Lessons Learned from a Community Math Project: Ethnomathematical Games & Opportunities for Teacher Leadership

Jan A. Yow
Associate Professor
University of South Carolina
Columbia, SC
YOW@mailbox.sc.edu

Crystal Hill Morton
Assistant Professor
Indiana University Purdue University Indianapolis
Indianapolis, IN

Daniella Cook
Assistant Professor
University of South Carolina

Abstract

Minority Access to Revolutionary Instructional Extensions (MATRIX) is a two-part supplemental elementary mathematics curriculum based on six games coupled with a focus on parental involvement and advocacy. One curricular goal incorporates student's culture into its design to show mathematics comes from many cultures and is an evolving discipline in which students can be active participants. The article data comes from a larger pilot study conducted in a rural African American community. This article speaks specifically about the ethnomathematical games in the curriculum in addition to discussing the "lessons learned" by the researchers for the opportunity for teachers to be leaders in incorporating community cultures into classroom practice.

Introduction

"I learned how to play new games and learn at the same time," one student shared in her journal following a Saturday MATRIX section. MATRIX stands for Minority Access to Revolutionary Instructional Extensions and is a supplemental elementary mathematics curriculum (Cook & Hill, 2007) based on six mathematically based games implemented in a rural community[1]. Unique to this curriculum is a strong focus on parental involvement and teaching advocacy to parents (Cook & Hill, 2007). The curriculum was designed for African American students who traditionally struggle to reach higher-level mathematics (Moses & Cobb, 2001). It incorporates student's culture into its design to demystify mathematics (Cangelosi, 2003) by showing students that mathematics comes from many cultures and is an evolved discipline. For example, Mancala, one of the games used in the MATRIX curriculum and featured in this article, originated in Ancient Egypt and is played throughout Africa, hence considered Africa's National Game (Hanson, 2003). The curriculum incorporates the nation's history and cultural contexts into the playing of the game, as opposed to only playing the game without sharing with students its origin. Knowing its origin allows African American students to see that multiple cultures, including diverse African cultures, contribute to the field of mathematics (Zaslavsky, 1999). In addition, as students, parents, and teachers play MATRIX games, conversation between the student and his/her culture larger cultural community enters into the mathematical play. This relationship between students, teachers and their cultural community was nurtured in part by the development and distribution of a parent's guide to the

[1] Z. Smith Reynolds Foundation provided funding for two year pilot study to the Institute of African American Research at the University of North Carolina at Chapel Hill to carry out project.

mathematical games. In this sense, as Bishop (1991) notes, “mathematics is a cultural phenomenon” (p. 3).

As part of the phenomenon, game playing is foundational work for mathematics development (Bishop, 1991). Therefore, MATRIX engages students and parents through games in informal settings. Rather than serving as recipients of mathematical knowledge, students are invited to participate in the construction of mathematics through games and thus be engaged as members of the discipline. Involving student’s own realities and cultures in mathematics can result in their own mathematical empowerment (Lesser, 2008). By doing so, students and parents have positive experiences with mathematics intended to transfer back into school mathematic classrooms. In order for this transfer to be successful, classroom teachers must also be a part of the process. This article speaks specifically about the ethnomathematical games in the MATRIX math curriculum as an opportunity for classroom teachers to be leaders in the field of incorporating community cultures into classroom practice. Through the initial implementation of the project, the authors observed instructors were empowered to learn and integrate the aspect of culture, both the historical culture of the games and the living culture of the students, into instruction. Thus, we focus on the ability of the MATRIX project to mobilize teacher leaders around community cultures. Two overarching areas exist for teacher leadership: engaging teachers in the community outreach and in the research process. Within the community outreach, teacher leaders can serve as MATRIX instructors, work alongside parents, and learn and share about ethnomathematical games. Within the research process, teacher leaders can serve as research partners and integrate the findings back into the community.

The data in this article is from a larger pilot study of the MATRIX project. A brief explanation of the research methodology is included because it was a central aspect of the project. However a thorough discussion of evaluation results (Hill & Cook, 2007) is not the focal point of this article. As this article focuses on the ethnomathematical games of the curriculum and lessons learned for teacher leadership opportunities, the reader will note that evaluation measures of teacher involvement were minimal in data collection and one area that developers would like to explore further in future data collection.

Literature Review

Ethnomathematical Games

As a field of study that concentrates on the relationship of mathematics to culture, ethnomathematics provides a rich ground for which learners of mathematics can experience content in a more personal way (D'Ambrosio, 1985). By understanding that mathematics is a field shared and approached differently by many cultures, learners can see themselves as participants in its creation rather than solely recipients (Ascher, 1991; Barta & Shockey, 2006). Culture is understanding derived from one's experiences about how to live together and interact within a community (Hollins, 1996). It is also a site through which individuals construct, experience, and interpret social realities in the world (Jhally, 1997) and as such, it is important to note that culture is not limited to people of color[2] (Carter, Helms, & Juby, 2004; Helms, 2007).

Ethnomathematics has also uncovered the multiple historical creators of mathematics in non-Western countries such as Africa and India (Zaslavsky, 1999; Joseph, 1987). A significant contribution of ethnomathematics is a more complex understanding of the role of games in developing mathematical knowledge. Playing is a universal term across cultures in mathematics (Bishop, 1991). Games foster community and reveal cultural aspects of how community relates to mathematical concepts (Barta & Schaelling, 1998). Zaslavsky (1999) discusses how numerical

[2] The phrase "people of color" here refers to all people of color. When referring specifically to African-Americans, the phrase "African-Americans" is used.

systems and geometric designs of Africa have developed into subtle games that are used today. Zaslavsky (2001) also notes that the tactile nature of concrete materials used in games also helps children in developing number sense. Bockarie (1993) shares forecasting games that children of the Mende culture of Sierra Leone, Africa, play that build computational skills and proportional reasoning. Gerdes (2001) offers findings from a French ethnographer, Lebeuf, who observed the Fulbe people of Garoua in northern Cameroon from 1936-1937. One game Lebeuf observed, "the game of the mosque" (or "julirde" in Fulfulde, the Fulbe language), develops problem-solving, concepts of symmetry, and numerical relations. Incorporation of mathematical games representative of diverse cultures creates space for students of color to see that people of color contribute to the field of mathematics (Powell & Frankenstein, 1997). In addition, games played by different cultures have historically provided insight into how different people enact mathematics (Gerdes, 2001; Powell & Temple, 2001; Zaslavsky, 1999) and that all people, regardless of culture, do math.

Parental Involvement

Access to higher level mathematics curricula is crucial to any dialogue surrounding improving educational access and equity for African American students. Community engagement and parental involvement as key components the MATRIX project were crucial to meeting this goal. An operating premise of MATRIX was that for African American students to have access to high quality math instruction, parents and those in the larger community must be effective advocates for such instruction. For MATRIX program designers, it was not enough to support the learning of the students. Families and communities had to be engaged in a systemic way to support long term change. Parent involvement buttresses student motivation (Grolnick & Slowiaczek, 1994), higher achievement (Hoover-Dempsey & Sandler, 1995; Eccles & Harold, 1993, Henderson & Berla, 1994) and community support for schooling (Sarason, 1995; 1990). So engaging families and communities is central to sustaining efforts to improve mathematics achievement.

Although the research literature speaks to the importance of parental involvement and the role of parents and community organizations in connecting schools to the communities they serve (Mediratta, K., Shah, S. McAlister, S., 2009; Shirley, D., 1997), all parents are not involved in the same way. Desimone (1999) notes "what is certain is that parents have a role in education, particularly in the reform of mathematics education; parents have been involved in mathematics education and will continue to influence the direction of reform. What is not certain is what role will enable parents to participate beneficially in the education of their children. To effectively involve parents in the reform of school mathematics, the mathematics education community needs both an understanding of the research regarding parental involvement and a commitment to future research on parents in mathematics education" (p. 579). Simmons, the executive director of The Annenberg Institute for School Reform at Brown University (2009) in his letter to President Obama articulates a similar sentiment, "The importance of parent and community engagement in education cannot be understated. Parents and community members provide the *demand* that helps ensure that needed changes take place and the *support* to keep changes in place during inevitable transitions." Thus, meaningful engagement promotes not only an exchange of ideas with communities but also the opportunity for communities to actively participate in making decisions about what happens in schools and classrooms. MATRIX sought to use the direct instruction provided students as a means to engage parents, and the larger community, in a discussion of access to high quality mathematics. Parents were given different ways to talk about mathematics with their children, namely through games, and their children's teachers. In addition, the community engagement component of MATRIX supported the mathematical gains of students in the program by increasing the capacity of parents to effectively navigate the educational system.

Teacher Leadership

Like culture, teacher leadership has been hard to define and often has different meaning in different contexts. Even though teacher leadership has appeared in the literature for over thirty years (Andrews 1974; Rogus, 1988; York-Barr & Duke, 2004; Zimpher, 1988), a concise definition has yet to be agreed upon. Traditional teacher leader roles already exist in our schools: grade level chairs, department chairs, and curriculum developers. Still under researched are non-traditional roles available to teacher leaders: leaders of teacher research inquiry groups in their schools, co-leaders of lesson study projects in their district, and community activist (MacLean & Mohr, 1999; Stigler & Hiebert, 1999; Moses & Cobb, 2001). Schools are realizing that the traditional roles and designs of schooling need to be changed in order for schools to work for all children (Meier, 2002; Sizer, 2004; Troen & Boles, 2003). Similarly, the teaching profession needs to realize that traditional roles and designs of teaching need to be changed in order for schools to work for all teachers (Troen & Boles, 2003). For example, workdays for teachers may involve outreach in the communities where they teach, working with parents and community leaders to better understand their students. Through this outreach, the community might also better understand the work of the teachers. Teachers must be given time, during the workday, to develop their leadership skills inside and outside their classrooms to better involve the parents and communicate the work of their school to the community. As Pellicer and Anderson (2001) proclaim, “Without question teacher leadership is more important today to the success of America’s schools than it has ever been before” (p. 1).

Less research exists in the field of mathematics teacher leadership (NCTM, 1991; Langbort, 2001; Miller, Moon, & Elko, 2000; Webb, Heck, & Tate, 1996, Hill & Cook, 2007). In her list of *Who are Teacher Leaders?*, Langbort (2001) lists eighteen attributes of a mathematics teacher leader including being a mentor to other mathematics teachers, a spokesperson for mathematics education, and an active member of the mathematics education community. As active members in the mathematics community, teachers participate in self-identified professional activities and extend further beyond formal professional development activities such as peer observation (Webb et al., 1996). For the purpose of this paper, teacher leadership is defined as master teachers who intentionally and purposefully influence (and seek to be influenced by) other people (Dozier, 2004; Lieberman, Saxls, & Miles, 2007).

Ethnomathematics, Parental Involvement & Teacher Leadership

Ethnomathematics provides a rich ground in which teachers can be leaders in their profession (D'Ambrosio, 2001) while involving parents (Desimone, 1999). As previously mentioned, we want to make the connection between teacher leadership, parental involvement, mathematics, and culture explicit. Currently underdeveloped and underresearched, teacher leadership that relates mathematics and culture needs further thought. Teacher leaders can foster students seeing the role culture, both their own and others, plays in the development of mathematical teaching and learning. One such project, The Algebra Project, began with one parent wanting to better incorporate the mathematics he was teaching at home (and his culture) into the mathematics his daughter was learning at school (Levine, 2001). So the one parent (Robert Moses) asked the one teacher to invite him into her classroom. Now, from the leadership of one parent and one teacher, the Algebra Project is in seven cities in the United States ("Where we are", 2009). Teacher leaders are open to influencing and being influenced by parents so that both can learn and incorporate family cultures into mathematics teaching and learning.

In addition, Gutstein (2003) used his position as a teacher leader to better relate mathematics and culture to urban middle school students over the course of two years. By utilizing student experiences and culture, he developed real-world projects that promoted deeper thinking mathematically as well as equity within a mathematics classroom and the larger society. Another research study in an urban setting, explored developing new teachers to become teacher leaders by critically looking at their roles as "social justice educators" (Goode, Quartz, Barraza-Lyons, & Thomas, 2004). Jones, Webb, and Neumann (2008) discuss developing teacher leaders in literacy by integrating the school community and culture into the literacy taught in schools. Although three studies discuss crucial areas in honoring culture as part of being a teacher leader, they do not address mathematics in a rural setting and how teacher leadership can be better utilized to produce sustainable change while involving parents. The MATRIX study sheds light in that area.

Overview of the MATRIX Pilot Project

Context

MATRIX was an innovative approach to improving the academic achievement of African American students in three rural counties in North Carolina. Building on the work of the Algebra Project, the literature in culture and mathematics and the tradition of community organizing, its uniqueness lies in its two-part approach designed to improve the mathematic achievement of students and empower parents to better advocate for their children. The project sought to increase student participation in accelerated mathematics curriculum by exposing students to six games[3] that enhance their mathematical reasoning. Thus, the games helped students develop the skills necessary to be good at mathematics.

A goal of the MATRIX project was supporting parents and those in the larger community in becoming more effective advocates on behalf of children through a series of trainings covering topics such as organizing and local and state education policy. The goals of the parental involvement component were (1) know their rights and the rights of their children, (2) gain an increase understanding how to negotiate the school system in order to better advocate for their students mathematics education and (3) have research skills to find the information they need and access resources. One aspect researchers determined missing from the MATRIX project was the involvement of teacher leaders. Thus, this article addresses some of those missed opportunities and roles for teacher leaders in future implementations.

Rural regions have experienced challenges in meeting the academic needs of African American children (Beeson & Strange, 2000). Therefore as a rural community with more than half of the total school population being African American, the greater area of Rock Crest[4] provided a rich context in which to implement MATRIX enrichment programming. The city of Spotted Rock is the county seat of Rock Crest. Spotted Rock school system serves approximately 18,000 students (53% African American, 36% White, 7% Hispanic, 3% multiracial and 1% Asian). There are 28 schools in the county that includes 16 elementary schools. The MATRIX program targeted schools in the greater Rock Crest area in three school districts: Hamilton Public Schools, Oxford County Public Schools, and the Howard County School District. In 2005, the year of the pilot study, demographics of each county are below (Table 1).

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[3] The six games included Gridworks, Oh No! 99!, Get to 1000, Mastermind, Mancala, and Sudoku. This paper specifically focuses on Mancala and Sudoku.
[4] Pseudonyms are used to protect anonymity.

County	Total Percentage of African Americans in the County	Percentage of African American Students in the Public Schools	Percentage of Students on Free/Reduced Lunch in the Public Schools	Percentage of Children who live in Poverty ($20,000 for a family of 4)
Hamilton County	34%	40.8%	56.3%	20.3%
Howard County	57.46%	57%	72.3%	29%
Oxford County	39.33%	52%	68.6%	24.7%

Table 1. Rock Crest Demographics[5]

Research

For the larger pilot study, thirty-eight 4th and 5th students applied for the program, all being African American, 16 boys and 22 girls. Of the 38 who applied, 26 showed up the first day (70% of the applicants attended), 14 boys and 12 girls. The students attended four consecutive Saturdays during the academic school year.

Quantitative and qualitative data were collected to address three research questions of the larger project: (1) the extent to which participation improved math achievement, (2) the extent to which participation improves students' confidence in math, and (3) the extent to which the project identified real parent advocacy needs.

This article focuses on the teacher leadership potential for mobilization in this project and the authors' reflections on "lessons learned" for future implementation. Therefore, of the nine instruments designed to address the three questions, the Teacher Statement (Appendix One), the Student Saturday Journals (Appendix Two), and the Teacher Program Post Survey (Appendix

[5] 2005 demographics found at the North Carolina Department of Public Instruction website (http://www.ncreportcards.org/src/) and the North Carolina Action for Children website (http://www.ncchild.org)

Three) are relevant to this paper. We will now briefly describe the design and results from each instrument.

Teacher Statement. The Teacher Statement asked classroom teachers of each student to respond to seven Likert scale questions with five possible responses ranging from *Strongly Agree* to *Strongly Disagree*. Two examples of the questions are: "Student is motivated to learn" and "Student enjoys math." Nine of the 26 students did not have teacher statements and the most common response to the seven questions was agree.

Student Saturday Journals. Each Saturday students were asked to respond to total of seven prompts by the program's conclusion. A total of 104 journals were collected over four consecutive Saturdays. Prompts included: *How did you make your decisions when playing Oh No 99!?* and *Did you learn anything last Saturday that helped you in math class? If so, what was it?*. All responses were transcribed with errors, typos, and misspellings preserved. Journal responses showed that students generally favored *Oh No 99* with many writing about the fun aspect of playing games. Although it was not clear from their responses why playing games was fun, working with another student was often cited as fun and helpful. Some students found computation challenging ("…get to 1,000[3] will help you count and add). Many students commented on the games helping them with fractions and place value ("I learned something that helped my in math class and that is fraction" and "…this game is fun because it helps you with your place value").

Teacher Program Post Survey. The classroom teachers were administered the Teacher Survey at the end of the 4-week Saturday program. The survey consisted of five questions such as "Student is more willing to try hard math problems" and "Student adds more to the discussion in math class" and teachers replied using a 4-choice Likert scale ranging from *Strongly Agree* to

Strongly Disagree. In general, teachers thought students' mathematical skills (e.g. computational skills) have improved, but the slight increases in the means were not statistically significant. For future research, coupling the teacher post survey with interviews will occur to better investigate growth.

Ethnomathematical Games within the MATRIX math curriculum

Access to higher level mathematics curricula is crucial to any dialogue surrounding improving educational access and equity for African American students. Academic rigor and quality of one's high school curriculum counts most in preparation for bachelor's degree completion (Adelman, 1999). Given that math is a significant gatekeeper for access to academic rigorous courses (Moses & Cobb, 2001), games help students develop the skills necessary to excel at mathematics and encourage inquiry (Powell, & Temple, 2001). Thus, the MATRIX developers were dedicated to including an array of games in the curriculum, specifically games influenced by other cultures such as Sudoku and Mancala.

Games provide insight into a people's culture, values and interests. Those rich in mathematical content allow students to develop a deeper understanding of mathematics as teachers decide what mathematical specifics they will concentrate on for each game. Student interactions with the games help them "construct personally meaningful understandings for the concepts they are applying" (Barta & Schaelling, 1998, p. 393).

Ethnomathematical games, activities that originate from non-Western cultures, help students see how mathematics is influenced by culture and, more importantly, understand it is an invented and living field (Barta & Schaelling, 1998). As students see the influence culture has in playing games, they too can see their ability to influence mathematics and how their own culture can influence mathematics (Barta & Schaelling, 1998; Zaslavsky, 1982)

Mancala

Mancala is a generic name for a group of African board games. The name, boards, and rules differ among regions of Africa. Wari is the two-row version of Mancala played by the Ashanti people of Ghana in West Africa and is the version more commonly played in the United States. Mancala provides students with opportunities to investigate numerical patterns, and build and extend arithmetical ideas and strategic thinking. The goal of Mancala is to capture 25 or more stones (more than half the total number of stones). Players must use logic and pay attention to their moves and the moves of their opponent (Krause, 2000; Powell & Temple, 2001). (See Appendix Four for directions on how to play.)

Sudoku

Sudoku is a puzzle that is typically a 9 x 9 square in which the solver has to fill in all rows with numbers 1 through 9 and all columns with numbers 1 through 9, both with no duplicates. A modern Sudoku puzzle resembles a Latin square ("an *n* x *n* MATRIX filled with *n* symbols such that the same symbol never appears twice in the same row or column" (Delahaye, 2006, p. 81)), which dates back to the Middle Ages. Later, mathematician Leonard Euler (1707-1783) named and studied them (Delahaye, 2006; Emanouilidis, 2008). The first puzzle appeared in 1979 and then appeared in a Japanese magazine in 1984. In 1997, a retired judge saw the puzzles while visiting Hong Kong and in 2004, the London *Times* granted his request to publish the puzzles (Delahaye, 2006). Some may argue that because of Sudoku's widespread popularity, it may not be considered an ethnomathematical games. The authors believe, however, that emphasis on Sudoku's rich cultural history allows it to be considered as ethnomathematical (Orey, 2008). Furthermore, we see its acceptance into the mainstream culture as an asset to help students see that ethnomathematical games can obtain success and offer platforms for cultural conversations.

Solutions to Sudoku puzzles have been found to involve linear programming and combinatorial optimization (Provan, 2008). Latin squares, closely related to a Sudoku grid, have been used in coding theory, statistics, and graph theory (Emanouilidis, 2008). Buckley (2008) uses Sudoku puzzles in grades 2 and 3 to teach logical reasoning through interactive bulletin boards. With such a varied and rich mathematical and cultural history, Sudoku's inclusion in the MATRIX math curriculum not only opens windows for learning about other the ways in which cultures influence each other, but also encourages higher-level thinking skills. (See Appendix Six for details on how to play.)

The details provided above offer support for the next section in what lessons were learned from attempting a research partnership between a university and a community. Specifically, the next section expounds upon how to better incorporate the classroom teacher into a community project like the MATRIX.

Using Community & Culture in the Mathematics Classroom: Opportunities for Teacher Leadership

Since MATRIX was a pilot project, the research component was a key element to its design. Because understanding the community and historical culture is imperative when teaching the children of that community (Ladson-Billings, 1994, 1997), teachers need to be included as leaders in the MATRIX project. The opportunities the MATRIX project provides for teacher leadership through the use of ethnomathematical games include teachers engaging in the community and in research.

Engaging in the Community

With teacher leaders being defined as great teachers who influence other people (Dozier, 2004), we propose that teacher leaders are also influenced by others, most importantly the community and culture within which they teach. The MATRIX project provides multiple opportunities for this engagement. Three areas exist for teacher leadership through ethnomathematical games with the project: serving as MATRIX instructors, working alongside parents, and learning and sharing about ethnomathematical games.

Expanding the role of teachers beyond the school setting: Serving as instructors. This component of the project is teacher leadership because it stretches the teachers' traditional classroom role outside the school walls and into the community. Teachers can serve as instructors during the Saturday workshops as a chance to interact with their students in a setting (the community center) other than the traditional, sometimes intimidating, larger mathematics classroom (Grouws, 1992). By working with students apart from the traditional school curriculum, opportunities arise to learn more about culture through ethnomathematical games and individual student cultures and family. By integrating conversation about culture and family among the games, both teacher and student are able to learn more about similarities and differences in culture and how those can influence the mathematics classroom. For example, several students commented on their unfamiliarity with playing cards (needed for the *Oh No 99* game), however their parents were familiar with cards leading into a discussion about culture across generations. Further conversation might include games that families play and their origin and how those origins manifest themselves into the games the families play today. How do those games, their origins, and their style of play differ among different families? Then, compare those games within the culture of the families to the ethnomathematical games of the MATRIX curriculum, such as Mancala, and how it is played among different tribes in Africa (Zaslavsky, 1999). Continual emphasis on both the culture and the mathematics within the games is also essential to developing familial mathematical skills.

It is important to note that the program originally employed working professionals such as a state's assistant attorney general as instructors for the program. This practice should be continued alongside employing community classroom teachers so that students see individuals that use mathematics other than math teachers. In addition, teachers working alongside community members provide further opportunities for teachers to influence and be influenced by the community and its culture.

Expanding the role of teachers to advocate: Working alongside parents. Teachers can be a part of the parent advocacy component of the curriculum. By attending the accompanying workshop and talking with parents during the Saturday classes, teachers find out more about parent needs and tell them of other opportunities that exist for mathematical advancement, again in a setting separate from a formal parent-teacher conference discussion. With teachers working alongside parents away from the school setting, teachers and parents can learn more about culture through the ethnomathematical games. Teachers can also learn more about the family cultures and ways to integrate that culture into the mathematics they teach. Also, teachers can take the MATRIX ethnomathematical games and hold a parent night to empower parents and provide support for their home mathematical conversations with their students. Much like the Parent Power Night discussed by Kosheleva, Lesser, Munter, and Trillo (2008) that unites Hispanic parents from a high-poverty area with pre-service teachers and university faculty, the MATRIX math curriculum can provide content with which to unite teacher leaders, university faculty, parents, and community members.

Expanding the role of teacher into the community: Learning and sharing about ethnomathematical games. An essential component of teacher leadership is sharing ideas with others (Langbort, 2001; Dozier, 2004). Teachers can learn more about the ethnomathematical games included in the MATRIX math curriculum, incorporate those ideas into their classroom, and share what they learn with colleagues. For example, Sudoku owns a rich mathematical and cultural journey to popular culture (Delahaye, 2006). By teachers learning and sharing its history, in addition to its mathematical richness, students learn that culture plays an important part in mathematics. In addition, Mancala offers insight into African cultures from the lens of mathematics rather than solely a social studies perspective. Students see that many different cultures and people use and develop the mathematics that evolves into a classroom textbook. By incorporating mathematical games from non-Western cultures into classrooms, teachers help students see that math is an evolving science to which many cultures contribute. With teachers integrating such ethnomathematical games in the classroom, the benefit is two fold. First, it further emphasizes to students the importance of their "ethnomathematical communities" in their education. Secondly, it "encourages teachers to be aware of the way in which all peoples—including children and out-of-school formal and informal users of mathematics—integrate their immediate ethnomathematical communities into their understandings of mathematical ideas" (Garii, Silverman, & Barta, 2008, 7). For example, students in the MATRIX project were from a rural community where agriculture and manufacturing lead in employment. Integrating the ethnomathematical community that exists among the agricultural settings and manufacturing plants allow the students to take settings of which they are familiar and connect their understanding of mathematics. Those connections give students, and parents, the opportunity to see how the mathematics directly connects to them, "out-of-school." It also provides an avenue for teacher leaders to extend their knowledge beyond traditional curriculum to incorporate community cultures into the curriculum.

Engaging in the research

A strength of the MATRIX project is its commitment to couple research with community involvement and curriculum implementation. The project was intentional about measuring how the curriculum was received, how it impacted student interactions with mathematics, and how it affected the community. Several lessons were learned about how to better measure those factors and how to improve future instruments, specifically around teacher involvement. Two areas exist for teacher leadership as engaging in the research aspect of the MATRIX project: involvement as a research partner and integration of findings back into community.

Teacher Leader Involvement as Research Partners. Two instruments directly involved the teacher in the research process: the Teacher Statement and the Teacher Post-Survey. The teacher, however, was merely a point at which to collect data rather than a partner in the research process. The Teacher Statement asked teachers to respond to prompts about how their students related to mathematics based on a Likert scale. With teachers included as instructors in the program, further information about the qualitative nature behind an *Agree* response could be incorporated into the pre-program research. A teacher leader asked to serve as an instructor would offer detail to *how* the "student is motivated to learn" or *what* evidence indicates the "student struggles with math but applies effort" (Teacher Statements in camp recommendation packet). Furthermore, this involvement helps the university researchers to be better informed of classroom practices and the teacher leaders to be more aware of data analysis practices, a more visible requirement of their job since the No Child Left Behind Act (NCLB, 2001).

The Teacher Post-Survey provides another intersection of the MATRIX project with classroom results. The five questions asked were informative, however, more detailed knowledge of how the Likert scale responses translated into student work in the math classroom would be more helpful for long-term effect. Coupling the survey with a teacher interview would offer such detail. Teachers who are also instructors in the program and therefore invested in its success could serve as the interviewer. With their understanding of the culture of the community implementing the MATRIX project, they have the unique ability to delve deeply into the interviewee's Likert scale response. Teacher Reflections (that is, instructors in the program) were not a part of the original data collection plan, however, one instructor reflected about her involvement in the program, writing, "I personally enjoyed interacting with the kids. The overwhelming majority of them seemed to enjoy and seemed to be engaged in the activities. I liked the flexibility to be able to work a little longer on something the group was having a hard time grasping." Including Teacher Reflections in further data collection plans for this project will provide more qualitative data with which to further improve the program and involve teachers.

Teacher Leader Integration back into Community. With teacher leaders serving as both instructor and researcher, they are better able to integrate the research findings back into the community and its culture. Not only because they are more informed about the findings, but also because they live in the community making it professionally beneficial and geographically easier. As teachers work with the ethnomathematical games of the MATRIX math curriculum, they will learn about alternative methods for delivering mathematics instruction, both from the cultural aspect of the ethnomathematics and the less-intimidating nature of the games. Data from the Saturday Journals demonstrates the less-intimidating nature of the MATRIX math curriculum. One 4^{th} grade female student wrote, "I learned that math games can help you learn too. I learned the game 'get to a 1,000' will help you count and add." A 4th grade male wrote, "The game get to a 1,000 was fun. The game has a lot of Math and add the number."

Data from the Saturday Journals also revealed students enjoyment of the two games borrowed from other cultures: Sudoku and Mancala. One 4th grade female enjoyed Sudoku: "Sudoku is a fun game you can learn how to play easy." Other students found Mancala fun. "The game I liked best was Mancala because I think I'm good at it" (4th grade female). Another student wrote, "I love to play Mancala because it is really fun and because you can come up with new strategies and is really challenging" (4th grade female). Teacher leaders involved with the MATRIX project can use the enjoyment students find from ethnomathematical games as a catalyst to incorporate more ethnomathematics within their classroom and discuss the intersections of culture and mathematics. They can also use what they learn about ethnomathematics with colleagues to use in their own mathematics classrooms.

Final Remarks

As discussed in this paper, the MATRIX project provides multiple opportunities for teachers to not only influence others but also engage in the important work of engaging the community and culture within which they teach. Five areas exist for teacher leadership through ethnomathematical games with the project. In the area of curricular implementation, teachers can (1) serve as MATRIX instructors, (2) work alongside parents, and (3) learn and share about ethnomathematical games. In the area of research, teachers can (4) serve as research partners and (5) disseminate findings back into the community. By teachers being a part of a community mathematics project that includes ethnomathematical games, community members and teachers see that culture is valued and is an imperative component of school mathematics. Teachers can lead in this area of integrating ethnomathematical cultures into local rural communities by serving as instructors in the MATRIX program and then introducing colleagues and administrators to the ideas and philosophies of the curriculum. As leaders of learning, teachers are viable, and necessary, bridges with which to connect community culture and mathematics classrooms.

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Appendix One

Teacher Statement: Teacher Recommendation

Student's Name: ___________________________________ Current Grade in School: ____

To the Recommender:
The student named above is applying to the MATRIX Project. This youth program offers mathematics enrichment in a camp setting for motivated 4th and 5th grade students. During the program, students attend classes and engage in fun and challenging mathematics games designed to enhance their mathematical reasoning. Your assessment will provide us with valuable information as we consider his/her request to participate. THANK YOU for your time.

1. Student is motivated to learn.

   Strongly Agree Agree Disagree Strongly Disagree

2. Student stays on task with little guidance.

   Strongly Agree Agree Disagree Strongly Disagree

3. Student works well with others.

   Strongly Agree Agree Disagree Strongly Disagree

4. Student follows directions.

   Strongly Agree Agree Disagree Strongly Disagree

5. Student enjoys math.

   Strongly Agree Agree Disagree Strongly Disagree

6. Student struggles with math but applies effort.

   Strongly Agree Agree Disagree Strongly Disagree

7. Student has strong computation skills (adding, subtracting, etc.)

   Strongly Agree Agree Disagree Strongly Disagree

Additional Comments:

Appendix Two

Saturday Student Journal Prompts

Day 1: Saturday, April 28th
How did you make your decisions when playing OhNo 99!?

Day 2: Saturday, May 5th

1. What did you like most about class last Saturday?
2. Talk about one thing you learned.
3. Did you learn anything last Saturday that helped you in math class? If so, what was it?
4. If you could change anything in school, home, etc., what would it be and why?

Day 3: Saturday, May 12th

What math game or activity did you like most? Why or why not?

Day 4: Saturday, May 19th

Would you attend this program again? Why or why not?

Appendix Three

Teacher Post Survey
MATRIX Project Saturday Math Camp

Teacher: ____
Student's Name: ____

To the Recommender:
The student named above participated in the MATRIX Project 2007 Saturday Camp program. This youth program offers mathematics enrichment in a camp setting for motivated 4th and 5th grade students. During the program, students attend classes and engage in fun and challenging mathematics games designed to enhance their mathematical reasoning. Your assessment will provide us with valuable information to help understand how to improve. **Please base your responses on any changes in the last month.**

1. **Student is more willing to try hard math problems.**

   Strongly Agree Agree Disagree Strongly Disagree

2. **Student is more excited about doing math.**

   Strongly Agree Agree Disagree Strongly Disagree

3. **Student adds more to the discussion in math class.**

   Strongly Agree Agree Disagree Strongly Disagree

4. **Student's computation skills (adding, subtracting, etc.) have improved.**

   Strongly Agree Agree Disagree Strongly Disagree

5. **Student talks about math more.**

   Strongly Agree Agree Disagree Strongly Disagree

Additional Comments (if any):

Appendix Four

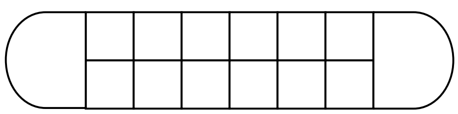
Mancala

Materials Needed:

Mancala board games can be brought from retail stores or online. Students can make a mancala game. To make the game students will need:

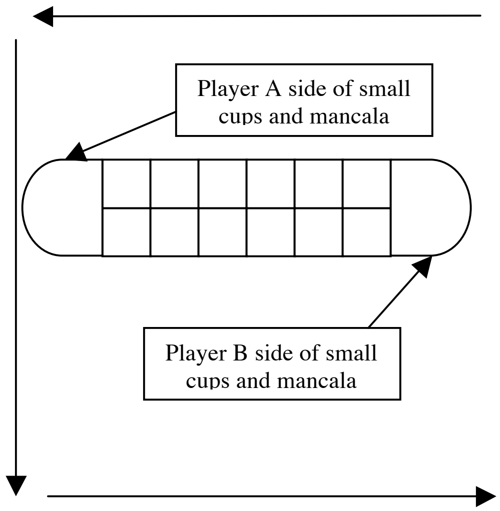
- egg cartoon that will hold 12 eggs
- 48 beans, pebbles, or small marbles

Remove the lid of the egg cartoon, cut the lid in half and place the pieces on the ends.



How to Play – (Level One)

1. Players should sit facing each other with the long side facing each player. The smaller holes are called cups and the two big cups are called the mancala. The six small cups closest to the player belongs to the player. The player's mancala is to his/her right. See the diagram below.



The arrows around the mancala show the counterclockwise direction students should move their stones.

2. Four colorful stones are placed in each small cup.

3. Players alternate turn.

4. During their turn, each player scoops up all the stones from a small cup on his/her side of the board.

5. Starting with the next hole in the counterclockwise direction, the player puts one stone in each successive hole. The first player removes four stones from his/her cups. Starting with the NEXT cup, the player puts one stone in each small successive cup including the player's mancala until the player no longer has stones in his/her hand. Players DO NOT PUT STONES IN THEIR OPPONENTS MANCALA. **On the first play, players may place stones on their opponent's side depending on their starting cup. During the game, it may be possible to go around the board more than once because one cup can hold many stones.** ***If the last stone lands in the player's mancala, the player goes again.***

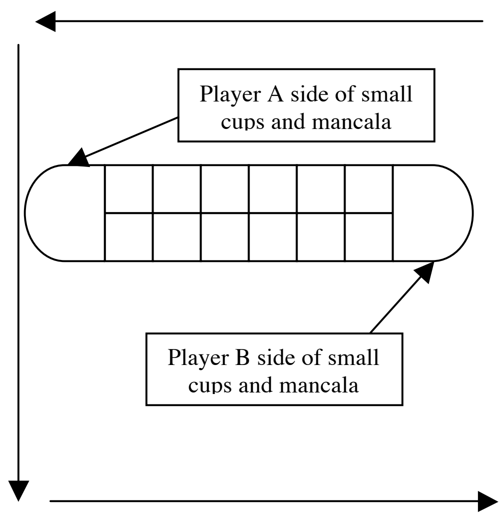
6. During the game, players should count the stones in their and their opponent's cups visually before making a move.

7. The game ends when one player no longer has stones in his/her small cups. The other player, who still has stones on his/her side places the remaining stones in his/her own mancala. The player with the most stones in their mancala wins.

How to Play – (Level Two)

The additional directions in number five add an additional level of difficulty to Mancala.

1. Players should sit facing each other with the long side facing each player. The smaller holes are called cups and the two big cups are called the mancala. The six small cups closest to the player belongs to the player. The player's mancala is to his/her right. See the diagram below.



The arrows around the mancala show the counterclockwise direction students should move their stones.

2. Four colorful stones are placed in each small cup.

3. Players alternate turn.

4. During their turn, each player scoops up all the stones from a small cup on his/her side of the board.

5. Starting with the next hole in the counterclockwise direction, the player puts one stone in each successive hole. The first player removes four stones from his/her cups. Starting with the NEXT cup, the player puts one stone in each small successive cup including the player's mancala until the player no longer has stones in his/her hand. Players DO NOT PUT STONES IN THEIR OPPONENTS MANCALA. On the first play, players may place stones on their opponents side depending on which cup they begin with. During the game, it may be possible to go around the board more than once because one cup can hold many stones. If the last stone lands in the player's mancala, the player goes again.

If the last colorful playing piece is placed in an empty cup on the player's own side, he/she may take all the colorful playing pieces from the opponent's cup directly opposite the cup. All the colorful playing pieces captured including the capturing stone are placed in the players own mancala

6. During the game, players should count the stones in their and their opponent's cups visually before making a move.

7. The game ends when one player no longer has stones in his/her small cups. The other player, who still has stones on his/her side places the remaining stones in his/her own mancala.

North Carolina Objectives Addressed:

Grade 3

1.06 Develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.

Grade 4

1.01 Develop number sense for rational numbers 0.01 through 99,999.
1.05 Develop flexibility in solving problems by selecting strategies and using mental computation, estimation, and paper and pencil.

Grade 5

1.03 Develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.

Suggestions for Teaching:

Mancala can be a difficult game to teach your students. It is important for students to see a visual demonstration of how the game is played. The demonstration could be showed to the entire class using a computer or the board game. If the whole class demonstration is complete with the actual board game, arrange students in a way that all students can follow the demonstration.

Another option is to divide students into small groups and demonstrate the game to each small group. While the game is, being demonstrated to one group of students, other students can practice previously learned games. It is important to keep all students actively engaged. If some students are familiar with mancala, these students could help to explain how to play mancala to other class members.

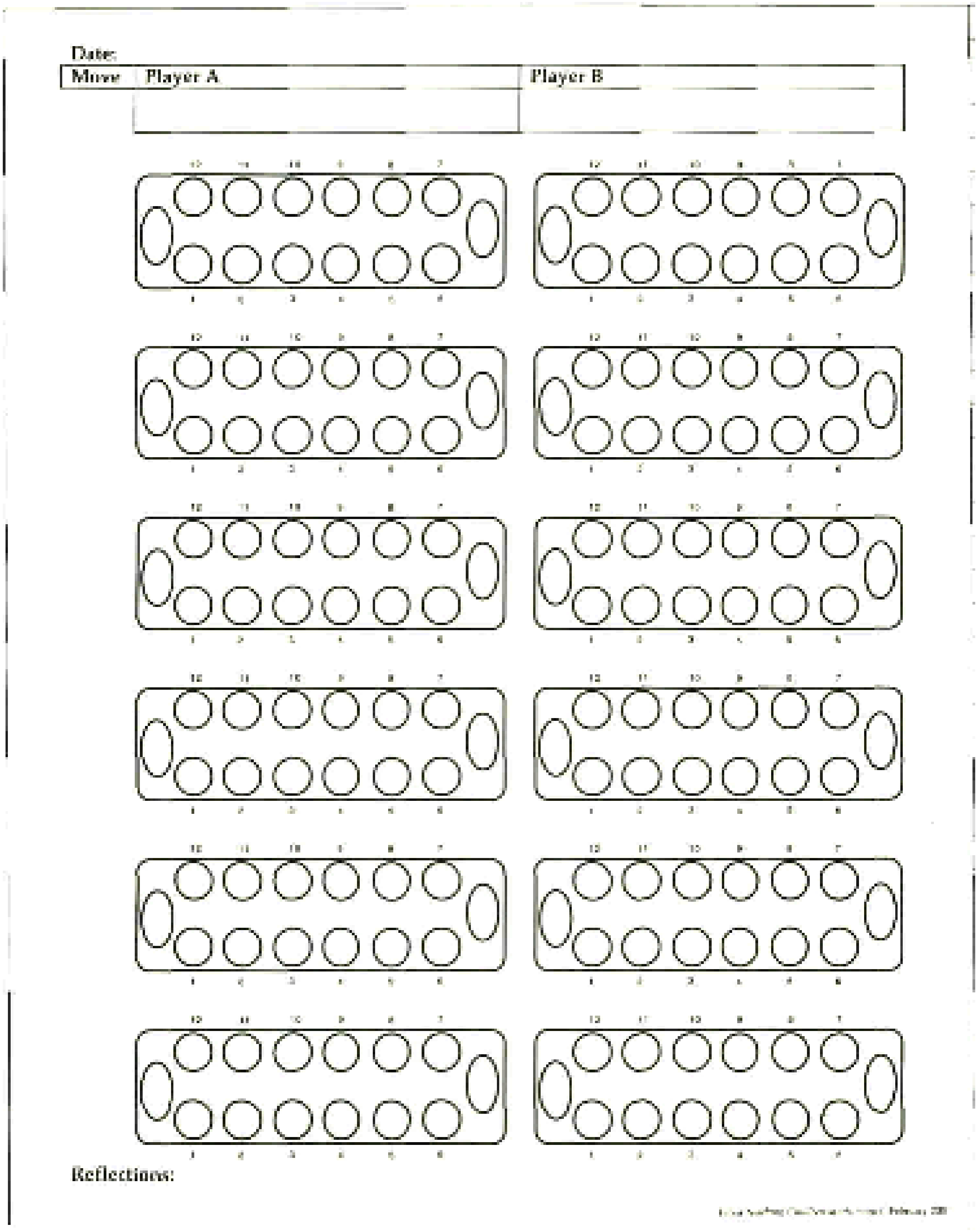
Writing Activity:

Have students used the attached Mancala template (See Appendix Five) to record six pairs of moves and write about their playing strategies.

Do you use any math skills to play this game? If so, what are they?

What strategies did you use in an attempt to win the game?

Appendix Five



Date:

Move	Player A	Player B

Reflections:

Appendix Six

Sudoku

Sudoku is a game of logic. Players must use logic to work out where numbers may go. Every Sudoku puzzle is different and varies from 4 x 4 to 9 x 9 from easy to diabolical.

How to Play

The object of the game is to fill in all blanks with numbers so that no row or column has a duplicate number and all of the small boxes have unique numbers as well. In a 6x6, this will mean that all rows have the numbers 1 through 6 and all columns have the numbers 1 through 6, both with no duplicates. In addition, each small 3x2 box will have all of the numbers 1 through 6. In a 9x9, this will mean that all rows have numbers 1 through 9 and all columns have the numbers 1 through 9, both with no duplicates. In addition, each 3x3 box will have all of the numbers 1 through 9.

?					6
?	3		5		4
?				5	2
3	5				
4		3		6	
6					

You can see that we need to place a 1, 2, and 5 in the first column. Look at the squares with the question marks (?). Can you work out why the bottom number can only be a 1? Then the middle number must be a 2 and the top number a 5.

5					6
2	3		5		4
1				5	2
3	5				

4		**3**		**6**	
6					

Here is another trick. Look at the highlighted squares. In the top left mini-grid, the 5 is in the left column. In the middle left mini-grid, the 5 is in the middle column. In the bottom left mini-grid, the 5 MUST go in the right column. These are called "triplets". See if you can do the rest of this puzzle.

Materials Needed:

Sudoku puzzles- hard copies or on-line versions

North Carolina Objectives Addressed:

Grade 3

5.01 Describe and extend numeric and geometric patterns.

5.02 Extend and find missing terms of repeating and growing patterns.

Grade 4

1.05 Develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.

Grade 5

1.03 Develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.

5.01 Describe, extend, and generalize numeric and geometric patterns using tables, graphs, words, and symbols.

Suggestion for Teaching

C1 C2

C3 C4 C5 C6

2	1			4	3
		6	2		
		3	4		
3	4			5	6

R1 R2 R3 R4 R5 R6

1. Explain the rows, columns, and grids
2. Label the columns **(C)** and rows **(R)**

Questions to help guide students to completing the puzzle:

1. Look at C1, C2, and C3. Are there any doubles (a number that repeats twice)
   Answer: 3
2. What row and columns is 3 in?
   Answer: R4-C3 and R6-C1
3. So in what position can we place a 3?
   Answer: R2-C2
4. Look at C4, C5, C6 are there any doubles
   Answer 4
5. What column and row is 4 in?
   Answer R5-C6
6. Since R1 has the most numbers let's try to fill in R1
   a) What numbers do we need?
   Answer 5 and 6
   Remind students that they cannot have the same number in one column so 6 cannot go in C3 and must go in C4.

The teacher should continue with questions of this nature to walk students through the completion of the puzzle.

Writing Activity:

Have students discuss the strategies they used to complete the puzzle and if the strategies worked.

Why are some Sudoku puzzles harder than other puzzles?

What patterns do you find in a Sudoku puzzle?