating artworks using a variety of colors and shapes to create

tessellating, symmetric, and colorful designs (see Figure 1). In this learning experience, the artworks served as a demonstration of understanding by serving as a student made manipulative or visualization of calculations to solve mathematical problems.

Students created drawings of geometric shapes on paper plates to design circles that illustrate mathematical patterns. Each drawing had meaning for the individual child and represented his or her understanding of the concept being taught. Each child represented their understanding in a unique and creative way which encouraged visual art integration through the use of color, shape, pattern, balance, and repetition. Supporting a student's choice to draw an illustration of the mathematical problem helps him or her to solve the problem through visualization strategies. Making interdisciplinary connections helps students to utilize their strengths in a variety of areas, including the visual arts (Towell et al., 2018). Authentic multi-level instructional strategies provide different avenues of thinking, reacting, and reflecting on what is being learned (Gardner, 1999). Just as students process information in different ways, effective teachers design a variety of lessons that take advantage of integrated learning (Gardner, 1999; Mitchell, 2020; Whole Learning Consortium, 2005).

Technology provides unique strategies for teaching mathematics such as, taking Internet field trips, exploring websites, and utilizing software programs/applications. For example, students can make the tessellations of M.C. Escher come to life and manipulate the designs through technology (Shodor, 2018). Many websites are designed to interactively assist students in learning and reinforcing mathematical concepts. The possibilities for mathematical teaching and learning are infinite and constantly changing as new devices, programs, and applications are designed. Students may also use *Paint* or *GeoGebra* to create their own artistic geometric

designs as the software can be very dynamic and motivating for the learner while learning mathematics (Furner & Marinas, 2013).

Implementation at the Selected Elementary School Classroom

Infusing mathematical lessons with visual art and technology provides unique learning opportunities for students with diverse needs (Mitchell, 2020). Sharing effective practices may encourage other educators to utilize this approach to teaching. Curriculum integration in the elementary classroom provides opportunities for all students to express their understanding in multiple ways, such as drawing, using objects in simulations, and discourse (Prast, et al., 2015). In this section, the authors describe an example of a cultural mathematics lesson that models this integrated approach (see Appendix A).

At the beginning of the lesson, fourth-grade students read the book, *Technology in the Time of Maya* (Crosher, 1997). Afterward, students discuss and share ideas about the Mayan culture's contribution to the development of mathematics. They were particularly fascinated by the Mayan Calendar Round. Gabriel, whose parents were born and raised in Campeche, Mexico, brought a replica of a Mayan calendar and other cultural icons from his parents' native country. The students discussed the cultural artifacts and asked questions about Mayan culture. Gabriel's parents were invited by the teacher to be a guest in the classroom and share their personal experiences with the students. Not only did the students learn more about Mayan culture, but food was shared with the class, including corn tortillas, avocado, and chocolate.

The classroom teacher explained to the students that the number twenty was the basis of the Mayan counting system in the same way that ten is the basis of our Arabic number system, and that the Mayan calendar had twenty-day months. Following the whole class sharing session,

the students worked in pairs at computer stations where they visited websites and took an 'Internet field trip'. The students noted from one site that Mayan symbols for numbers were written vertically as opposed to horizontally. They enjoyed playing online games and learning about the Mayan culture through websites such as *Living Maya Time* by the Smithsonian National Museum of the American Indian (2019). The students researched Maya symbols and were especially interested in the jaguar symbols, which represent strength, confidence, and leadership. Students drew Maya symbols that were meaningful to them personally and related historical information to what they were experiencing in contemporary society. They also wrote their names using Maya glyphs and the online guide, *Writing Mayan Glyphs* (Conklin, 2019).

Afterward, the students worked in groups of four where they used dried mais (corn) and popsicle sticks to make base twenty blocks. They had already learned from their website experiences that corn was a staple of the Mayan economy. The connection between mais and counting material appealed to all learners as they enjoyed making their own math manipulatives. The base-twenty materials were then used to compute and solve mathematics problems and then placed in the math center where the students could revisit the resources for future activities. While this lesson focused on the number system and counting, teachers could also allow students to draw using different shapes and colors to create designs that incorporate ideas related to symmetry, tessellations, congruency, similarity, rotation, translation, and reflections of shapes (see Figure 1). Teachers or family members may bring in quilts, rugs, and other art designs that come from Guatemala and Mexico as sharing such cultural artifacts gives students ideas for creating their artworks (Towell et al., 2018).

This sample mathematics lesson is interdisciplinary in that it incorporated technology, manipulatives, visual art, and multicultural experiences with mathematical concepts. Some

students, particularly those who are reluctant mathematicians or who are limited in their language proficiency, may be supported through the high interest and risk-free nature of the learning experiences described in the sample mathematics lesson (Gupta, 2019; Mitchell, 2020; Prast, et al., 2015). Various resources, such as children's literature, websites, and visual art materials may be used to modify and enhance the sample lesson to meet diverse populations of students by providing opportunities to use a variety of media to express understanding (see Appendix A). For example, as an extension, students who wish to share cultural items from their homes may select to create a video tour using a cell phone or tablet, which is narrated by family members to explain the history of the featured items.

Conclusions and Future Study

Teachers in today's mathematics classroom are confronted with the challenge of meeting the needs of students with diverse capabilities and backgrounds. The NCTM principles and standards (2000, 2014) and the literature (Gupta, 2019; Prast, et al., 2015) on diverse learners suggests that all students may benefit from strategies which promote cultural and historical connections and the use of technology and manipulatives which focus upon the active engagement of students through exploration and communication. In a passionate plea for bridging the culture gap in our classrooms, Moore (1994) proposes that "Mathematics is definitely not culture-free...no mathematics teacher could even contemplate seriously taking only the values of his culture and a textbook which is a product of his culture and imposing both himself and the textbook upon individuals possessed by a culture that diverges from his in any significant area" (p. 13).

Teachers who use a variety of resources and who incorporate innovative ideas into their teaching in order to make learning more meaningful have the opportunity to create more engaging learning environments (Jung & Schutte, 2018; Prast, et al., 2015). The inclusion of realia and demonstrations may support vocabulary development through web site field trips, literature, and the study of cultural artifacts. Prior knowledge and background are enriched through the study of the historical context of the evolution of number systems, while developmentally appropriate activities using manipulatives provide concrete examples that may reinforce concept development (Mitchell, 2020). Exploring learning through various media such as drawing, painting, sketching, and creating collages addresses a variety of learning styles and promotes creativity (Towell et al., 2018). Discussion about readings, field trips (actual or virtual/online), activities, and guest speakers may prompt analytical and critical thinking as well as metacognition by encouraging students to verbalize their perceptions of learning (Prast, et al., 2015).

Furthermore, in the described lesson sample, cultural connections between Mayan mathematical concepts and the modern mathematical base 10 system may be supported through the inclusion of historical and literature readings, discussions of economic and marketplace functions, and explorations of artistic and scientific contributions, such as the Mayan calendar as compared to a modern calendar. Through lessons that integrate mathematics, visual art, and technology in creative ways, educators may provide opportunities for students to be creative, discuss their own work and the work of others in a respectful manner, study historical and cultural connections, and consider how concepts are possibly linked together to support a potentially deeper understanding of the world around them (Prast, et al., 2015). The approach to learning described in this practice oriented article at a specific school site, although not

generalizable, may provide ideas for other educators to design learning environments that support students' mathematical content learning and may create for educators and students, a further awareness of the purposes and uses of mathematics in possible aspects of daily life. Future studies in curriculum are encouraged to explore the integration of mathematics, visual arts, and technology, which may engage diverse students in meaningful learning experiences.

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Appendix A

Sample Lesson Plan

The following are suggestions for incorporating the historical context and symbolic notation system of the Mayans into a teaching unit. The lesson might be taught from an interdisciplinary, integrated curriculum perspective, and modified to meet age appropriate needs of the students. This lesson too can serve in reinforcing concepts related to place value in mathematics. The strategies specifically include effective learning techniques for diverse students.

Objective(s):

Students will:

- Explore similarities and differences of number systems of other cultures
- Calculate place values with base-10 and base-20 system.

Menu of Suggested Activities:

Menu of Motivation (Initiating) Activities:

1) Pairs of students of varying abilities will take an Internet Field Trip and visit websites to read about Mayan numerical systems.
2) Students view the video, *Mystery of the Maya* (Howell, 1995).
3) Students meet in discussion groups of four. Possible topics for discussion might be:
    a) defining terms such as decimal system, non-decimal system, place value.
    b) describe similarities and differences between (among) systems.

Menu of Core Activities:

1) Create Mayan "manipulatives" to use in Mayan calculations.

2) Calculate and solve problems using their Mayan manipulatives.

3) Create and solve coded puzzles.

4) Read literature that relates to cultural differences in mathematics (particularly Mayan Mathematics). A suggested book would be *Skywatchers of Ancient Mexico* (Aveni, 1983).

5) Develop and refine discussion groups and paired activities.

   - Possible questions for discussion group:
   - Why do you think the Mayans chose a base-20 numeral system?
   - How does the Mayan system compare to that of the Egyptians or Romans?
   - Why do you think the Mayans chose a shell to symbolize zero? What symbol for zero would you choose? Why?

6) Practice writing Mayan numerals 0 to 100.

7) Write reflective essays on web site visits.

8) Create a fictional number system with a unique base and symbols.

9) Keep a journal of math activities and ideas.

10) Illustrate Mayan mathematics with a selected artistic medium such a magazine photo collage, pencil sketch, etc.

11) Locate additional books and websites about Mayan math and other math systems.

12) Invite parents and selected community guest speakers who

are knowledgeable about the Mayan or other number systems.

Resources:

Readings:

Aveni, A. (1980). Skywatchers of ancient Mexico.University of Texas Press.

Howell, B. (1995). *Mystery of the Maya.* Canada: The National Film Board of Canada and The Canadian Museum of Civilization. Mexico: The Instituto Mexicano de Cinematografia.

Mayan Mathematics Websites:

http://www.hanksville.org/yucatan/mayamath.html

http://www.michielb.nl/maya/math.html

http://mathforum.org/k12/mayan.math/]

Mayan Numbers Websites:

http://www.niti.org/mayan/lesson.htm

History of the Mayans Websites:

http://www.cancunsteve.com/mayan.htm

http://www-groups.dcs.st-and.ac.uk/~history/HistTopics/Mayan_mathematics.html