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The Mathematical Ecology of the Shoshoni and Implications for Elementary Mathematics Education and the Young Learner

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The Shoshoni are an indigenous people who traditionally inhabited parts of what is now northern Utah, central and southern Idaho, and western Wyoming for the past 14,000 years. While many facets of their historical and recent culture have been analyzed, little investigation has taken place to date concerning their use of mathematics in culturally specific ways. This manuscript is the report of a two-year study involving semi-structured interviews of Shoshoni representatives to describe the culturally specific use of mathematics in Shoshoni traditional living practices. Qualitative research methods were selected in order to gain a rich understanding of the mathematical insight and uses of mathematics for the Shoshoni. The inquiry methods and related interview questions may serve as a model to structure research investigating mathematical practices of other American Indian cultures, thus allowing for a broader understanding of indigenous people and the culturally - specific mathematical practices of each tribe. Insight gained from this research prepares the way for American Indian educators to create culturally specific mathematics curricula reflecting the local culture of those they teach.

A Brief History of the Shoshoni

Oh, yes, my people had ways of counting things that we used, for instance we counted seme’ (one), wahatehwe (two), bahaitee’ (three), and so on. 10 is “seemote”. We usually counted bigger numbers using groups of ten. Eleven was “seemote seme’ mando’aingende” and it meant one on top of ten or one out of ten. Twelve was seemote wahatem mando’aingende”. You would make 20 by saying “ wahaseemote”. 100 was said as “biaseemote” and 1000 was “seemotemam biaseemote”. We used buffalo hides to indicate these large numbers. For numbers too many to count, we said this meant more [of them] than the hairs on a horse.

The Shoshoni historically consisted of at least four bands of distinct groups of American Indians. These included the Lemhi, the Boise Bruneau (later termed the Fort Hall Shoshoni), several bands of Northwestern Shoshoni, and a related band of Northern Paiute, the Bannock. The traditional homeland of the Shoshoni incorporated the Salmon River Mountains and the Snake River Plains, where various cultural groups lived since prehistoric times. Two differing cultural groups emerged from these areas, one of which developed along the southern area of the Snake River Plains in current day western Wyoming and eastern Utah. This group made up the present day Western Shoshoni. People identified as Northern Shoshoni developed farther north and west, in the current states of Idaho and Northern Utah. At one time, these two bands most likely formed a single group thus having common roots that extend back in time nearly 8000 years.

Today, the majority of Shoshoni people live on or near the Shoshoni-Bannock reservation near Pocatello, Idaho or the Wind River Reservation north of Lander, Wyoming. Cultural values maintained by the Shoshoni demonstrate harmony and balance, autonomy, and social equality (E. Galindo, personal communication, April 25, 2000). These values are reflected in several of the mathematical applications to be described. Traditional Shoshoni culture is most frequently practiced by the senior members of those communities. While educational and cultural efforts are being made to preserve the culture and its traditional ways, it appears that memories and practices of old ways is slowly being lost.

The history of the Shoshoni is an illustration of a people who throughout time have been in a nearly constant state of cultural change and modification. Contact, interaction, and response to members of other tribes, European explorers and invaders, and continuing today the multiple interactions in contemporary society both on and off of the reservation have all affected an ongoing cultural evolution of the Shoshoni. While many factors need be considered to attempt an understanding of this cultural transformation and how it has influenced Shoshoni culture today, few other factors have had as a dramatic effect as that of western education.

Education or Eradication?

Systems of education involving Native youth existed long before the forced intervention by outsiders wishing to civilize and improve on Native culture. Education from a traditional perspective meant knowing oneself and one's place in the world. With this knowledge came the obligation of acting responsibly for the sake of the tribe, family, and individual. What was learned was done within a context provided by interaction in the environment respectful of the multiple dimensions of being – spiritual, mental, social, physical (Cajete, 1994).

Early contemporary western educational practices attempted to remove the students from their traditional practices. Rather than learn about one's people and tribal ways of life from an elder, Indian children were forced to learn about the ways of others in an alien context and environment from teachers knowing little about the culture or its influence on the teaching and learning of children. Reyhner and Eder (1994) write, "Had the goal of coercive assimilation been reached, there would be no recognizable Indian people today" (p. 33).

Sadly, today much of the same ideology and racism that was used to justify the educational enculturation process still exists in our schools attended by American Indian students. The trend to separate the child from his or her culture for what passes as "public education" continues. This is damaging not only for the Native child but also for all children. It does not have to be this way and it should not be this way. It is the authors' opinion that a change for the better is taking place, albeit slowly.

We call for a return to an acceptance for and implementation of traditional educational practices where culture is again respected in the public educational setting. The first step must be to use the culture of the children as the basis for building a humanistic foundation. Will we only be satisfied when we enter classrooms to find Indian children again dressed in feathers and buckskins? We think not! As the Shoshoni culture has adapted and evolved resulting from invited and forced interaction throughout time, so does it change today. The greatest strength of the Shoshoni is their culture and the greatest opportunity for involving the children in the educational process is to acknowledge the necessity of incorporating culture in the curriculum.

Culturally Inclusive Mathematics Curricula and American Indian Students

Traditionally, the mathematics taught in schools seldom includes overt connections with culture. Consequently, many students view mathematics as a spectator sport rather than one in which they can participate. For the American Indian student, this cultural disconnection poses additional obstacles for achievement in mathematics. In a review of studies concerning indigenous students, Saxe (1982) found that many American Indian students experience particular difficulties in solving mathematical problems when the problems are not perceived as being culturally relevant. The National Council of Teachers of Mathematics (NCTM) articulated the necessity for all students to more fully understand the many connections that exist between mathematics and its real world applications (NCTM, 2000).

In a summary of studies in which the first author examined what constitutes effective mathematical instruction and curricula for American Indian students, Davison (1994) articulated several of the critical components: the instruction should be multisensory 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. According to Dilworth (1992), it is necessary to investigate various educational models designed to work with diverse populations. She recommends an environment that allows for the development of multiple models of teaching in settings that are multicultural, each being open for examination.

In "Culturally Negotiated Schooling: Toward a Yup'ik Mathematics" (1994), Lipka discussed the process and effects of constructing curricula with those who are likely to be most affected by it (incorporating language, culture, and daily living practices). Educators must realize the role of culture in both the teaching and the learning. if indigenous people are to successfully participate in today's technological society and still survive as a culture, Rauff (1996) maintains. Culturally relevant ethnomathematical curricula connect the student with his or her heritage. It is the bridge between his or her world on the reserve, reservation, or in the community and the different world that may often exist in the school setting. Such curricula provide a basis for exploring and learning how many of the same mathematical principles of their people are applied in different ways today by mainstream society. Nelson-Barber and Estrin (1995) state:

> The apparent value of incorporating ethnomathematical and ethnoscientific activities from students' communities lies in their potential for showing connections to common conceptual underpinnings and/or ways which epistemologies converge or diverge. Such a move goes well beyond the sort of cultural validation educators assume leads to student self-esteem, and which they justify on those grounds alone (p. 26).

Reducing the ethnocentrism and racism associated with traditional educational curriculum and teaching methods is possible as more indigenous cultural connections are made (Garcia & Ahler, 1992). The benefits extend to those beyond the students into the community itself. "The society at large stands to benefit from gaining perspective on the ways in which values and practices based in mathematics, science, and technology affect human relationships and the very earth itself. The issues go beyond empowering single groups to opening up greater possibilities for the whole society (Nelson-Barber & Estrin, 1995, p. 41)."

Mathematics and Culture

The development and use of culturally inclusive curriculum requires that "mathematics" be seen in different light than from what is typically witnessed in many of today's classrooms. Standard mathematical classrooms often promote a western perspective where the assumption is made that cultural connections are not necessary or valued. Through the study of Ethnomathematics, or the analysis of the relationships between mathematics and culture, western mathematics is presented as but one example of a culturally derived mathematical system rather than the only valid system. A teacher embracing this perspective recognizes the importance of helping his/her students acquire a solid understanding of contemporary (western) mathematics while also demonstrating the value and use of the same mathematical principles whose applications illustrate characteristics of their cultural community.

The term ethnomathematics is descriptive of both past and present histories of mathematical development. Zaslavsky (1996) describes mathematical development and applications throughout the world related to and shaped by cultural influences across the millennia. D'Ambrosio (1987), who many view as the "father" of ethnomathematics, explains that ethno describes "all of the ingredients that make up the cultural identity of a group: language, codes, values, jargon, beliefs, food and dress, habits, and physical traits (p. 3-4). Mathematics, on the other hand, expresses a "broad view of arithmetic, which includes ciphering, measuring, classifying, ordering, inferring, and modeling" (pp. 2-3). Ascher and Ascher (1986) define ethnomathematics as "the study of the mathematical ideas of non-literate people (p. 125)" and describe mathematical practices of non-literate societies that are at least as sophisticated as those of modern "Western" mathematics.

D'Ambrosio's (1991) study proposes that mathematics have been culturally derived since man's first steps on Earth. Evolving mathematical ability, as a component of human intelligence, helped human beings to not only survive but to succeed in their environment. Different cultures (Powell & Frankenstein, 1997) produce different mathematics that change over time to reflect their cultural experience and evolution. Therefore knowing the culturally derived mathematics of a society allows one to gain a more substantial understanding of that culture in general.

A growing body of ethnomathematical research is being conducted on the mathematical practices of distinct cultures in everyday situations (ISGEm Website, 2001). Ethnomathematical researchers have described specific uses of mathematics by distinct populations around the world and throughout history related to and shaped by culture (Ascher & Ascher, 1986; Barta, in press; Hiebert & Lefevre, 1986; Lampert, 1986; Masingila, 1994; Reyes & Stanic, 1988; Saxe, 1988; Zaslavsky, 1996). A number of these descriptions involve a focus on the "mathematical anthropology or uses (of) mathematical modeling in ethnographic and archaeological studies to describe material and cognitive patterns generally without attributing conscious intent to the population under study" (Eglash, 1997, p. 80).

While a few studies exist where uses of mathematics in American Indian Indigenous populations have been examined (Closs, 1997), for the majority of nations, including the Shoshoni, no Shoshoni-specific studies of ethnomathematical skills have been located. Anthropological studies of some of the traditional living practices of the Shoshoni do exist (mainly focused on numeration systems). The authors of these studies typically describe the practice or the behaviors of these people without an analysis of what mathematical skills were necessary to allow these practices to occur or suggestions for how this information may be instructionally useful in classrooms today.

Comparisons of mathematical applications (Joseph, 1994) of people throughout the world and across time, illustrate that a number of universal mathematical principles have existed. Bishop (1991) has stated that many of the everyday activities of people (past and present) involve a substantial amount of mathematical application. Six universal mathematical behaviors that are thought to be practiced by any culture are counting, measuring, designing, locating, explaining, and playing (Bishop, 1991). Within these behaviors exist mathematical principles reflective of the categories to which they belong. Mathematical connections to daily living practices of any culture can be identified using these behaviors. This theoretical framework, predicated on Bishop's six mathematical behaviors, was selected as the basis for identifying and describing practices of the Shoshoni as a way of illustrating the way mathematics was used. Since nearly all of the activities of a people involve mathematics, such analysis remains a critical component in fully comprehending a people and their culture.

Zaslavsky (1999) describes sociomathematics or the application of mathematics in the lives of the people. Mathematics reflects the codification of thoughts and ideas representing numerical concepts and principles. Mathematical principles embedded in the language of those speaking are therefore reflective of the culture in which it is used. Its symbolism, both verbal and physical, represents a language system peculiar to the culture in which it was derived. This idea is of critical value when considering the influence of language (culture) on education. Connecting mathematics and the particular cultures of the American Indian students can have beneficial effects on their ability to learn mathematics and the way that they value the acquisition of this knowledge (Cajete, 1994).

Methods of Study

The design is grounded in the discipline of cultural anthropology using ethnographic interviewing techniques, specifically those using structural questions (Spradley, 1979). Structural questioning was used to discover basic units of cultural knowledge in those being interviewed.

Research methods included: (a) standard ethnographic techniques, including face-to-face key informant and life history interviews; (b) structured formal and informal interviews; (c) inspection of archival documents and directed library/archival research, including official government records, scholarly descriptions in books and articles (historical [numeration systems] and anthropological), less formal written documents including tribal legends, and stories; and (d) an examination of collections of non-written artifacts, such as traditional tools and weapons, craft items, artwork, maps, photographs, and videotapes.

The study was conducted for one year as five Shoshoni tribal representatives who possessed the memory of traditional practices of their people on the Shoshoni - Bannock reservation near Pocatello, Idaho were interviewed. Two trained interviewers who were college students were themselves members of the Shoshoni tribe conducted the structured interviews. They were selected because of their tribal affiliation and the fact that they were perceived as insiders by those interviewed. They were seen as tribal relatives wanting to increase their own understanding of their people and culture.

Those interviewed were considered as “elders” in the tribe possessing substantial wisdom and traditional knowledge. Wisdom and knowledge were gained by having grown up in families where traditional ways were integrated whenever possible in contemporary life. The elders were selected after consultation with the student interviewers and upon further recommendation of other tribal members. The researchers asked members of this Native community to suggest people thought to hold substantial knowledge of Shoshoni traditional culture. The elders selected were those whose names repeatedly surfaced. It seemed a consensual agreement that these tribal elders were well respected in the tribe for their historical and cultural knowledge and that many lived their lives embracing traditional customs and practices. Additionally, the students also asked those being interviewed for recommendations about others who would know the information being sought.

The elders were asked to explain how the six aspects of mathematical behavior (counting, measuring, designing, locating, explaining, and playing) were a substantial part of Shoshoni traditional daily living (see Appendix A). Bishop (1991) has stated that many of the everyday activities of people (past and present) involve a substantial amount of mathematics. According to Bishop, these universals (counting, locating, designing, measuring, explaining, and playing) are inseparably intertwined with other aspects of the culture and provide the fundamental facets one can use to probe for mathematics embedded in cultural activities and study how mathematics was used in virtually any cultural context.

Audiotaped descriptions were collected and verbatim transcriptions made of interviews for later analysis. A Shoshoni Native speaker was consulted and provided translations of Shoshoni words named during the interviews. Efforts to include "trustworthiness" of the collected information included: triangulation of data-member checking (comparing data from each interviewee to substantiate comments they make in references to comments previously provided) and submission of excerpts of field notes and related interpretations to respective tribal representatives who assessed the credibility of the researcher's findings and conclusions. These representatives were suggested as being appropriate evaluators by the student interviewers and for the esteem they hold among many in the tribe. Information collected was checked and validated additionally by one of those who had been interviewed. Checks to evaluate and confirm accuracy of transcriptions made by a co-researcher were conducted by the first author.

Interview responses were categorized according to their best fit in the categories that comprise the formal structured interview questions (counting, measuring, locating, designing, explaining, and playing). Integrating observations from all other sources (i.e., archival data) further condensed these data. Analysis consisted of examining related clusters of mathematical/cultural descriptions from all data sources illustrating those mathematical behaviors specific to the Shoshoni culture. While much of the data acquired has been condensed to succinctly report informants' comments, in certain cases it will be quoted directly. These declarations have been selected because of their clarifying nature in illustrating the cultural mathematical practice being described. Where direct quotes have been used, the comments have been coded using the fictitious initials of the informants to ensure confidentiality. This had been agreed to at the outset of the research.

Informants ranged in age from 58 to 79 years old. Those interviewed were selected upon recommendation of tribal members for their community reputation for having knowledge of traditional practices of the tribe. Names of the interviewed have been changed. Details of the informants are as follows:

Mae Johns (MJ) – Female, Age 58

Betty Jumper (BJ) – Female, Age 60

Shirley Tiger (ST) – Female, Age 62

Alice Snow (AS) – Female, Age 59

Billy Tom (BT) – Male, Age 79

The research described is a summary of mathematical key concepts shared by the informants. Shoshoni mathematical applications are described and related classroom activities are suggested.

Shoshoni Mathematics

In the Shoshoni language, no word exists for the English word of “mathematics”. Mathematics appears instead to be an issue of correspondence: interpreted as what one did while going about daily living. The findings are reported in relation to the mathematical behavioral category that had been probed. The authors are well aware that the mathematical practices described will invariably incorporate some degree of western influence. This is to say that while a traditional and unadulterated Shoshoni mathematical perspective was sought, the perspectives shared undoubtedly reflect some degree of ongoing cultural inclusion.

Counting (dede zee'). The counting system of the Shoshoni illustrates a number of mathematical counting principles found in other counting systems throughout the world. This reflects the fact that a number of mathematical principles appear to be universal yet have been culturally modified by a people to support their needs and desires. The following activities involving counting illustrate a variety of applications in the daily lives of the people.

The Shoshoni counting system was based on groupings of ten that were used to quantify objects, people, and events encountered in daily living. Values ranging from one to countless (infinity) could be described. Gai hai wa'te (zero) "meant gone or nothing". Gai gazunga'nde meaning, "having no end" was the term used to describe infinity. The eastern Shoshoni band (Wyoming) described counts having no end as "more of those than there are hairs on a horse." Hand gestures to count from zero into the hundreds were used. Gestures could accompany verbal counting or could be used in isolation. The speaker would verbally indicate the value, such as tens or hundreds prior to gesturing.

Shoshoni counting incorporated the operations of addition, subtraction, and multiplication or combinations thereof. Names for numbers one through 20 and 30 through 100 are listed (Gould, 1998).

1	seme'	11	seemote seme' mando'aingende
2	wahatehwe	12	seemote wahatem mando'aingende
3	bahaitee'	13	seemote bahaitem mando'aingende

4	watsewite	14	seemote watsewitem mando'aingende
5	manegite	15	seemote manegitem mando'aingende
6	naafaite	16	seemote naafaitem mando'aingende
7	daatsewite	17	seemote daatsewitem mando'aingende
8	nawiwatsewite	18	seemote nawiwatsewitem mando'aingende
9	seemonowemihyande	19	wahaseemono wemihyande
10	seemote	20	wahaseemote
30	bahaiseemote	40	watsewiseemote
50	manegiseemote	60	nafaiseemote
70	daatsewiseemote	80	nawiwatsewiseemote
90	seemono wemihyaseemote	100	biaseemote

Eleven, twelve, etc. were literally translated as “one surfacing above ten,” “two surfacing above ten”, etc. 20, 30, were translated as “two counts of ten”, “three counts of ten”. The number 25 wahaseemote manegitemando’aingende for instance was translated as “two groups of ten and five more than”. For the number preceding ten or a value of ten, the word wemihyand*e* was added and is translated as “being not up to par”. While numbers were not written, the verbal naming process is mathematically rich. Contemporary coding of the number system would use a combination of numerical and operational symbols [i.e. 25 = (2 x 10) + 5]. The Shoshoni had several ways of indicating quantities that were uncountable. This equates with the contemporary notion of infinity.

> It means like never ending, just going on and on and on. They used this long ago to count way up. They used the horsehide, the fur. They said it is like how many hairs on a horse. (ST)

Mathematical Operations. Shoshoni counting incorporated the operations of addition, subtraction, and multiplication or combinations thereof.

> We would add, subtract, multiply, and divide. Them days we used to ration out flour and sugar. Like you, have four of your relatives or other people eating. First, you divide them all up. You took some from here (gesturing to an imaginary bowl) to give there. Sometimes someone would bring in a deer or an elk. The meat would be divided among the tribe. Like long time ago, they had families living together, like their daughter and their sons. They had little clans. People would go out and hunt for the clan. (BJ)

It was not always necessary to name a count when describing a group of objects. In these situations tukkumpai meaning “many/lots” or he’tes meaning “a few” adequately described the group. When subtracting from a group, the people would often use a phrase meaning “what was left”.

> Then we added by counting. A long time ago a person would go down and get a whole bunch of ducks and bring them back and add them, count them and then we would divide them out and take so many away from them like subtracting. When they get done its all even. (ST)

Division was used as in the activity of a hunter sharing a recently killed deer. In this case, the number of people or families getting meat determined the divisor. The division was solved intuitively. Equal parcels meant everyone got what they needed rather than everyone received the same amount. In this case, the divisor was determined by the problem posed and the operation seemed to be intuitive dealing with a relatively small number of divisions (see fractions below).

Counting–Hand. Hand gestures were also used to indicate numerical values. The gestures may have accompanied the verbal expression they symbolized or they could be used in isolation. Values could be signaled for values of ones, tens, and hundreds. The speaker would verbally indicate the value of the fingers if they were used to indicate tens or hundreds prior to the hand gesture.

> We can count with our fingers, it is the same thing as by counting. (On one hand, we have one through five) … then, we have on the other hand six through 10. Then we keep going to the tens. We use the single fingers the same way, just adding ten to them. Each time you do that, you use fingers to show the numbers you are counting. This lets the listener know you are going to count by tens. We used the word sumo, which is the number, plus sumo and what we actually do is say it's one times ten equals ten. Wahaseemot*e* would be two times ten equals 20. So we have a lot of mathematics going on inside our heads where you're calculating and you know two times this equals this…. Like when you get to 500, you use one hand to mean 500. We called it manegimbiaseemote. Bia means big – you are actually saying five big fingers equals 500. Others know you are talking about 500 and if you use two hands then you are saying 1000. (AS)

Numerical Symbolic Representations. Sometimes values were represented with actual pictures of the objects painted or drawn on buffalo hides. Lines drawn in pictograph fashion on rock faces were also used to represent values in a more symbolic representation with a less obvious connection to what exactly was being counted.

> There were no written symbols but sometimes marks were made on raw hide or on rocks. Sometimes the markings looked like Roman numerals. We didn't have symbols for numbers. We might have four bars and then across for the five. If you needed to count the number of days then that's how it works. They would have a line down and count each day so they show one week...how many days. A lot of times on the petroglyphs, they have the symbols, which tell how many days traveled, so they use them. (BT)

Fractions. The Shoshoni had several ways to describe parts of things. U sengwai'bi was the word to name one-half of something and it meant in the middle (often accompanied with a slicing motion of one hand). One – quarter meant half of a half. These common fractions were in use. There does not appear to have been ways to specifically name smaller divisions, i.e. one-eighth, etc.

For such fractions, those communicating were both aware of what was being described (animals, number of people in a village, etc.). At times, the fraction being described was named literally as an indicated ratio. If one spoke of one half of a horse herd of 100 horses, one would name 50. The Shoshoni did have an understanding of fractional parts of a whole and the indicated fraction was a function of the situation being discussed. For instance, a hunter bringing a deer into camp would often share the kill. As the deer was partitioned out, the fraction those sharing received was in relation to their number and need. In a sense, equivalency (based on need) was maintained because each got their share albeit the shares may have been of differing sizes.

Significant Numbers. Four and twelve were significant numbers and considered special to the people. The number four could indicate the cardinal directions or the number of times a prayer or a song was repeated. Twelve poles were used to construct the perimeter of the Sundance enclosure. Some said the twelve represented the twelve apostles.

> Everything is done in fours. There are four directions. Everything we do we do in four times. In our Sundance for instance, we often go for four days and fast without food or water. Most of the spiritual prayers are done in four rounds. Four songs in the morning, four rounds in the sweat lodge. We have four directions and four colors. (BJ)

Measuring (mana'kai). Mana' ki was to measure by laying of the hands. A number of standard units existed although there were variations in each. Parts of the body such as hands, length of an outstretched arm, paces, etc. were used and were specific to the person to which they belonged. With such individualized measures, what was constructed (a bow and arrows for instance) was proportionately appropriate for the user. If a shirt or a dress was to be made, the body of the person for whom the item was being constructed was used as a template. Other measurement devices included sticks and poles or strips of rawhide. These scales would often be kept and used repeatedly. For measuring circles (sweat lodges, teepee rings) the men would select what was to become the center of the circle and using a length of rawhide strip as the radius, they would mark the circle's circumference. Perimeter, area, volume were measured and described in very practical ways. Often a person would "step off" (dategi'p) a distance and count the steps that were taken. To outline a circle for the construction of a sweat lodge, one would use a peg placed in the ground that would become the center for the circle and then would use a length of rawhide strip as the radius.

> In those days, they put a peg in the middle where you're going to set your sweat lodge or tipi or ceremony tipi, you put a peg there and measure it around, like them days they had like rawhide. Nowadays you have a rope. (MJ)

The area of a space was determined if its space was adequate for the function for which it was used. A teepee ring, for instance, was a function of the length of the poles used to construct it and then number of hides used to make the covering. The area was appropriate for the people who used that space as their home.

Volume was measured in relation to the size of the container in which a liquid or material was placed. A buffalo horn was one of the items used as a cup. While horns may have varied in size depending on the age of the buffalo from which it came, the volume of water that could be carried in it was somewhat consistent. For cooking and food preparation, measurement played a part. Those doing the cooking used pinches, handfuls, and dashes of ingredients (such as crushed berries, salt, and other flavorings) as standard units. The size of the container also functioned as a measurement device. The experienced cook knew that a particular bowl or woven container when filled half full would produce a specified amount of food. If the cook was preparing food for a greater number of people the container could have more added to it with the cook again having a sense of how much more food would result and the size of group that could be fed.

Distances were described as a function of time and/or speed. It was said that anything more than a pace was considered a journey. A distance might have been described by the "number of suns or sleeps" occurring during the travel. For instance, a distance between two places was understood in relation to the time that it took one to make the journey and was influenced by the mode of travel such as on foot or horseback.

Weight was measured in relation to another object to which it was compared. What was heavy (petten) to one person may not have been to another. Sometimes a person would heft a rock in one hand and compare it against an object held in the other hand. People would describe temperature in similar ways as they used their own reference for whether it was hot or cold.

> My mom used to take a rock on her left side, and she measured it against what she was holding on her other side. I've seen them do it. You picked a rock and then you needed to find something else that same weight. (ST)

Time. Time was measured in several ways and the measurement devices most often were affiliated with events of nature. Because of constant observation, people were keenly aware of cycles of nature such as where the sun rose and set daily. This time unit in effect was reset each day and the people aligned their schedules and events in relation to this variation of day lengths throughout the year. The solar cycle, from sun up to sun down determined the length of one day or what was commonly referred to as "one sun." Increments of time throughout the day were specified in reference to the location of the sun in the sky on its seemingly daily path. The lengths and directions shadows faced (from a stick in the ground or a person standing upright) were also used as indicators of the "time" of day.

For measuring longer durations, the people named them in relation to the number of suns or moons one counted during the event. This was particularly important while traveling from place to place as it was used in conjunction with navigation. Trips lasting several months were described as taking "two moons". One's age was described (if at all) by the number of seasons one had lived. Age was described in reference to the number of winters that had transpired since one was born. Sometimes, an age was inferred rather than counted. Ages were also described in relation to an important event that may have occurred around the time of someone's birthday, such a big fire or storm that those living at the time could recall. Physical calendars marking time were of several varieties. Notches cut in a counting stick or knots tied in lengths of rope or rawhide helped one keep count of the passing of time.

Designing (oyo'de nai). The construction of a structure, tool, or beadwork design incorporated many geometrical and mathematical principles. A person who knew how to make an object implicitly used the mathematics necessary for construction in a most practical way.

There existed various designs for the homes of the Shoshoni. The most typical base shape for the traditional home was the circle. Mathematically, for a given perimeter of a home, a circular shape provided the greatest amount of interior floor area. Building materials were collected from nature (sticks and branches) and the use of circular-shaped constructions reduced the impact on the environment and the amount of work required to gather those resources.

> Some of the older types of homes were constructed of birch and aspen and were covered with just leaves and a few branches. We had different kinds of homes. We had what's called he'gi-ga'hni. He'gi-ga'hni is a shade house. This one you see at a Sundance, You know you have a teepee yuun ga' hni and then a shade house. The shade house is used for just relaxing. It's not for cooking or anything because, you know, the leaves are dry and can burn your he'gi-ga'hni . We had a wana kahni which was just like a makeshift tent with shrubs and then it had a cloth cover on the outside. So it has a small frame and cloth cover. And this teepee, we call it a yuun ga' hni. Yu means to be at peace. So when you come in here, we call it   yuun ga, hni, which is actually a place of peace. You find comfort there. It's very peaceful. (AS)

Shapes. The Shoshoni had names for several of the basic shapes. The names were descriptive in that a feature of the shape itself was used to help name the shape. The term doto' aga'nd means having corners. The number of corners they had named shapes such as squares, rectangles, or triangles. Therefore a square or rectangle was named watsewite doto' aga'nde meaning literally "four cornered". Bahaitei doto'agande or triangle is three-cornered. Hand gestures were sometimes used as the words were spoken to indicate that the sides were of a certain length.

Circle was puinu and the word meant "round." The circular shape was used frequently in the culture as incorporated in tepee rings, sweat lodge circles, and even dancing hoops. It is said to represent the circle of life; something with no beginning or end (gaigazunga'ndi.) The shapes were not named simply to identify shapes but rather referred to the physical appearance of something real.

> Seems that almost everything in our culture is round. Even with our hoops, the tepees and the sweat lodge tie in with the circle symbol. Circles are very important because they represent the circle of life. The circle has no lines. It has no beginning and no end. So, that's real important to us. Triangles were very important to us also. We find these in our parfleches (skin bags). The triangles represent the things like mountains--homes would be the teepees and things like that. They also represent individuals. You see on those parfleches, you know a lot of them have the stripes down here and they got the triangles that come out like this. So each one represents like a home or mountains or what ever might be in the area. Then the colors signify something different also. But you notice that when you have these parfleches and the beadwork, they're always symmetrical. (AS)

<u>Patterns</u>. Creating a tool, item of clothing, or some other functional object often involved the use of a pattern. Sometimes the patterns were physical such as an object that was used as a template or a new one being constructed. This is not meant to imply any sense of mass production but did incorporate the skillful planning and manufacture of an item. The construction of a structure, tool, or beadwork design incorporated geometrical and mathematical principles and concepts at a nearly subconscious level.

The applied mathematics functioned as both a guide to the construction of the object and as a nearly invisible byproduct.

Clothing was usually tailored for the person and their body became the template. In essence, each person carried with them their own standard units and their identity was reflected in the colors and designs they wore.

> Most of the designs that people came up with were ones they dreamt about. Like maybe, you have a dream of how your dress is going to be and how the pattern is going to be on there. You follow your dream on it. But, nowadays you don't do that. That person's got a real pretty dress, I think I'll make a dress like hers. They don't stick to their own traditional dress designs. (MR)

Both men and women did beadwork. There were certain ceremonial items that women were not to touch. Their construction and decoration were left to the men. Beadwork was a very mathematical endeavor. The stringing of the beads in the proper sequence involved counting, calculating, and patterning.

> When you're beading designs, in order for your designs to turn out, I always do one right down the middle first and then I balance it out. That's the way I do because otherwise you mess up. Mostly people start from the bottom on up and they already have their pattern cut out and stuff like that. Me, I can't do that. I have to start from the middle and go upwards or downwards first, so my pattern can set in good. Maybe by the time I get to the other end by starting at the bottom, I run out of space or else my design won't come out right. For loom beading, you need to start with an odd number of beads. (BJ)

Spiritual Significance of Shapes. Shapes were used as symbolic representations and often conveyed a spiritual significance. The diamond shape with its four points was at times used to represent the four directions. The circle was a reminder of the never-ending cyclical nature of life as in the circle of life.

Locating (da'ooda). The Shoshoni had maps that were usually held in the minds of those who had made the trip before. To survive, it was necessary to be very aware of one's environment and terrain along the yearly migratory hunting and foraging routes. Topological features were used as benchmarks as well as one's location in reference to where the sun rose and set at different times of the year. Star positions were also used in navigation.

> The stars were like a clock, it's turning right now. But in the night is when you see it. The way it's turning is like a clock every day. (MR)

Rivers were also followed. Pictographs and petroglyphs helped communicate where people had previously hunted and camped. Several physical maps were described and consisted of hides upon which drawings were made. Certain signs or symbols were used to represent certain geographic features and were peculiar to the tribe.

Shoshoni language allowed the speaker to describe their proximity to an object that could be modified to describe a variety of nearness or distance. The word tekamin for instance meant something near. Aishe would be something farther away. Left was described as to my left or nea o'haindembai'du. Dogwainde meant on your right side. Up was pa'a. Down--wastetennaa.

The Shoshoni used the rising and setting of the sun and knowledge of the typical direction of wind and weather patterns as orientation systems. The words and meanings of the terms for the four directions were: west- o-ve-dey-no-wyats, where the sun goes down; east- day-va-doy-ny-yoot, where the sun comes up; south- yu-was-so, where it is warm; north is e-zee-so-wyatt,s where it is cold.

Height or depth was described in reference to how many of something it would take to equal that measurement. If a person were a certain height and he or she was describing height or depth, they would say it is a certain number of that person. Vertical or horizontal orientations were described by phrases indicating “it was standing straight up or lying flat on the ground."

To describe the location of “above”, duhm-bak was used. This meant over you. Du-kaht meant below or under. Bon meant high and du-kaht was low. While the same word was used to convey two differing meanings, the context in which it was used allowed the appropriate meaning to be conveyed and understood. (Note: this was often the case for much of what could be described in Shoshoni; the language is very contextually specific.

Explaining (nademu'inge).Mathematics by its very nature is a form of communicating ideas and therefore is a form of explaining. Explaining helps build a consensual context for understanding not only the event that is being experienced but also allows for that isolated event to be viewed as one of the many such events necessary to comprise an understanding of the culture itself. Virtually any of the mathematics previously described could be considered a form of explanation. The distinction of the activities found here is that they provide examples of mathematical connections between different cultural phenomena and therefore explain the use or importance of the phenomena. The examples provide us a deeper look into Shoshoni culture and how important cultural aspects are displayed and interpreted. The behaviors involving mathematics described in this category are related to situations where the Shoshoni shared ideas of wealth and prominence, time, and history.

Prominence or wealth was displayed in several ways. Physical items such as clothing, tools, weapons, etc. that were crafted were highly valued because of the effort, time, and skill it took to obtain the materials and to produce them. The number of elk teeth or the kind of fur one wore were indications of prominence, as were the number of horses or teepees one possessed. Although wealth was described as related to material items, there existed other conceptions of wealth that were not material. Richness was a function of one's family, the number of relatives they had, and their status among the people. With a strong family one had the collective knowledge and support which were often more highly valued than anything material.

Wealth and Prominence.

> The number of horses you had and how many tepees showed wealth and prominence. The number of elk teeth you wore on your dress or the kind of fur also showed that. My mom used to tell me, too, that if a woman had a real pretty elk tooth dress or something that had a lot of that elk teeth on it, it showed that you were rich in that way. A large strong family showed wealth and prominence. That's basically it. It wasn't the number of horses you had. It wasn't who had more things than the other person did. It was family because families were this much. It was more important than actually money. If you have parents, if you have grandparents, you're much wealthier than someone who doesn't. Because you have the resources, the knowledge, right here with you now as opposed to someone that doesn't. So it's the family. It was measured by family. (AS)

Time and Calendrics. While the Shoshoni traditionally lived in villages or camps of related people, they often migrated throughout the region to harvest plants and animals that could be found in particular places at particular times. Distinctions were noted between seasonal changes but there does not appear to have been a tradition of naming those phases as specifically as is done today. These migrations were closely related to seasonal cycles and the Shoshoni knew them well. They accommodated their lives to align with them. The cyclical nature of the seasons, animal and fish migrations, and plant harvesting could function as a predictable calendar of yearly events. Additionally, observation of the various stellar alignments functioned as a perpetual clock that could be used to locate oneself temporally throughout the year.

The Shoshoni did name the seasons and had names for the twelve months. The fact that 12 months (moons) were named rather than 13 most likely reflects the eventual acceptance of the western calendric system. The names of the months described an event that was likely to occur during that time. The Shoshoni did recognize phases of the year and had names for their months. The name of the month referred to an event that usually occurred during that time.

January – goa-mea’a (the freezing moon)

February – isha-mea’a (the coyote moon)

March – ya’a-mea’a (the warming moon)

April – badua’a-mea’a (the melting moon)

May – bu’hissea-mea’a (the budding moon)

June – no name was remembered for this

July - daza-mea’a (the summer moon)

August – no name was remembered for this

September - yeba-mea’a (the fall moon)

October - naa-mea’a (the rutting moon)

November – ezhe’i-mea’a (the cold moon)

December – domo-mea’a (the winter moon)

Other ways to describe time included noting the length and direction of shadows during the day. The Shoshoni did have ways to describe the parts of a day (i.e. sun up, mid-day or noon, evening, etc.). The following terms were used: Morning – beaiche’ku; Noon – dogwai-dabai’yi; Evening – yeika; and Midnight – dogwai-duga’ni. They did not name time in terms of hours or minutes. For example, a person would eat when hungry rather than when time indicated they should eat. Often, an amount of food was prepared in advance from which people would eat throughout the day.

Other “records” kept by the Shoshoni were similar to pictorial calendars illustrating historical events and were a part of the oral tradition. Buffalo robes and other animal hides were used upon which pictures were drawn describing battles, the coming of the white settlers, etc. Such a robe is displayed at the Museum of Central Utah in Price, Utah and depicts Chief Wasakie’s (one of the most famous Shoshoni chiefs) vision of the future which included automobiles and airplanes prior to their actual existence. These robes represent a cultural record of events inclusive of temporal markers.

Playing (nu’hi).The Shoshoni played a variety of games. There were games for men, women, boys, and girls. Some tested physical abilities and others involved objects and chance. Mathematics was a common aspect of every game. In some games, the use of mathematics was apparent, such as in those games where scores were kept. In others, the mathematics were embedded in the activities. Measuring was used to build the sticks used to play the hockey-like game of Shinny. In the Hand Game, players considered probability when guessing.

> Well there were a lot of different games for the girls. Girls, just little girls, they just played with homemade dolls, the buckskin dolls, and played with the babies. Little boys, they just played with bows and arrows and pretended they were like the older boys. Teenagers played other games. They would actually make things--they were productive. When they became teenagers, they actually were assigned someone to mentor them so they could learn from them. So they actually learned these things you need to survive. Then there were games for all the Indian people. The women played different games than the men. There were games both could play. (AS)

Games played by men were typically more physical and demonstrated one's prowess at horse riding, running, shooting, etc. The women played a game called rock juggling. Women played for fun and didn't really compete. They would mark a space where they would walk from one spot to another. Whoever walked the farthest while juggling a certain number of rocks was considered the winner. Older women usually played the Shinny Game (ne'e to'aip) in numbers sufficient to field two teams. Teams each had a goal on each end with a goalie. In many ways, the game resembled today's hockey. Clubs much like hockey sticks are crafted from stout tree branches and had a flat area like a paddle at one end. The ball was comprised of two stuffed rawhide balls connected together with a rawhide thong. Players could not touch the ball with their hands and instead moved the ball with their stick. Players would try to keep the ball moving along the ground toward the other team's goal. Another variation of the game was played by up to 40 women. They play it much the same way, but they could touch the ball with their hands or lift it with their forked stick. They could pick up that ball and they could throw it to their goalie or another team member. A goal was scored when one team got the ball into the other's goalie counted as one point. A team won when they had the most points or when players grew tired of playing or whose team was the first to arrive at a predetermined score.

The Hand Game (naya'hui) was and still is a popular guessing game played by two teams comprised of any number of men and women who gathered on either side of two long sticks or poles laid parallel to each other. Each team began the game with ten or twelve short sticks and several bones measuring two to three inches in length. One of the bones would have a piece of rawhide strip wrapped around it. The object of the game was to guess the hand in which one of the players on the opposing team was hiding the white bone (with no strip). When the opposing team guessed correctly, the losing team passed them one of the sticks. The first team to lose all of their sticks lost the game. Betting preceded the game. Items such as hides, clothing, personal items, or even horses were wagered. Players sang and chanted songs as they beat on their poles with sticks.

The game of dopaidi was a stick game played on a piece of rawhide upon which marks were made along the edges. Four women usually played. The stick dice were made of split willow and the sticks were marked with specific colors or designs. A person would hold the sticks and roll them between their hands. The sticks were thrown upon a large stone in the center of the hide. The number of points one earned was determined by the orientation in which they fell. Players would move their game piece that number. The winner was the first to move his or her piece completely around the hide. The game was usually played by adults and only in daytime.

> There are game pieces; pieces of wood that were shaped into animals or whatever. You had a starting point and three or four sticks. They were willows and they were split in half. They were about one-half inch wide and were split in half. On the inside, you would take out the marrow and you would put a stripe down the middle with charcoal. On the round side, there was a spider shape (crossed cuts) on one and a diamond on the other. Each mark represented a certain number of points. You would hold the sticks and roll them between your hands. A large stone was placed in the center of your hide. Then you hit the sticks down on this rock and the pile of sticks split. The way they fell were the number of points earned. You took your game piece and you moved it how ever many points you made. Whoever made it all the way around would win. If you landed on somebody else's player, you would have to go back to the start. This was a really old traditional game and you would only play it during the daytime. It was never played at night. (MJ)

Summary

By now it is clear that nearly every aspect of Shoshoni life incorporated the use of mathematics. The mathematics that has been illustrated reflects its practical application by a people whose very existence relied on the effective use of mathematical concepts and principles.

It is now possible to begin to see how their indigenous mathematics was not only an integral part of daily life but is deeply reflective of their culture. The following activities provide an initial demonstration of the instructional mathematical opportunities present. It is our hope that these examples will stimulate and motivate teachers to create and develop additional culturally relevant mathematical curriculum. Shoshoni children may not know their people count if they are not taught this now obvious fact. It is the hope of the researchers that those who teach these American Indian children will, having read this research, seek ways to integrate traditional (Shoshoni/indigenous) mathematical knowledge in their instruction. This knowledge may not only may help a Shoshoni child to develop a deeper understanding of mathematics but also assist them in significantly expanding their comprehension and awareness of themselves and their people.

Classroom Implications and Activities

The activities are described using a short summary of the ethnomathematical information acquired through this research. The mathematical concepts presented are

first explained using examples that illustrate how they were aspects of traditional Shoshoni culture. Students can learn that the mathematical concepts and principles they are expected to learn today are very similar to those used by their people traditionally. While specific objectives are presented, the activities are designed to encourage students to begin asking their own questions and seeking their own solutions, relative to the mathematics being taught (and inclusive of the students' current and historical cultural identities). These activities, illustrating the long history of mathematical application and prowess among the Shoshoni have been created to supplement existing commercial
curricula already in use.

Counting (dede zee')

Objective - Students will analyze patterns of counting in the Shoshoni system and describe the values in a number sentence.

Summary -The Shoshoni have a counting system which is based on groupings of 10. Numerical values range from 0 to infinity. The Shoshoni numbering system is richly descriptive in that each number is comprised of combinations of other numbers involving the operations of addition, subtraction, and/or multiplication. Eleven, twelve, etc. were literally translated as “one surfacing above ten,” “two surfacing above ten”, etc. For the number preceding ten or a value of ten, the word wemihyande was added and is translated as “being not up to par”. 20, 30, were translated as “two counts of ten”, “three counts of ten”. The number 35 bahaiseemote manegitemando’aingende, for instance, was translated as “three groups of ten and five more than”. Contemporary coding of the numbering system would use a combination of numerical and operational symbols. These words are the counting names for the numbers 1 - 20 and 10 - 100.

1	seme'	11	seemote seme' mando'aingende
2	wahatehwe	12	seemote wahatem mando'aingende
3	bahaitee'	13	seemote bahaitem mando'aingende
4	watsewite	14	seemote watsewitem mando'aingende
5	manegite	15	seemote manegitem mando'aingende
6	naafaite	16	seemote naafaitem mando'aingende
7	daatsewite	17	seemote daatsewitem mando'aingende
8	nawiwatsewite	18	seemote nawiwatsewitem mando'aingende
9	seemonowemihyande	19	wahaseemono wemihyande
10	seemote	20	wahaseemote
30	bahaiseemote	40	watsewiseemote
50	manegiseemote	60	nafaiseemote
70	daatsewiseemote	80	nawiwatsewiseemote
90	seemono wemihyaseemote	100	biaseemote

Activity - Study the number names and describes any patterns that you see. Select a number and write it as a number sentence using the appropriate numeric and operational symbols [i.e. 35 or bahaiseemote manegitemando’aingende = (3 x 10) + 5].

Measuring (mana’kai)

Objective - Students will create a number of units of measure using parts of their body as their individual standards to measure objects around them.

Summary – Shoshoni measurement units were often derived by the person doing the constructing (clothing, bows/arrows, and sweat lodges) and were proportionately appropriate for their use. Parts of the body (i.e. length between the nose and one extended arm, the span of one open hand, or the length of a stride) functioned as units of measure. A stick or length of rawhide previously used to measure may be kept as a personal standard for repeated use.

Activity - Forage outdoors to select sticks or cut lengths of rope that are the same length as numerous body dimensions of your body. With several classmates select objects to measure and do so using your personal scales. Compare results and discuss the differences. What are several advantages and disadvantages of personal versus standard units of measure?

Locating (da'ooda)

Objective - Students will create maps of locations important to them using self-selected frames of reference.

Summary – The Shoshoni located places in their surroundings using a variety of techniques. Although written maps were apparently not created, occasionally maps were drawn or painted on hides. These served as historical maps yet are inclusive of mathematics (time/measurement, topography, and proportion). Many held mental maps in their minds and used familiar landmarks as points of reference. The Shoshoni were aware of the four cardinal directions and used the rising and setting of the sun and knowledge of the typical direction of wind and weather patterns as orientation systems. Directions used to locate a position were literally named. For instance, west or "o-ve-dey-no-wyats" meant where the sun goes down; south or "yu-was-so" meant where it is warm.

Activity - Interview your tribal elders to hear how routes (maps) for long trips were known. Think of a map for a journey that you want to make and draw it. What important features will you describe? How will the map be oriented and scaled? If you had to explain to someone where a particular point or place was on your map, how would you do it?

Designing (oyo'de nai)

Objective - The students will describe the use of mathematical concepts and principles apparent in beadwork patterns as they design their own beadwork patterns.

Summary **–** Beadwork was used to decorate a variety of clothing and items of daily use. The beadworker incorporated a great deal of creativity in deciding what colors or designs to use. Those choices were personal and usually there was a purpose for the selection known by the beadworker. The spiritually important number four (four-fold symmetry) is often reflected in the patterns, as the symmetrical harmony and balance of the beadwork. Nearly every elementary mathematical concept taught in schools can be demonstrated using beadwork.

Activity – Collect photos or actual items of beadwork. Work with a partner to describe how the following mathematical concepts are embedded and illustrated in the piece that you examine: addition, multiplication, time, percentage, ratio, geometry (shapes, symmetries, transformations), and money. Can you think of other mathematical concepts used?

Explaining (nademu'inge)

Objective - Students will create ways to describe the passage of time (minutes, hours, days, years) and compare these with Shoshoni techniques used to explain similar aspects.

Summary - The Shoshoni recognized a variety of cycles in nature and used these observations as references to mark increments of time. The event noted might be the movement of the sun from dawn until dusk, the stages of the moon, animal migrations, or the growth and ripening of certain edible plants or berries, to name a few. To the Shoshoni, the natural world provided an effective clock and calendar. Knowing "time" was important because of its connection to the occurrence of an important event (when a particular food item would become naturally available or probable).

Activity - Students are presented information on traditional ways that the Shoshoni kept track of time. Students are then asked to consider how they could describe the passage of time (minutes, hours, days, years) if there did not exist clocks and watches in use today. Students are given time to cooperatively create and describe contemporary events that could be used to mark time. Students are asked to describe the similarities and differences between the traditional methods of the Shoshoni and the new methods they have.

Playing (nu'hi)

Objective - Students will explore probability in playing a traditional guessing game (Hand Game). Later they will invent their own guessing game and determine the probability of successfully selecting playing objects.

Summary - Playing games was an important aspect of the Shoshoni culture. The "HandGame" (naya'hui) was a guessing game played between teams. Each team began the game with ten or twelve short sticks and several bones (one specially marked) measuring two to three inches in length. The object of the game was to guess the hand in which one of the players on the opposing team was hiding the unmarked bone. Feints were used as distractions. When the opposing team guessed correctly, the losing team passed them one of the sticks. The first team to lose all of their sticks lost the game. Since the game involved two pieces, the probability of guessing correctly is 50%. Students should invent new guessing "hand" games involving differing numbers of objects and/or combinations of colors. The probability of correctly guessing a predetermined object should be calculated. Students can graph the “guesses” to see if the data supports their calculations.

Authors’ Note

I would like to thank collectively numerous unnamed members of the Shoshone-Bannnock tribe for what they have shared with me. It is hoped this information and related activities benefit the continuing efforts of the Shoshoni to help educate their children in the ways of the people.

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Appendix A

Date:________________________ Interviewer's Initials___________

Name of person being interviewed____

Interviewee's tribal connection____Age______

Approximate length of interview____________________

Formal Structured Interview Questions

Counting

Names of counting numbers?
Written symbols?
How did you describe "0"?
How did you describe "infinity"?
Were numbers represented using body parts or gestures?
What was the grouping system(s) counting by 5s or 10s? Were certain things counted in groups?
How were large numbers described?
Did certain numbers have spiritual significance?
How did you add, subtract, multiply, divide?
How were fractions used?
Other?

Measurement

Did you have a standard unit?

Were body parts used?
Were specific tools used as measurement devices?
How were small things measured/described?
How were large things measured/described?
How were great distances measured/described?
How was rate/speed measured/described?
How was weight measured/described?
How was time (hours, minutes, etc.?) measured/described?
Was some sort of calendar used?
How were the parts (seasons) of the year measured/described?
How was age measured/described?
How was temperature measured/described?
How were perimeter, area, volume measured/described?
Was a currency used? How?
Other?

Locating
Were "maps" used?
How were things described spatially?
Left/right?
Up/down?
Above/below?
Depth/height?
Horizontal/vertical?
Cardinal directions?
Navigation?
Was sorting/classifying (of objects) used in any way?
Other?

Designing
What shapes were used for various purposes?
Names?
Spiritual significance?
Angles (square angle)?
What patterns were important and how were they constructed (tessellations)?
Designs for clothing, pottery, etc.?
Other?

Explaining
Were values recorded in any way?
How was wealth/prominence shown?
Was any historical data concerning numbers kept (census, food supplies for the people, etc.)?
Other?

Playing

What games were played and how? Artifacts?
Was gambling or betting done? If so, how?
Other?
Comments/Insights of Interviewer: