Determining the Effectiveness of
COLLABORATIVELY DESIGNED AND IMPLEMENTED
Cultural Curriculum on Classroom Pedagogy

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Chapter One

Introduction

The surest path to high self-esteem is to be successful at something once perceived to be difficult. Each time we steal a student's struggle, we steal the opportunity for them to build self-confidence. They must learn to do hard things to feel good about themselves.

-Sylvia Rimm

This study is part of an on-going line of research on effective mathematics instruction for Native American students in an urban area. The study is grounded on the research-based premise that culturally responsive methods of teaching will promote mathematics achievement of Native students. The primary goal of this study was to observe, record, and evaluate the process of developing an integrated geometry unit. The study was motivated by the fact that the underachievement of Native American students in mathematics has been historically and continues to be a serious problem. In 2003, a National Assessment of Educational progress (NAEP) sample of 4th graders found the mathematics achievement gap between white and Native American student subgroups was significant (National Center for Educational Statistics, 2003).

Researcher Backgrounds

Joni Theobald

In 1992, during my 2nd year at Nicolet College in northern Wisconsin, the opportunity to become a teacher fell in my lap. Through a partnership with the University of Wisconsin, and because of my high grade point average, I was selected as a qualified teaching candidate. Initially, I wasn't enthusiastic about the possibility. I never considered teaching as a career. I didn't really even like school, much less my teachers. Irony would have its way with my fate however. Here I am, 14 years later. I taught social studies for several years after graduating until I began coordinating the Title VII Indian Education Program in Madison. So, while I've not had my own classroom for some time, I am still very much a part of the educational system here in Madison.

My experience in math varied from elementary to high school. In my elementary grades, I was included in a small group of six advanced students, who worked on higher level math skills at a quicker pace than the class. I lived off the reservation during these times and recall reciting multiplication to music, receiving individual or small group instruction (our group consisted of 6 students). My transition to middle school started with a new school and on the reservation. My experience with math remained in the advanced groups until high school. During high school, math became a subject with which I struggled and was satisfied with just receiving a passing grade. Classes were lecture driven, and we remained in desks for the duration of class, with drills and home work consisting of the odd number questions of text assignments. During my years in college, I steered away from math courses and consciously selected majors that didn't require many math courses. Required courses, such as Geometry for Teachers, and statistics, I struggled through with the assistance of tutors, and after class discussions with teaching assistants.

RunningHorse Livingston

After a misguided effort in an architecture program at the University of Minnesota, and a consolation major in American Indian Studies, chance experiences refocused my career to the study of culturally responsive mathematics instruction of Native American students.

One of my most significant experiences was working as an instructor for the American Indian Science and Engineering Society's Summer Math Camp, a program developed to promote math and science to Native American 8^{th} graders. As an instructor, I observed that most of the students did very well in the “tailored” summer math classes. However, upon later encounters, I found that these same students' high school math experiences, without exception, were miserable. Even more troubling, was the fact that most of the students declared that they were never truly “good at math.”

Perplexed by the discrepancy between these students’ apparent ability yet extreme underachievement, I accepted a position as a high school counselor, determined to find the cause. I struggled to keep my personal theories separated from the rampant excuses that were granted students concerning their underachievement, and when students were threatened that their parents would go to jail if they didn’t attend school, I also came to realize that mandatory school attendance serves apathy better than it does motivation. My own experiences, having grown up on the reservation, assured me that resiliency is not a reaction. It is a choice. Students will become motivated to overcome barriers if they experience success.

An equally valuable career altering experience was helping with the development of elementary level math curriculum for an after-school program aimed at increasing Ho-Chunk students’ standardized test scores. While working with the after-school mathematics program, I was fortunate to be invited to work as a research assistant for the Mid-continent Research for

Education and Learning (McREL) on a regional study investigating how different mathematics curriculums influenced the math achievement of Indian students. Over the course of two years, I was given the opportunity to observe in ten classrooms, and interviewed ten elementary teachers. This valuable experience contributed significantly to the study reported in this paper.

Statement of the Problem

The school district in which the research was done, initiated a mandatory policy requiring the successful completion of Algebra I and Geometry for high school graduation. This policy directly impacted the high school completion of minority students. Specifically, a review of the district's achievement database indicated that, of 50 Native American sophomores, juniors, and seniors, only *one* had taken and successfully completed geometry. Why was this the case? Why were Native students not taking or successfully completing these basic math courses? Were the students simply not trying? Why weren't they trying? The study reported in this paper was conducted to begin to understand the cause of this problem and to begin to resolve it by developing a culturally responsive geometry unit.

Sic questions focused this study:

1. What does culturally responsive mean, with regard to curriculum?
2. Will situating geometry in a cultural context engage more students and teachers?
3. How important is collaboration in the curriculum building process?
4. Does curriculum development affect pedagogy?
5. What would a culturally responsive curriculum look like?
6. How do you make a culturally relevant curriculum rigorous?

Situating the Problem

As Native American educators, we, the researchers conducting this study, have always taken offense to the statement that "Indians just can't do math." This statement is subjective of course, but when a subjective notion is supported with extensive statistical evidence documenting the math achievement failure of Native Americans, a subjective notion risks the potential of becoming perceived as truth. Unfortunately, many Native Americans have accepted this notion as truth and, consequently, believe that they cannot do math simply because they are Native Americans. At times, our quest to disprove this belief caused us to experience the same feelings that we imagine Copernicus felt when he attempted to explain that the world was not round. While struggling with the challenge of convincing math phobic students to believe that they possessed the ability to do math, we reflected on our own achievement in mathematics. This combination of experience, working with math phobic students and reflecting on how we personally learned math, led us to conclude that the most important aspect of teaching mathematics is how instructional decisions regard or disregard student thinking and motivation in relationship to culture.

The thoughts expressed in the preceding paragraph directly relate to the fact that math underachievement of Native students in urban areas is a serious concern. In this district, Native American freshmen are filtered into pre-algebra, survey math, and math applications courses according to their performance on the standardized state assessment. This particular assessment is a multiple-choice exam administered to fourth, eight, and tenth grade students to evaluate performance in each of five core academic content areas (reading, language arts, mathematics, science, and social studies). Four proficiency categories help to describe scores on all of these exams:

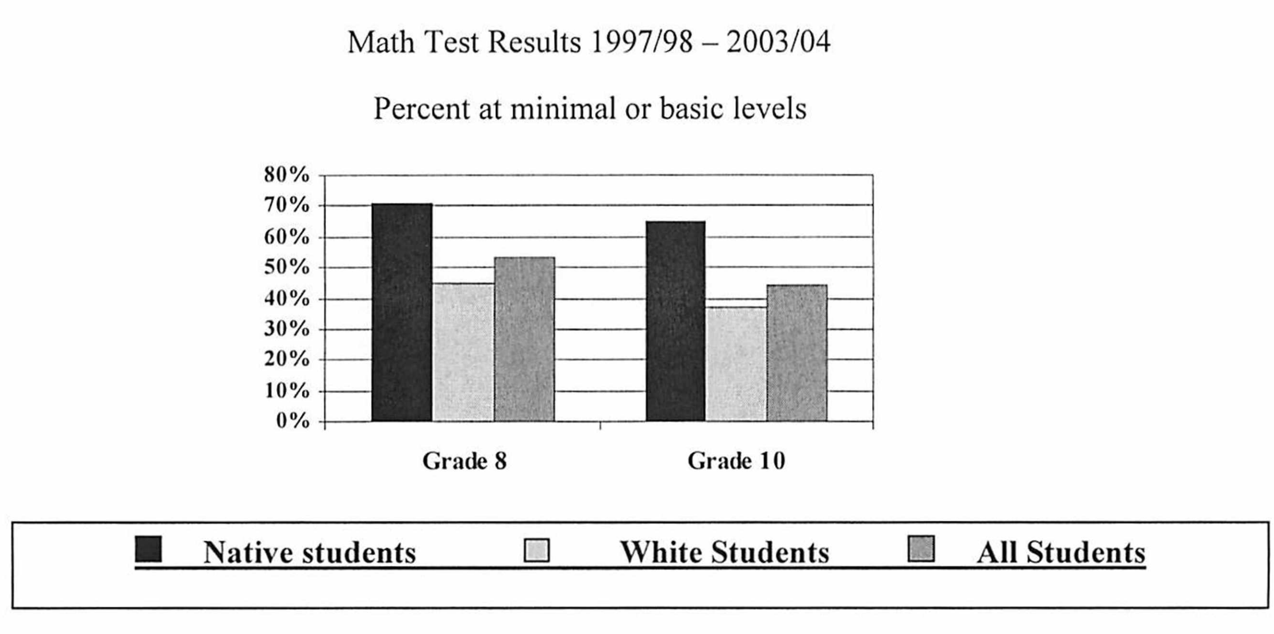
Minimal: *limited achievement;* evidence of major gaps in knowledge and skills.

Basic: somewhat competent; evidence of major flaws in understanding.

Proficient: competent; evidence of mastery of important knowledge.

Advanced: beyond mastery; evidence of in-depth knowledge.

Native American students consistently perform well below their non-minority peers and often below the entire student population in terms of the percentage of students meeting "proficiency." Achievement of Native students on this test is significantly lower than that of Caucasian students. However, before administration of the test, deficits in the academic profiles of incoming high school students are often predicted by the inordinate number of unsatisfactory middle school grades, typically D's and U's (the district does not use Fs at the middle level) on student reports, and notes in the cumulative folders of many of these students describe them as not being able to focus or concentrate, possessing low motivation, and not at grade level in math.



In 2002 the district Title VII (Indian Education) staff conducted a survey of students to identify what they perceived as barriers to their achievement in math. Many described their math classes as boring followed by statements like, "I don't understand the material. It's over my head.” or “There is too much homework to keep up with.” and “We aren't going to be using this stuff anyway.” While some took responsibility for their failures saying, “I just am lazy.” or “I don’t try hard enough.” others identified the following changes as ones that would increase their interest and achievement in mathematics:

- more hands-on learning,
- teachers being personally interested in them,
- doing a variation of activities in class
- not sitting for the duration of the class period listening to lecture

In summation, the mathematics failure of Native American students in this school district was the motivation behind conducting the study reported in this paper. The Title VII survey was the starting point in resolving this problem. The following literature review addresses both of these matters, why Native students underachieve mathematically and how teaching mathematics differently can produce math achievement.

Chapter Two

Literature Review

The mathematics underachievement of Native American students in urban areas reflects a nationwide trend. This trend might best be illustrated as a downward spiral. The Civil Rights Project at Harvard in conjunction with the Urban Institute as well as Advocates for Children of New York and Results for America revealed that over half of black, Hispanic, and Native American students are not on track to graduate in time (Civil Rights, 2004). Minority students are also more likely to be exposed to less rigorous curriculum by a less experienced teacher (Oakes, 1992). This inequity manifests itself at the professional level as Native American students remain underrepresented in math and science-related careers and the mandatory courses that prepare them for these fields (National Center for Education Statistics, 1994).

The National Science Foundation (NSF) in 1994 reports that while African Americans, Hispanics, and American Indians/Alaska Natives make up 19 percent of the total labor force in our country, they comprise only 8 percent of the science, math, engineering and technology work force (Clark, 1999). National achievement data attest to the fact that the mathematics instruction in the US does not meet the needs of low-income minority populations. The seriousness of this problem is compounded by the fact that minorities represent the most rapidly growing segment of the population. (Hodgkinson, 1992) predicts that by the year 2050, minority subgroups will outnumber white subgroups at the elementary school level. In a related study, George D. Nelson, director of Project 2061 for the American Association for the Advancement of Science commented, “If the United States is to continue to lead the world in scientific research and technology development, then future generations of scientists, engineers, and technicians must reflect our nation's diversity" (National Science Teachers, 2002). If Hodgkinson's prediction is correct, lack of participation of minority students in mathematics and science related fields will have far-reaching implications. This is cause for serious concern. The National Council for Teachers of Mathematics has identified mathematics as the "gate-keeping" content (,2000). It is common knowledge that social status and career opportunities accompany mathematical competence. Mathematics is an empowering content. However, the empowerment of mathematics does not reside in numbers and equations; it resides in the mental acuity and reasoning ability that the discipline develops. The intellectual merit of this proposal resides in the belief that mathematics is an empowering content and that increasing the mathematics achievement of Native students is a pragmatic content choice for culture groups that have been historically disempowered and stripped of dignity.

On the 2004 National Assessment of Educational Progress, only 15% of Native American 8^{th} graders scored "proficient" while the national average was a mere 27%. The following year, while all other races demonstrated slight to moderate increases in ability, Native American scores dropped. (NAEP, 2004) In the October 2005 issue of Indian Education Today, Lydia Whirlwind Soldier, a Lakota educator, writes, "While the Federal government has a trust responsibility to provide education for our children, they have failed to meet (our children's) unique educational needs" (Soldier, 2005, p. 15) Low-test scores, low graduation rates, and truancy reflect the fact that something is seriously wrong with the type of education offered to Indian children. Soldier proposes that culturally biased materials presented through culturally insensitive instruction contributes directly to the fact that high school drop-out rates in Indian Country still number 50% or higher. Tragically, the consequences of such failure (school failure's collateral damage) have contributed to the condition of tribal communities burdened with poverty, illness, and addiction.

In studies examined to determine what constitutes effective mathematical instruction and curricula for Native American students, Davison (1994) articulated several of the critical components: the instruction should be multi-sensory and relevant, the concepts taught should be framed within contexts familiar and interesting to the students, and the instructional emphasis should be on helping students see the big picture, rich in relationships and cultural connections. Rauff (1996) maintained that if indigenous people are to successfully participate in today's technological society and still survive as a culture, then educators must realize the role of culture in both the teaching and the learning.

Improving the way mathematics is taught in schools serving Native American children is critically important in addressing underachievement. Technology is advancing so rapidly that there is a growing inequality within the way people gather knowledge (Sorensen, 2002). For centuries, Native American populations understood their environment with a particular unbroken awareness. Education, occupation, and spirituality were not as distinctly separate as they are today. Learning must oblige this inclination. If not, all children will continue to see learning as an obligation and not as self-fulfillment. Culturally relevant curricula can bridge the gap between the different worlds that often exist in the school setting. Recent research focused on the use of culturally relevant mathematics and pedagogy further supports its use (Lipka & Adams, 2002).

A survey of 185 Navajo students in grades 7 and 11 examined the relationship between their identification with traditional Navajo culture and their achievement level on standardized tests. Results suggest that student identification with Navajo language, culture, and tradition helps develop self-esteem and promote academic success (Vadas, 1995). Native Alaskan students who were taught geometric concepts inclusive of a mentoring model consistent with traditional ways of their Yupik people showed significant achievement. These benefits were also shown when the curriculum was used with non-Native mathematics students (Lipka et al., 2005). Finally, in a study of Sioux college students, cultural identity and retention of cultural traditions was critical to their success in school (Huffman, Sill, & Brokenleg, 1986).

Ira Shor stated that unilateral teacher authority in a passive curriculum arouses in many negative emotions within students such as self-doubt, hostility, resentment, boredom, indignation, cynicism, disrespect, frustration, and the desire to escape. (Shor, 1992). Passive curriculum assumes that students are unfilled basins awaiting daily refills of academic nourishment. It also carries the presumption that learning does not require thought. Sadly, this is the state of affairs in education. Children sit quietly in lecture-style classrooms preoccupied by thoughts of amusement, instinctually longing for movement, and tactile enjoyment. They all have the ability to do math, they simply lack the means of improving their problem-solving proficiencies (Hankes, 1998).

In 2000, the National Center for Improving Student Learning and Achievement in Mathematics and Science displayed 10 years of research about Cognitively Guided Instruction (CGI) at the inaugural Decade of Behavior symposium in Washington, D.C. Developed at the Wisconsin Center for Education Research, CGI is a constructivist-based approach to teaching primary mathematics. It is based on the premise that children progress through various levels of reasoning to solve an array of problem-types. Teachers guide students through these levels with formative assessment, while posing problems that require various solution strategies. This pedagogy requires intensive professional development (Carpenter & Romberg, 2004).

In math, practice should be used with feedback to support all strands of mathematical proficiency, not just procedural fluency. Practice on computational procedures should be designed to build on and extend understanding (Adding It Up, 2001). This notion supports the close relationship of reform learning models and traditional Native American learning models (Hankes, 2002). The strong sense of community in many Native American cultures, and autonomy of individuals, even as toddlers, forms a pattern in the learning process that is consistent with the need for group learning, student discourse, teacher guidance, relevancy, and time-generosity (Hankes, 2002). When these factors are present, classroom environments enhance attitude.

Attitude, however, must be accompanied by a fundamental belief in learning. In 1994, an attitudinal study conducted in the Southwest showed that a majority of fifth and sixth graders are optimistic about math (Mather, 1997). They agreed on the importance of math and the relative ease of learning it. The findings did not demonstrate a correlation between the perceptions of a student's ability and his or her ethnicity. There was a discrepancy however, regarding the perceptions of their performances in math. Almost 20% of Indian students felt they were "awful in math" while the percentages of non-Indian students were half that. The significant affirmation ordered by this study is that Indian children *believe* they can do math despite their lack of success in it.

Curriculum reform has been proposed for decades (Sharpes, 1978; Schulz & Bravi, 1986; Reyhner 1992; Butterfield, 1994; St. Germaine, 1995; Bergstrom, Cleary, Peacock, 2003). In a series of studies conducted over the past 30 years, it is evident that Native language and cultural programs increase achievement, decrease dropout rates, improve school attendance, decrease clinical symptoms, and improve personal behavior (Lipka & McCarty, 1994; Smith, Leake & Kamekona, 1998; Stiles, 1997).

While language and culture are vital to the preservation of heritage and academic achievement, they often overshadow the need for academic rigor to fulfill standards put forth by the public institutions and states that educate almost half a million Native students (NCES, 1994). Typically, learning their Native language does not help Indian students understand abstract mathematical concepts. The good news is that language and math do not have to be disconnected.

Compartmentalizing formal education has created an incoherent reality in the minds of many students (Orr, 1994). The knowledge imposed in traditional classrooms is separate and divided. Consequently, so are the perceptions of real world affairs in the cognitive capacities of America's children. This is no wonder. If a student masters the concept of supply-and-demand he or she has the potential to be a great economist and simultaneously a terrible ecologist. The reality is that economy and ecology are not dichotomous. Their disposition lies within the same realm. That is to say economics and ecology, like most things, have a relationship.

Pedagogy and curriculum are no different. The hope here is that a teaching approach and its manual would complement, not dictate one another. Critical education leader Ira Shor would agree. In his book Empowering Education, Shor explains that a truly student-centered approach instantly integrates content and methodology to meet the learning needs of students. (Shor, 1992). The only concern is that they both oblige the learner. Indian students have particular learning needs that are currently not being met (Read, 1999). Consequently the delivery of curriculum and its accommodation of Indian learning styles are vital to achievement as well as engagement (Bergstrom et. al., 2003).

The Connected Math Project (CMP) is a specific example of a complementary curriculum. CMP lessons focus on the development and deep understanding of essential mathematical concepts. The attentiveness of CMP to comprehension allows connections across content, investigation, and grade level. CMP also supports inquiry instruction and learning with an instructional model based on findings from recent cognitive research. An NSF-funded project, CMP is based on numerous studies with over 45,000 students and 390 teachers. It is linked to high academic achievement, and long-term retention. (Connected Math Project, n.d.).

In the book, *Collected Wisdom* published in 1998, Dr. Linda Cleary and Dr. Thomas Peacock interview over 60 teachers of Native American students on effective practices for teaching. Strategies such as: need for feelings of self-determination; raising student curiosity by making curriculum relevant; tapping into student real life interests; spurring cultural interests; receiving positive and frequent feedback; feelings of competence; teacher acceptance and belief in student; establishing a safe environment; creating supportive student group; and ethnically similar role models will be reflected throughout the design of Wigwametry curriculum.

Chapter Three

Methods

In December, 2003 the idea to study geometry through the traditional living structure of the Ojibwe was conceived. To that end, the primary goal of this study was to observe, record, and evaluate the process of developing an integrated geometry unit in the context of an undergraduate teacher education program. This curriculum was designed to integrate culture, but more importantly meet Wisconsin State Math Standards. Mathematically speaking, wigwams are an arrangement of geometric patterns and numerical order. This structure offered the possibility of meeting both goals. The physical space of the structure could be analyzed as a hemisphere, its base shape of course, a circle. The positions of the poles that support the frame are conducive to the examination of symmetry and angle measurement. The structural frame also requires knowledge of arc length and proportion. Covering the structure floor necessitates the comprehension of area, while the exterior lends itself to the investigation of surface area. It was speculated that the construction of a scale model would impel learners to contemplate these mathematical concepts. This study is a collection of observations, interactions, and assessments encompassed by the development and delivery of, as perceived by the researchers, a culturally responsive curriculum.

Participants

This development process was conducted with three math education professors and their students, in two classrooms, at a private college in south central Wisconsin. The courses were held in the fall and spring of 2004, respectively. The initial classroom consisted of 3 male and 13 female pre-service teachers. Seven of these students were non-traditional, adults over twenty-five, returning to school for a career change, and the rest graduated high school within the previous 4 years. The second classroom was similar demographically, with four male students and twelve female.

Data Sources and Analysis

Data sources included teacher and student surveys. Student feedback was also collected and analyzed to determine responsiveness and participation in the project (Appendix A).

Curriculum Development Process

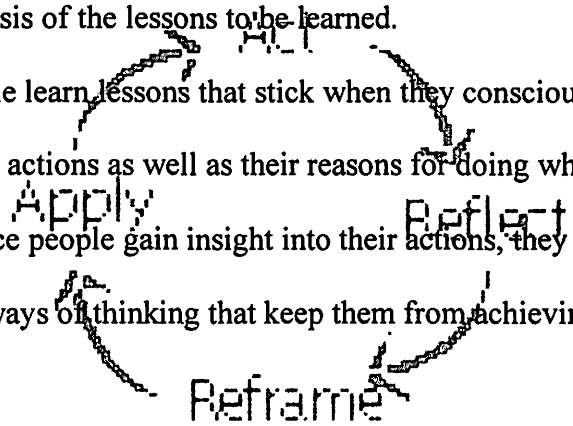
In February of 2004, researchers met with 3 professors from the mathematics department at the college. The college's leadership had recently adopted new initiatives to reach out to minority communities in the state of Wisconsin. A PowerPoint was created and shown to the faculty about the Wigwametry project (Appendix B). The professors were very excited about the value of the curriculum, both academically and culturally. They expressed a very sincere interest in helping to further develop it. One of the professors talked about including various science and social concepts.

The team discussed the possibility of integrating Wigwametry into the Geometric Structures course required for Education majors (Appendix C). The initial goal was to develop lessons within the unit, focused on concepts of circles and spheres. By March, it was decided that the pedagogical approach of the Connected Math Project curriculum would be used as a model for the unit. This model consists of four components:

Act: Experiential learning takes observable behavior —what someone said or did—as the basis of the lessons to be learned.

Reflect: People learn lessons that stick when they consciously explore the results of their actions as well as their reasons for doing what they did

Reframe: Once people gain insight into their actions, they are able to change fundamental ways of thinking that keep them from achieving the results they want.



Apply: Learning is contextual; understanding when and how to apply new learning in the workplace is the crucial last step of the cycle.

Instructional strategies from Cognitively Guided Instruction would be applied as well. It was also decided that the best way to incorporate Wigwametry within the course outline was for the students to participate in the project itself.

A pre-test was given to assess the cultural knowledge of the students. There was a lot of discussion about how to have the students work, and how much direct instruction to give. The students asked a lot of questions regarding the culture. One of the class sessions was devoted to giving this information, and talking about our experiences. The class was told that this would serve as a service-learning project. Eventually, the researchers were given access to the interactive website “Blackboard” to receive out-of-school inquiries and requests regarding the project. As a requirement for the project, they posted comments, observations, and suggestions as an evaluation of the course, as shown in the table in the findings.

The team decided that Fridays would be set aside for constructing and examining the model. The researchers attended each of these sessions. It was also decided that the scope and sequence of the curriculum would be established by the construction process. For example, generating the base outline would require the need to draft an exact circle, since the rigidity of the structure depended on its precision. This initiated conversation about the definition of circles and their properties (radius, diameter, center, and circumference).

Styrofoam (see Appendix B) was used to simulate the ground, since the frame poles require a bit of depth at the base. Basketry reed simulated the willow saplings used in real life for the frame and floss as the basswood fiber that lashed the poles together. Students used a variety of ways to determine the position of the poles along the base. Most students bisected halves and quarters with alternating diameters. This produced 16 points (traditionally, 16 poles were used to build the structure) along the circumference.

As the poles were placed into the base, there was quite a bit of confusion as to their arrangement over the top of the structure. The students asked to see photos of the finished frame and the team obliged with one photo, and two models, built by one of the researchers and the main instructor. The finished models were slightly different, but both gave the students a clear pattern to follow. The primary difference between the instructor's model and the researcher's model was the pole placement. The instructor placed the poles uniformly along the diameter and the researcher placed them uniformly along the perimeter. This created the potential to integrate other geometry concepts including the Pythagorean Theorem.

The researchers observed that the student-teams took various approaches to completing the building project. Several teams finished their structure very quickly without much planning. Others used a variety of formulas to determine the length of each pole with respect to its position along the circumference. All of the teams experienced difficulty lashing the poles at each intersection along the erected frame. It required both team members to accomplish this task; one to hold the poles while the other lashed.

When they were done, the teams were asked to reflect on the building project. Only two teams attempted to cover their structures, so surface area and volume were not taken into account. Specifically, they were asked to consider the math topics related to its construction. They were also instructed to review NCTM's Principles and Standards, as well as Wisconsin State Standards to cross-reference these topics with correlating strands and expectations. Their second assignment was to consider how CMP lessons are put together based on the learning cycle it uses and the one used in Wigwametry.

Near the end of the semester, as part of their final, students were assigned to develop a Wigwametry Unit with at least three completed lessons (Appendix D). They were given the option to develop the curriculum as a stand-alone or integrated project. The project had to be complete with goals, objectives, procedures, materials, and assessment. The instructor also assigned a pedagogical analysis to demonstrate the project's relationship to standards, the learning model, and cross-disciplinary topics.

In September, 2004 an overview of Wigwametry was presented again to another geometric structures course. The focus of the new project was on primary level geometry. The purpose was to enhance the curriculum development process and integrate instructional strategies from Cognitively Guided Instruction. Another member was added to the collaboration team because of her background in CGI Geometry. She was also one of the teachers in the original 1990 CGI study conducted in Madison, WI. This original case study followed current teachers who were trained in CGI methods and tracked the performance of their students during their elementary years (Greenbiz Toolbox, n.d.). After the initial class with this second group, students raised concerns about the “math” involved in the project. They also raised issues of sensitivity to the politically correct term for Native people. Most felt ignorant and did not want to pose questions in front of one another, so we had questions written anonymously. These questions addressed cultural concerns (i.e., how do we avoid issues of children visualizing Native people historically, as opposed to presently). Many students commented about the lack of concrete examples. Particular inquiries were made about the circle lesson, and how it would actually look in a classroom. This led to a conversation about assessment. Students were curious about how to demonstrate student progress with a project like Wigwametry. Finally, as in the original course, students wanted to know what their role was in this process.

In response to these concerns, the researchers provided the class with two articles. The first article was entitled “Investigating the Correspondence between Native American Pedagogy and Constructivist-Based Instruction” by Dr. Judith Hankes, and “Finding Out What Works for Native Students” by Rhonda Barton. The first was a compilation of the latest research on math instructional methods and culturally integrated curriculum. The second article explored proofs, properties, parameter, and area within Alaskan Native fish camps. Both articles examine the indistinct relationships between Native cultures and formalized mathematics concepts. The intervention in this classroom was limited, though researchers communicated with the instructor on a weekly basis. The beginning of the semester was devoted to researching lesson plan development and methodology. The instructor felt this was necessary before getting into culturally responsive curriculum design. Afterward, midway through the semester, the class started and completed the construction component of the project. The researchers again assisted with this element. As an introduction, students analyzed 3-dimensional shapes and space while building and designing “box” cities with paper.

The final project for the course was to develop a 4th - 5th grade Wigwametry lesson. The five lesson topics included circles, spheres, area, scaling, and measuring. Each student was assigned a specific topic for which to create a professional lesson plan including benchmarks, homework examples, quizzes, and explicit directions to help the teacher facilitate activities. The project description included detailed examples for connecting concepts and skills as well as activities for each topic. To conclude the final project, the students were asked to write a one or two-page "idea" paper to integrate culture or other topics in the last lesson "Wigwam village."

Chapter Four

Findings

The primary goal of this study was to observe, record, and evaluate the process of developing an integrated geometry unit. To that end, the following guiding questions were considered throughout the study:

- What does culturally responsive mean, with regard to curriculum?

During the early stages of development, prior to the collaboration with the college, much of the existing research associated the notion of culturally responsive curriculum with seasonal Native American activities, cultural artifacts, and language. It became evident in the review of the literature however, that this variety of curriculum, while abundant, is not culturally responsive but merely relevant. Consequently, the pedagogical impacts of the curriculum also became a focus. In order to surpass relevancy, Wigwametry needed to accommodate the learning needs of students, beyond content. Building the structure while incorporating geometry concepts however, proved to be difficult. The construction process provided a hands-on activity, and constructive student-to-student discourse which are characteristics of a responsive curriculum. It also allowed the instructors and researchers to facilitate rather than lecture or direct. Students however, were often left wondering, "where is the math?" Cultural responsiveness also meant collaborating with Native people. The students, even the instructors lacked prior cultural knowledge as shown in the results in the survey administered at the beginning of the course. (Appendix E). For example, one instructor suggested, as an extended learning opportunity for 4th graders, to research where the "chiefs' wigwams sit in the village." Furthermore, the procedural components of the curriculum had to be explicit; otherwise the construction process was left open for interpretation. Students need to have prior knowledge of the community to contextualize the curriculum. Stereotypes were exposed during the development process, which allowed for constructive conversations.

- How will situating geometry in a cultural context engage more students and teachers?

Initially, the curriculum was designed to address the need for more culturally integrated curriculum in mainstream classrooms. This request came from the Native American student population during the annual Title VII Indian Education Program Assessment.

The pre-service students expressed that this type of project would be interesting NOT just for Native students, but many non-Native students as well. Judging by the reactions, and attitudes posted by pre-service students, Wigwametry was viewed as an extremely engaging experience at the post-secondary level.

Geometric Structures 103
Spring 2004
Class Evaluations

Question: The three aspects of the course I liked best were:
The wigwametry aspect of the class was good. When we did problems in class, it was catching and interesting.
We had a good time; the environment was relaxed and would have been great for learning. However, we got side tracked way too often.
Wigwametry blackboard accessability instructor
I KNEW MOST OF THE MATERIAL FROM FRESHMEN YEAR OF HIGH SCHOOL!
I enjoyed the class material, and did learn new ways to look at geometry. I liked the lesson plan, and you made geometry fun for everyone in class.
wigwametry with joni and horse, challenging problems, ken's humor
Planning the Wigwam lesson.
1. very hands on. 2. teacher very involved in learning. 3. teacher wanted to get student excited about math
the one thing i liked the most...WIGWOMETERY!! i thought this was a great idea to show us students how to apply a topic that we will be teaching to something that is fun and useful.
the unit plan attendance making the wigwams
i really do not have 3, but i liked that he worked with me individually when i asked.

The construction process itself provoked questions about Ojibwe culture (i.e. Why do poles go here? How many were used? What other kinds of materials were used?). We also found that if the process was a little more detailed, the students tended to enjoy it more. The constructivist nature of the curriculum seemed to be the cause. Many students indicated that developing their own definition of a line, or describing pi in their own words was more meaningful.

- How important is collaboration in the curriculum building process?

Collaboration was critical because each team member brought different strengths to the project.

This produced a balance of culture and academic rigor in the content of the curriculum.

Collaborative processes themselves are culturally responsive. Often curriculum development is done individually, without community involvement or input. The collectivity of the group is important as are the individual strengths that team members possess. For example, the notion of pi as a ratio would not have been stressed conceptually without the content knowledge of the instructors. Similarly, the knowledge that the precision of the base shape is directly related to the sturdiness of the structure was contributed by the researchers. Non-Native educators, Native educators, pre-service teachers need to develop an understanding of delivery, curriculum planning and collaboration, to build a curriculum that is meaningful, hands-on, and emphasizes traditional values. These components need to be examined individually and discussed in further detail. It is important to establish a clear understanding of the end goal. The collective understanding of the needs of all teachers and learners involved should be clearly defined, as well as bringing the team's strengths to the table. In our group we had members who possessed advanced content knowledge of mathematics, and some who possessed a high competency of cultural knowledge. You need teachers who are able to think outside the box, who are able to apply the mathematics that is in question.

- How does curriculum development shape pedagogy?

We attempted to model a culturally responsive approach with the pre-service teachers. To us, this meant the exclusion of "frontloading" knowledge, or simply giving the curriculum to students to discuss, interpret, and analyze. Experiencing the lessons and activities forced students to work in groups and rely on each other. It compelled them to ask questions about math and culture of the instructors, as well as one another. It drove them to consider teaching issues such as time-driven curriculum, scope and sequence, and standards-based learning. They participated in activities that were hands-on which required them to be actively involved in problem-solving. Each team was allowed to establish its own work pace. Initially, students seemed uncomfortable with a problem-based, constructivist model. This type of learning was foreign from many of their early experiences in math. The curriculum was also introduced as a service learning project so students viewed it as providing meaningful service to meet a real community need. The instructors, as well as students realized the need to consult someone familiar with the community when developing responsive cultural curriculum. This also helps to reduce anxiety about teaching cultural content correctly.

- What does a culturally responsive curriculum look like?

Curriculum that meets the needs of Native American students, as well as others, ought to have explicit directions and a context to guide learners, who lack prior knowledge of the community being served. It provides concrete examples of strategies that are modeled throughout the learning process. Pre-service teachers saw their instructor as a learner. Cultural resource references are essential for developing the cultural content and should contain local or regional organizations that can provide directions for collaborations. Curriculum should address a perceived community need from the perspective of the individuals being served. Providing an overview of how these needs were assessed and sharing ownership in problem solving will help in developing motivation and buy in. Frequent feedback is critical from both students and staff and should be gathered in various ways, such as the blackboard discussions, questions to be addressed sent to the teaching staff so anonymity can be afforded. Sometimes students can feel intimidated in the beginning because providing feedback early on is novel and must be stressed as a constructive for the whole group. Academic rigor is necessary and should contain math content to address the local standards set for the grade level being served. Collaboration and facilitation is a focus, at the student level, and teaching level. Everyone is viewed as a learner, as well as teacher. It avoids direct instruction where information is given as students passively listen. There's a balance of individual and cooperative work. Students worked independently on circle properties and proportions and during application to the structure, brought their ideas for problem solving to the team to discuss efficient ways for application.

- How do you make a culturally relevant curriculum rigorous?

Having a team with members with strong backgrounds in math, teaching, and cultural knowledge and who have developed a shared collective understanding of the community experience in the beginning is key. More importantly, you need a process to capture and maximize the team member's strengths to effectively develop a pre-service course. This process also needs parameters about the learner, the cultural and mathematical content and delivery. The team defined the grade levels (8^{th} grade - 1^{st} cohort, 4^{th} grade - 2^{nd} cohort) of the curriculum. The benefit of this decision was that more instruction was centered on defining culturally responsive content, mathematical application and construction of the Wigwam. The intent is to expose students to a different way to view learning and teaching geometry. Students are instructed to pull out math application from the building process of the structure, instead of being given applied mathematical equations. Students struggled with "seeing" the math which could suggest their understanding of math application is limited and reflective of early learning of concepts. Wigwametry forced students to understand cultural responsiveness from a Native American point of view, as opposed to simply adding culture to existing curriculum. Cultural Responsive was defined early during the semester with students in both cohorts to provide students with a shared framework and and understanding of how it relates to delivery. Culturally responsive is not just content-based, many students found it difficult to relate "responsiveness" with delivery. Two students from the initial classroom incorporated extensions into their science classroom lessons and a local science fair for students. Their lessons reflected a deeper understanding of cultural responsiveness in both content and delivery. They went on further to use their experiences in employment in local schools and continue to implement Wigwametry as a unit for their classrooms.

Teachers and students alike did NOT know how to apply or abstract the math in the project. Cultural knowledge is easily taken for granted, especially by Native people. When cultural context and cultural learning are integrated in mathematics instruction, there are a lot of assumptions, generalizations and definitions to be clarified. This is particularly true when introducing these concepts to non-native educators and students. For example, learning the importance of placement of family members and sleeping arrangements within a wigwam and why this is important are cultural assumptions not easily assumed by non-Native people. The roles of the family in building the wigwam and how these rules are separated by gender or by age is also critical. The placement of the door and why it must face east is part of the construction but is a larger part of the beliefs and values within the culture.

Additional Learnings

To further develop the construction process of the project, two pre-service teachers from the original Geometric Structures course modified the curriculum to present at a Science Fair hosted by the college. The curriculum was showcased with an accompanying PowerPoint, a large poster board, a model-building activity for attendees, and a full-scale structure. The researchers and students assisted parents and children in building their own wigwam frames. The Science Fair provided evidence that young children could assemble the structure with little difficulty and a great deal of engagement.

Some of the values that are not apparent are the use of materials and conservation. The goal should be minimizing waste. There is so much encompassed within the wigwam such as the smoke rising and its symbolism that we could not go in-depth about it. Spirituality is also important in the culture and within a wigwam, but not always apparent to a non-native educator. This is why it is critical when developing culturally responsive curriculum, to educate team members with the knowledge and experience about the community culture being represented.

The second class seemed more organized overall. Also, the team was using the approach of developing curriculum that models culturally responsive learning and teaching. It is the collectivity of the group that is important and the individual strengths and abilities that each team member brings to the table. Everyone is a leader in some regards and in some area. Without these individual strengths, the curriculum is not as holistic. Non-Native educators, Native educators, pre-service teachers need to know delivery, curriculum planning and collaboration to build a curriculum that is meaningful, hands-on, and emphasizes traditional values. It is important to establish a clear understanding of the end goal. The collective understanding of the needs of all teachers and learners involved should be clearly defined, as well as bringing the team's strengths to the table. In our group we had some members who possessed advanced content knowledge of mathematics.

Chapter Five

Conclusions

This study was based on the premise that a culturally responsive, hands-on, interdisciplinary approach to exploring geometric concepts would engage Native American students and learners in general with moderate or better success. Non-Native educators, Native educators, and pre-service teachers need to develop an understanding of delivery, curriculum planning and collaboration in order to build a curriculum that is meaningful, hands-on, and emphasizes traditional values.

Ensuring that education students do not come away with a generalization that there is one learning style for all Native students but instead dominant characteristics within the group, is a must. Also, when speaking to a class, being cognizant of using the terms "Indian," "non-Native," and "Native American," and how this affects the comfort levels of those involved is critical. An excellent way to begin a discussion is to talk about the use of these terms in conversation. Establishing their political correctness is extremely helpful. It should also be noted that the best approach, when speaking with a Native American individual or small group is simply to ask their preference.

Educational Implications

Teacher education programs need to provide students with culturally responsive curriculum content and delivery. In order for change to happen at the local school level, change must occur at post-secondary institutions. School-wide reform in curriculum and delivery moves at a very slow pace. Addressing the issue at the college level is putting the fire out at the source. Teacher education programs need to model and provide prospective teachers with the necessary experience.

Professional development for teachers needs to change to meet the demand of the evolving composition of the student body. Designing culturally responsive curriculum requires the teacher to consciously and explicitly incorporate modeling and learning experiences that resemble the desired pedagogy. Presently, lessons are developed with inexplicit instruction and are open to interpretation. Teachers become more engaged and open to new experiences if they feel they are meeting a real need.

Considerations for Future Curriculum Development

Looking at current processes, teachers attend workshops, receive information, and try it out at their school. There isn't a process that addresses the lack of prior knowledge of the communities of students being served. Recently, the Teaching and Learning department in this particular school district removed funding for face-to-face workshops and moved to an on-line approach. This goes against the current recommendations in educational research on most effective practices in professional development. The one-approach method generalizes curriculum and is unable to focus on the unique needs of the group and address identified weaknesses. Professional development also needs to incorporate responsive teaching by modeling within classrooms, and providing follow-up over an extended period.

The intent of Wigwametry was to explore the development of meaningful, culturally responsive lessons that would engage all learners, as well as harness the collective creativity found in collaborative teams. It served as a catalyst for change in pre-service education training and current professional development practices, as well as provided post-secondary faculty a fresh approach. These small steps toward curriculum reform and the inclusion of culturally responsive methods bring our educational systems closer to training our future teachers to meet the needs of diverse learning groups.

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Appendix A

Wigwametry Unit
“Developing Culturally Appropriate Curriculum "”
Survey

1. Define the word wigwam.

2. Which Wisconsin tribe(s) used Wigwams?

3. What is the extent of your knowledge on Wisconsin Native Americans?

4. Describe the high school experience on learning about Wisconsin Native Americans.

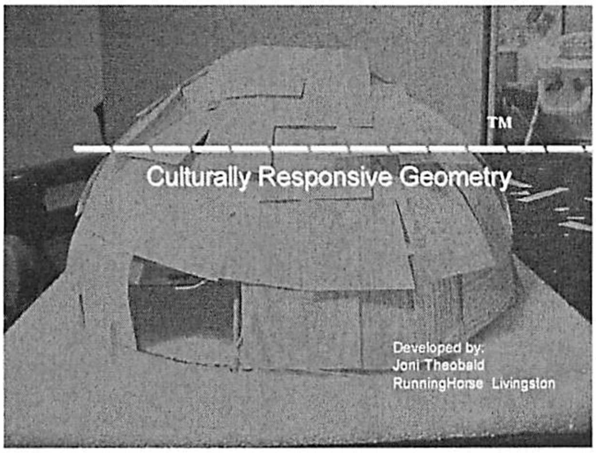
5. Describe your comfort level with geometry? Math, in general?

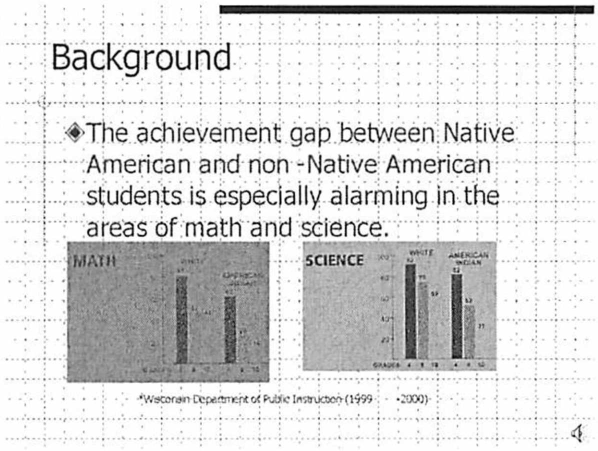
6. Are you familiar with CGI (Cognitive Guided Instruction) Math curriculum?

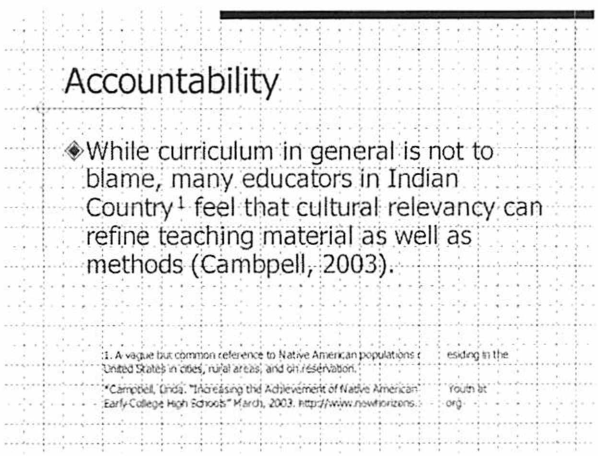
7. Describe how you learn best? (Environment, Group, individually, hands-on, listening, (lecture format, etc.)

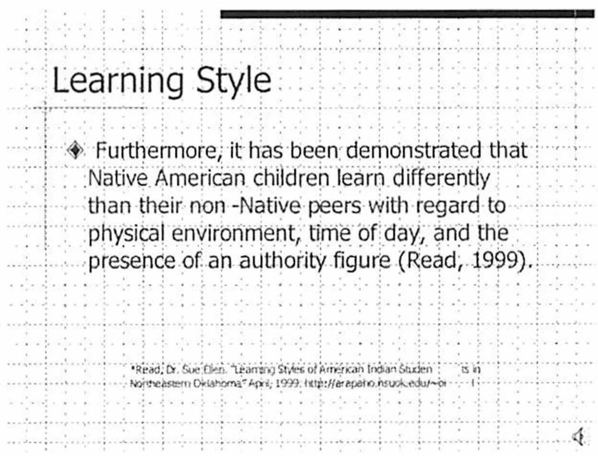
8. Comments or questions? Responses from Wigwametry Overview/introduction?

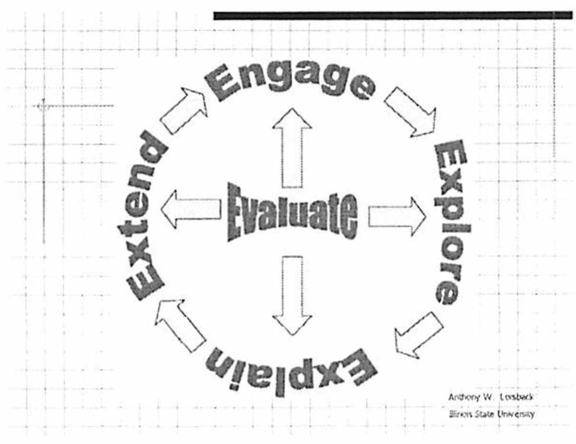
Appendix B

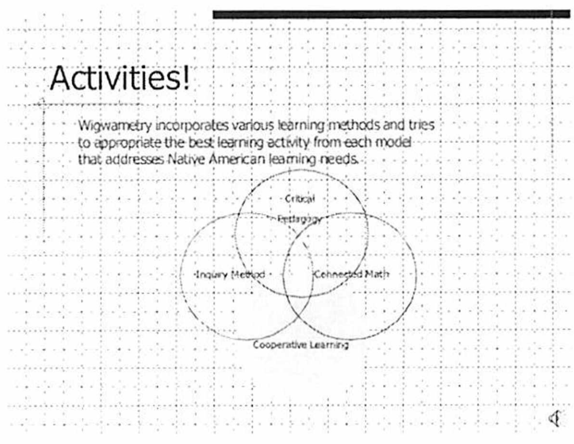

TM
Culturally Responsive Geometry
Developed by:
Joni Theobald
RunningHorse Livingston


Background
The achievement gap between Native American and non -Native American students is especially alarming in the areas of math and science.
MATH
SCIENCE
WHITE
AMERICAN INDIAN
*Wisconsin Department of Public Instruction (1999 -2000)


Accountability
While curriculum in general is not to blame, many educators in Indian Country 1 feel that cultural relevancy can refine teaching material as well as methods (Cambpell, 2003).
1. A vague but common reference to Native American populations esiding in the United States in cities, rural areas, and on reservation.
*Campbell, Linda. "Increasing the Achievement of Native American Youth at Early College High Schools" March, 2003. http://www.newhorizons. org


Learning Style
Furthermore, it has been demonstrated that Native American children learn differently than their non -Native peers with regard to physical environment, time of day, and the presence of an authority figure (Read, 1999).
*Read, Dr. Sue Ellen. "Learning Styles of American Indian Studen ts in Northeastern Oklahoma" April, 1999. http://arapaho.nsuok.edu/~or


Engage
Explore
Explain
Extend
Evaluate
Anthony W. Lorsback
Illinois State University


Activities!
Wigwametry incorporates various learning methods and tries to appropriate the best learning activity from each model that addresses Native American learning needs.
Critical Pedagogy
Inquiry Method
Connected Math
Cooperative Learning

Appendix C

Course Goals: Math 103, Geometric Structures

Catalog description:

This course focuses on the geometric and measurement *content* of Pre-K-8 mathematics and appropriate teaching *methods*. Instruction will be guided by the NCTM Principles and Standards for School Mathematics and the Wisconsin Model Academic Standards for Mathematics. Emphasis is on problem solving, critical thinking, and communication. This course does NOT satisfy the college general education requirement in math. (Prerequisite: Math 102 with a grade of "C" or above.)

Student will demonstrate each of the following abilities.

Regarding professional standards:

- State each of the six NCTM Principles and the five Process Standards.
- Identify, with justification, principles and standards addressed within specific examples of lesson plans.
- Identify, with justification, the grade band (corresponding with NCTM P&S and the Wisconsin Model Academic Standards) in which a given problem occur.
- Analyze a unit from a mathematics curriculum that is currently in use in area school districts.

Regarding formal pedagogy:

- Articulate basic structure of a lesson plan and explore a specific type (Review-Teach-Practice, Investigate/Problem-Based, or Direct Instruction)
- Articulate learning objectives using the language of Bloom's taxonomy.
- Articulate the van Hiele level of understanding supported by a given learning activity and recommend subsequent activities designed to move the learner to the next level.
- Construct (original or based on materials explored within the course) classroom activities around a variety of different types of goals: concept introduction, exploration, reinforcement and generalization.
- Design problems that assess a given geometric concept.
- Identify topics that exhibit the interconnectedness of algebra and geometry.

Within geometric concepts:

- Describe two- and three-dimensional geometric objects by: naming them; comparing, sorting and classifying; drawing and constructing physical models to specifications; identifying properties (such as isosceles, parallel sides, or rotational symmetry).
- Identify three-dimensional shapes from two-dimensional perspectives and draw two dimensional sketches of three-dimensional objects that suggest depth perspective accurately.

- Compare objects and components of objects for qualities such as adjacent, interior, parallel, and perpendicular; and, in the case of two-dimensional objects only, region of intersection.
- Identify symmetry, congruence, and similarity through use of physical materials and motion geometry (slides, flips, and turns). Use compass and straight-edge to perform common transformations on two-dimensional figures and describe and analyze the affects of such transformations. Use transformations to develop patterns.
- Solve problems using geometric objects and spatial reasoning to visualize, represent, and solve. This may include use of transformations.
- Locate and represent objects on a rectangular coordinate system.
- Evaluate others reasoning and solutions for correctness.
- Recommend ways that teachers may anticipate and work to prevent common geometric misconceptions. Recommend ways that teachers may address such misconceptions, once they have occurred.

Within measurement concepts:

- Describe measurable attributes such as length, liquid capacity, time, weight, temperature, volume, angle size; and use appropriate tools and units to measure them.
- Use arbitrary and standard units (metric and US Customary) to describe quantities; convert units within a system (*e.g.*, miles to inches); convert units between systems (*e.g.*, meters to inches). Demonstrate understanding that direct measurement produces approximate, not exact results and use smaller units to determine more precise results.
- Identify and describe attributes in situations where they are not easily measurable; such as distance or area of an irregular figure.
- Determine measurements indirectly using each of the following: estimation, conversion of units, ratio and proportion (*e.g.*, similarity and scaling), geometric relationships and properties for angle size (*e.g.*, sum of angles in a triangle), Pythagorean relationship.
- Evaluate the reasonableness of an obtained measurement.
- Recommend ways that teachers may anticipate and work to prevent common misconceptions regarding measurement. Recommend ways that teachers may address such misconceptions, once they have occurred.

Appendix D

Wigwametry Unit/Lesson Plan

Group Size: any size from 1 to whole class.

Objective: Develop a unit plan together with at least three individual lessons using the learning cycle model

Parameters of the Unit: Any time length from a stand alone enrichment project to a semester-long integrated project

Components of Unit Plan:

1) Statement of Unit Goals
2) List of Objectives
3) Table of Contents with Timeline
4) How the unit would potentially fit into the larger curriculum depending upon the parameters you have chosen

Components of each Lesson Plan:

1) Objectives (only one or two per lesson)
2) Procedures Section (following Learning Cycle Format)
3) Assessment (this can be formal of informal; homework, class activities, etc)
4) Materials (with two subsections; what teacher would need)
5) Strategies for Differentiating Instruction (for instance, for special needs students, ESL students, gifted and talented students, etc.)

Pedagogical Analysis of the Entire Project:

Your pedagogical analysis should address:

1) How this lesson reflects the NCTM Principles and Standards
2) Articulate how the learning cycle is expressed in each lesson
3) Articulate how the learning cycle is expressed in the whole unit
4) An indication of where other content areas can be integrated into the plan

Number of copies of project to turn in: at least 2 per group (or number of group members plus 1 if you want a written copy with comments to put into your portfolio); I will return all but one of the copies.

Appendix E

Wigwametry Results
14 returned assessments

1.		15/15	Home, house-like structure
2.		8/15	Somewhat comfortable, little
		4/15	Good comfort level
		3/15	Very comfortable
3.	Difficult situations:	2/15	Fast pace of class
		3/15	Being able to visualize problems/abstractness
		2/15	Application/relevancy to real-life
		1/15	Understanding formulas
		5/15	Style of Teaching-lecture format
		2/15	Other-no reasons stated
4.	Significance of ∏	4/15	Measuring circles
		2/15	3.14
		2/15	Circumference formula for circles
		1/15	Calculations of circles and spheres
		1/15	Finding radius of circles
		1/15	Ratio of circumference of a circle to diameter
		1/15	Finding volume of circles
		1/15	Represents a numerical expression
		1/15	measures distance around ½ a circle with radius
		1/15	Finding area of a circle
5.	Tribes-Wigwams	8/15	Not sure/don't know
		1/15	Most of them
		3/15	Ojibwe/Chippewa
		1/15	Northern Woodlands
		1/15	Oneida
		1/15	Oneida and Ojibwe/Chippewa
6.	Extent of Knowledge	10/15	Extreme/very limited
		3/15	low
		2/15	extensive/very much
8.	Connected Math	7/15	None/don't know what it is
		3/15	very little/minimal
		5/15	some/somewhat

9. Comments "Just make it interesting" " Kids my age will slack off if it's not interesting." "Do lots of hands-on activities."