A Cultural and Environmental Spin to Mathematics Education: Research Implementation Experience in a Canadian Aboriginal Community

Anthony N. Ezeife
University of Windsor

Contemporary research in the field of science education has dwelt extensively on the persistent problem of low enrolment in science courses among students of indigenous cultural backgrounds at the secondary school level. This flight from science and science-related courses is prevalent even in industrialized and technologically advanced societies worldwide. In Canada, for example, low enrolment and high dropout rates from mathematics and science courses are common among aboriginal students. The few who persist and complete their mathematics courses in high school often end up with low grades, a situation that has resulted in the paucity of qualified aboriginal students in mathematics-related careers at higher levels of education. Why is the situation as it is? What can be done to change the status quo? Several researchers have opined that the situation arises due to the lack of relevance of school mathematics and science to the aboriginal learner's everyday life and culture. These researchers have, therefore, suggested that there is need to incorporate into the mathematics curriculum such cultural practices, ideas, and beliefs (the students' schema) that would connect the school to the community in which it exists and functions. This study implemented an innovative (culture-sensitive) mathematics curriculum, developed with the active participation of community Elders, in the Walpole Island First Nation elementary school in Ontario, Canada. Results showed that students who were taught with the culture-sensitive curriculum performed significantly better than their counterparts taught with the existing (regular) provincial curriculum.

INTRODUCTION

The issue of lack of interest, and consequent low enrolment in school mathematics and science courses has been recognized in the educational setting for a long time (Alonge, 1982; Bates, 1977; Davison, 1992; Ezeife, 1989; Matthews, 1989). This issue is, unfortunately, still inadequately addressed especially as it affects students in the developing world, and learners of ethnic minority and Indigenous cultural backgrounds in Western societies (Assem-

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bly of Manitoba Chiefs, 1999; Ezeife, 2006; Mel, 2001; Smith & Ezeife, 2000). Related to the issue of low enrolment in mathematics and science by Indigenous and ethnic minority students is the problem of poor performance in examinations by the relatively few students from these cultural backgrounds who venture into these areas of study (Binda, 2001; Johnson, 1999; Katz & McCluskey, 2003). The low enrolment and poor performance, in turn, culminate in the under-representation of this category of students in mathematics, science, and related disciplines. Citing Lawrenz and McCreath (1988), Schilk, Arewa, Thomson, and White (1995) lucidly described the situation, stating: "Native Americans have the lowest representation percentage of all minorities in scientific careers and are at risk in pursuing science in high school and post-secondary education" (p. 1). Davison (1992) particularly highlighted the status quo in mathematics, saying: "What cannot be questioned is that the mathematics achievement of American Indian students as a group is below that of white students in the United States" (p. 241). The plight of Canadian Aboriginal students closely resembles that of Native American students with regard to low enrolment, substandard achievement, high dropout rates, and hence, under-representation in science, mathematics, and technological fields, as observed by several researchers (Binda, 2001; Ezeife, 2006; Ignas, 2004; MacIvor, 1995). For instance, commenting on the situation in the province of British Columbia, Canada, Ignas (2004), stated: "Research continues to document the persistent nature of under-representation of Indigenous students in science and professional programs leading to certification" (p. 51).

Historically, research findings attest to the fact that long before contact with Western civilizations, Aboriginal people were not just active practitioners in the realm of mathematics, science, and astronomy, but also actually excelled in these fields – recording time-tested accomplishments in these challenging areas of endeavour. For example, Smith (1994) has drawn attention to the feat attained in ancient times by the Skidi Pawnee, an Aboriginal group, who by studiously and enthusiastically observing the outer space and constellations, were able to identify the planet Venus. Also, by patiently and correctly tracking the movements of the stars and planets, the same group "conceptualized the summer solstice" and "…in this way they could predict reoccurring summer solstice" (Smith, 1994, p. 46). Similarly, writing from the privileged stance of a native Pueblo, the anthropologist, Oritz (1969) documented the informative, age-old interactions of space, time, and being of the

Pueblo people, an Indigenous North American civilization. Additionally, many authors and researchers (Cajete, 1994; D'Ambrosio, 1985; Ezeife, 2006; Hatfield, Edwards, Bitter, & Marrow, 2004) have recorded several remarkable mathematical and scientific achievements and practices of various Indigenous cultures across the globe, dating back to several centuries of history. With the foregoing as the background, one then wonders why contemporary Indigenous students, for example, Canadian Aboriginal students, shy away from mathematics and science – the very disciplines in which their progenitors excelled.

THEORETICAL FRAMEWORK: WHY THE FLIGHT FROM MATHEMATICS?

Many contemporary educational researchers (Ezeife, 2002; Hauffman, 2001; Ignas, 2004; Matang, 2001; Pewewardy, 2002; Piquemal & Nickles, 2005; Smith & Ezeife, 2000; Snively & Corsiglia, 2001) agree that there is a discontinuity between the home or community culture of Indigenous students and the education they receive in mainstream schools in North America and other parts of the world. For instance, in drawing attention to this discontinuity, Piquemal and Nickels (2005) cited Hauffman's (2001) cultural discontinuity hypothesis which "suggests that differing cultural elements between in-school and out-of-school experiences…have a significant effect on young Aboriginal students' school experiences" (p. 119). Aboriginal students are often faced with hazardous cultural border crossing situations (Jegede & Aikenhead, 1999) as they make the transition from their life-world culture into the mainstream school culture, especially in the fields of mathematics and science. Essentially, this situation arises because the mathematics and science taught in school is bereft of Aboriginal cultural, traditional, and environmental content (Ezeife, 2006; Smith, 1994). Thus, from the perspective of Aboriginal students, the curricula used to teach them, especially in the disciplines of mathematics and science, are not meaningful and relevant since, as Ignas (2004) emphasized: "…meaningful curriculum must necessarily be rooted in local knowledge and history and this is especially so in the case of Indigenous students whose typical experience of mainstream education is one that has distanced and denied First Nations knowledge" (p. 49). Realizing that their life-world culture is not reflected in the curriculum, a spontaneous feeling of foreignness and alienation sprouts, and with passing years, takes a firm root in the students, with regard to the school subjects in question. This feeling of foreignness toward mathematics and science by Indigenous/Aboriginal students leads to a distaste for these fields of study, poor performance in them, with the consequent and foreseeable, if familiar result – under-representation of this group of students in scientific and technological fields. The term "Indigenous" is defined by De Wolf et al (1998) as "native to a particular country, region, etc., not brought from elsewhere" (p. 780). Thus, "Indigenous populations", as used in this study, refers to those people who were the original natives of a given country or geographical region before contact, and often permanent modern-day societal interaction with people from other cultures and backgrounds; a situation that arose essentially through colonization and large-scale historical movements of populations across erstwhile geographical borders and regions. Some examples of Indigenous populations across the globe include the Aboriginal people of Australia, the Maori of New Zealand, the American Native Indians, Brazil's Indian populations, Canadian Aboriginal people, Mapuche Indians of Chile, the Masai of Kenya in East Africa, and the Igbos, Yorubas, Hausa/Fulani of Nigeria on the West Coast of Africa, etc.

This paper builds on the theoretical framework that a mathematics curriculum fashioned to include Aboriginal learners' life-world culture that is centred on the environment in which they live, their flora and fauna, their schema, traditional knowledge and values, and their communal experiences and aspirations – would strike a firm cord of harmony with the learners, and help them develop a more receptive attitude toward the study of mathematics. This stance is supported by Shockey and Gustafson (2007) who, in their study of Indigenous students' passive resistance to mathematics learning, hypothesized that "a contributor to caring less about mathematics has to do with the fact that new knowledge is not built on the existing knowledge of these Indigenous youth" (p. 96). The schema-based mathematics study reported in this paper involved the development and implementation of a theory-backed culture-sensitive mathematics curriculum in an Aboriginal community school. The term 'schema', as used in this context, refers to the global or generalized views of past experiences, or an individual's mental maps, that have saliency or prominence for the individual (Anderson, 1972). Thus, the schema-based curriculum utilized in this study dwelt on the lived experiences of young mathematics learners in Grades 5 and 6 in an Aboriginal school mathematics education of these young students.

This curriculum made it possible for the learners to explore their flora and fauna, traditional housing practices, methods of transportation, traditional methods of counting and recording, their local community games and recreational practices, eating and drinking habits, folklore and natural phenomena like thunder, lightning, and rainbow, their traditional methods of time keeping and calendar, measurement practices in their culture, and their environment in its entirety – in the context of their mathematics education. In using this curriculum, the learners were exposed to a learning situation where it was possible for them to connect academic mathematics knowledge with their own lived, real world experiences. This curriculum was aimed at making the young learners aware of the fact that mathematics and science can be found in the environment, not just in books. As Ignas (2004) pointed out: "science is not only found in textbooks – materials that do not usually include the world view, experiences, and knowledge and wisdom of Indigenous people – but it is also found in the world within which Indigenous students live" (p. 58). Ignas (2004) developed a science curriculum that was hinged on the meaningful linkage of "local traditional ecological knowledge" and "local understanding of knowledge construction" to the science education of Indigenous science learners in the Tsimshian community of British Columbia (p. 49). In addition to Ignas' (2004) project, some researchers have recently undertaken studies that involved the development of Indigenous-oriented curriculum materials. Some of these works include Kanu's (2002) *Cultural Mediators* study, Greenwood's and de Leeuw's (2007) *Teachings from the Land* project, Shizha's (2007) *Incorporating Indigenous Knowledge in Science Teaching* study, and Gaskell's (2003) work which dwelt on *Engaging Science Education within Diverse Cultures*. The common running theme amongst these studies is the call to approach the teaching of mathematics and science through the use of enabling environmentally and culturally based curricula that would appeal to the specific needs of Indigenous learners. The present schema-based mathematics project, not only hearkened to this call – the development of a culture-sensitive mathematics curriculum, but actually pursed the next logical step – the implementation and evaluation of the developed curriculum in the Anishnabe-speaking First Nations' community of Walpole Island, Ontario.

METHOD

The study dwelt on the development and implementation of a culture-sensitive mathematics curriculum in Grades 5 and 6 classes of the community school in Walpole Island, a First Nations' community in Ontario, Canada. The project was executed in three inter-related phases:

Phase 1: Tapping and Compiling Indigenous Mathematics Knowledge

In this phase of the study, the archival holdings of the Walpole Island Heritage Centre (Nin Da Waab Jig) – a research centre that has functioned in the Island since 1973 (Jacobs, 1992) – were extensively examined, and valuable resource materials on the past and current mathematics-related traditional practices in the Anishnabe-speaking First Nations community were obtained. This was followed up with several field visits to sites of mathematical interest in the Island such as the *High Banks* park, traditional log houses, communal recreational facilities, the picturesque confluence of the bodies of water that border the Island, the *Tall Grass* zone, and some communal farms. Furthermore, several community Elders (Knowledge Keepers), and other knowledgeable Indigenous educators were interviewed in a loosely guided, and largely free-flowing interview format. During the interviews they were prompted with leading questions to narrate, and explicate traditional practices, phenomena, folklore, and stories in their culture and environment that have relevance to mathematics. As detailed in Appendix 1, ten broad themes of interest or topics were the focus of the interview, though the Elders/educators were encouraged to bring up and discuss topics that might be of interest to them, but which were not covered or listed in the ten broad areas of focus. Tapping into the wealth of Indigenous Knowledge possessed by community Elders was a key goal of the study because this researcher shares the position of Ignas (2004) that a relevant curriculum should be largely hinged on local knowledge and history.

Phase 2: Interview Analysis and Integration

After transcribing the audio-taped interview records, the transcripts were sent back to the interviewees for cross-checking, confirmation, and possible modifications. When they received the transcripts, some of the interviewees surprisingly added new material to their original submissions. This was indicative of their enthusiastic involvement in the study. It also brought to the open the fact that they had done their own research in the intervening period between the interview and the returning of the transcripts, to find out more information on the interplay of their culture, traditional life, environment, and mathematics – from an Anishnabe community perspective.

A group comprising mostly of Indigenous graduate students in the researcher's team were then charged with gleaning and itemizing the mathematics content from the interview transcripts, and categorizing the content into relevant strands of the Ontario mathematics curriculum, Grades 1 to 8. In correspondence with the curriculum, the content fell into one or more of the following strands – Number Sense and Numeration, Patterning and Algebra, Geometry and Spatial Sense, Data Management and Probability, and Measurement. The researcher then edited the categorized mathematics content prepared by the graduate students and finally integrated these materials from the interviews, and those earlier gleaned from the archival holdings of the Heritage Research Centre, into the existing Ontario mathematics curriculum. This gave rise to an innovative (culture-sensitive) curriculum, styled the integrated curriculum. Sample categorizations from the interviews and archival holdings, adapted from Ezeife (2006) are shown in Appendix 2.

Phase 3: Classroom Implementation of the Integrated Curriculum

The instructional phase of the study was carried out in Grades 5 and 6 over a two-year period for the same set of students. Thus, at the beginning of the study, when the students were in Grade 5, a convenience sample of 28 participants was struck from the existing Grade 5 classes in Walpole Island community school. The sample was then divided into two groups with 14 students in each group. Randomization procedures were then used to assign each of the two groups to a treatment condition. Students in the "regular curriculum" instruction group constituted the control group (Group A), and were taught with the regular (existing) Grade 5 Ontario mathematics curriculum which does not contain culture-prone materials. On the other hand, the students in the experimental group (Group B) were instructed with the integrated (culture-sensitive) curriculum.

A highly dedicated teacher of Aboriginal origin, who was recruited from a pool of certified teachers, served as instructor for both groups, thus controlling for teacher variability factor. Before the commencement of instruction, the two research groups were given the same pretest to ascertain their *Entry Behaviour* and readiness for the study. Additionally, the researcher mounted an intensive two-week training workshop for the instructor at which appropriate classroom mannerisms to ensure the coverage of the same course (subject-matter) content for each group, the need for a deep commitment to the study, and the importance of the study to the overall development and enhancement of mathematics education were extensively discussed. However, to control for instructor bias, the instructor was not informed about the intended comparison of the existing (regular) and integrated (culture-sensitive) curriculums.

Furthermore, to minimize, if not completely eliminate, a possible Hawthorne effect (Gay & Airasian, 2003), and to control for test anxiety, the participants were re-assured, as per their informed consent to participate, that their academic performance in the study would not affect their school grades in any manner. In other words, that their scores in the quizzes and tests given in the study would not be transferred to their school records. However, both instructional groups were advised of the ultimate goal of the study – the overall improvement of their mathematics education, and the need for them to participate actively in all the learning experiences during class sessions. Again, to make the study fit closely with the regular school routine, and to maintain students' focus throughout the study, continuous assessment exercises and end-of-unit quizzes were factored into the instructional format. Also, the teaching times and testing conditions were made uniform for the two groups. The researcher effectively monitored instructor compliance and course material coverage all through the four weeks of instruction, thereby ensuring that the intended curriculum materials were adequately implemented. The instruction in Grade 5 covered two strands – Number Sense and Numeration, and Geometry and Spatial Sense of the Ontario Grades 1-8 curriculum (2005).

In line with the thrust and focus of the study, most of the lessons on Geometry and Spatial Sense for the experimental (culture-sensitive curriculum) group were taught in a traditional log house kindly provided by a community Elder. Doing the lessons in a real life geometrical setting enabled the students to see firsthand the relationships among the various angles, plans, and elevations that were webbed together to constitute the completed log house. They were able to measure and record the dimensions of various constituent units of the house both in the interior and exterior parts of the structure. The students' enthusiasm even extended to guided forays into the attic of the house where they made measurements of whatever component units that attracted them, and out of their own volition, matched these units with some geometrical shapes they had studied, for instance, polygons, cylindrical shapes, pyramids, and so on. Finally, they drew and labeled a sketch of the log house, noting on it any distinct geometrical observation that particularly stood out for them.

When the students moved on to Grade 6, the two groups, which remained intact, were again instructed by another teacher of Aboriginal origin, who also underwent a similar workshop training mounted by the researcher before the commencement of instruction. To ensure an adequate measure of continuity and retention, the Grade 6 instruction commenced early in the school year, covering some parts of Number Sense and Numeration that were carried over from Grade 5, and the remaining three Ontario mathematics strands – Algebra and Patterning, Measurement, and Data Management and Probability. The Grade 6 instruction lasted six continuous weeks. As was the case in Grade 5, most of the lessons in the three strands were done in outdoor natural settings for the experimental (culture-sensitive curriculum) group. For instance, many of the Data Management and Probability lessons were taught in the *High Banks* park in the Island where the students carried out learn-as-you-do experiments using the circumferences of the trees (which they measured) to set up ratio relationships. From the measurements, they were able to accurately predict the ages of some of the trees, aided by data on the trees supplied by the park keepers. Also, they successfully collected and analyzed data on the diameters of the trees in the park, the distances (spacing) between nearby trees, and the optimal abundance of trees in a typical park. Armed with such data, the students were able to complete the unit project that required them to create on paper a "dream park" of their own, that they could translate into a real community park as they grow up. At the end of the six weeks of instruction both groups were given the same posttest.

SAMPLE LESSON PLANS

For the participants in the regular curriculum group (the control group), the learning experiences and follow-up application exercises used throughout this study were drawn from, and modeled largely on, the contents of the Ontario mathematics curriculum for each Grade level. On the other hand, the learning experiences for the integrated curriculum group (the experimental group) had an environmental, culture-related focus. The sample lesson plans for the two groups based on the unit on Set Theory show the contrasts in the approaches and resources used for the two instructional groups, even though the subject-matter and the level of coverage were the same. These sample lessons are outlined below.

Lesson Plan Group A: The Regular (Existing) Curriculum Group –Control Group

Date: March 15, 2007

Duration: 60 minutes

Class: Grade 6

Subject: Mathematics

Topic: Set Theory

Instructional objectives: at the end of the lesson, students should be able to:

1. Define the term "set" and give examples of sets.
2. Distinguish between properly and improperly defined sets, giving examples of each category.
3. Represent/denote sets in symbolic form.
4. Use Venn diagrams to represent sets.
5. Explain the meaning of these terms used in set theory – Empty set, the Universal set, Complement of a set, and Subset of a set.
6. Relate the terms explained in Objective 5 to their day-to-day life using suitable examples, and work numerical exercises involving some of the terms, for example, Subsets and Complements of sets.

Materials and Teaching Aids/Resources

1. Source Books

Early Math Strategy: The Report of the Expert Panel on Early Math in Ontario- Ministry of Education (http://www.edu.gov.on.ca)

Hatfield, M.M., Edwards, N.T., Bitter, G.G., & Marrow, J. (2007). *Mathematics Methods for Elementary and Middle School Teachers, 4th edition.* New York: John Wiley & Sons Inc.

Helping Children Learn Mathematics. New York: John Wiley & Sons Inc.

Reys, R.E., Lindquist, M.M, Lambdin, D.L. Smith, N.L., & Suydam, M.N. (2007).

The Ontario Curriculum, Grades 1 -8*: Mathematics* (2005). Toronto: Ministry of Education and Training.

Van De Walle, J.A., & Folk, S. (2010). *Elementary and Middle School Mathematics: Teaching developmentally, 2nd Canadian edition*. Toronto: Pearson Canada.

2. Teaching Aids/Resources

- Classroom computers with draw software (Paint, Word Perfect Corel draw, Microsoft Word Processor).
- Teacher-made charts illustrating Universal sets, Complements of sets, and Subsets.
- Overhead transparencies showing set representation and set notation.
- Drawing boards and papers, pencils, colouring pencils, rulers, and tapes.
- Samples of sets of objects/things in the students' school – trophies won by the school, sports equipment in the school gymnasium, books in the library, different sets of school furniture, etc.

Lesson Presentation (For Group A)

Objective 1

Formally define a set as a collection of things, objects, animals, humans, and so on.
Elements of a set: The items that make up a set are called elements or members of the set.
Examples of sets: The set of all months of the year, the set of vowels in the English alphabet, the set of all female teachers in the school.
Here, prompt the students to give their own examples.

Objective 2: Properly and improperly defined sets.

Define a set as follows: The set of all young students in Walpole Island Elementary School. Ask the class to name such students (This will be difficult. The expectation is that the students will not agree on who and who to put in the list of "young" students, since the word "young" is vague

– it is not specific/quantified). From this, generate a class discussion, and ask the students: What specific age is regarded as "young"? For the set to qualify as a properly defined set, we can say, for example: The set of all students less than six years old, or the set of all students in Kindergarten. Ask students to give more examples of improperly defined sets.

Objective 3: Symbolic representation of sets.

a) Listing in braces/brackets

We use opening and closing braces to enclose the members (or elements) of a set. For example, we can write the set of vowels in the English alphabet as follows: {a, e, i, o, u}. Note that:

i) commas separate the elements of the set

ii) the use of braces (brackets) to show a set is called **set notation**.

b) Member of a set

"Member of" is denoted by $\in$ and read "is a member of", while $\notin$ means "is not a member of". For example, if we define the set V as follows: V = set of vowels in the English alphabet or V = {a, e, i, o, u}, then we can write $u \in V$ (u is a member of V), and we can also write $b \notin V$ (b is not a member of V).

Objective 4: Pictorial representation of sets using Venn diagrams

Venn diagrams are used to represent/show sets in picture form. The title "Venn" is used in honour of the famous English mathematician, John Venn (1834-1923), who did a lot of work related to Set Theory.

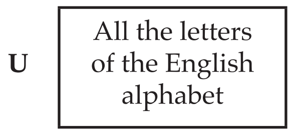
Colouring and shading or cross-hatching are often used to represent and distinguish the various sets in a Venn diagram (Teacher to show examples - by drawing).

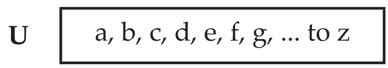
THE UNIVERSAL SET

The term 'Universal set' is used to explain and represent a general set that includes all the things that belong to a set. Thus, a universal set consists of a general collection or group of things with subdivisions/subgroups inside it.

Representation of Universal Set

The Universal set, denoted by U, is represented by a rectangle. Hence, all elements within the rectangle belong to (are members of) U. For example, if a Universal set is defined as the set made up of all the letters of the English alphabet, then we use a Venn diagram to show U, as follows:





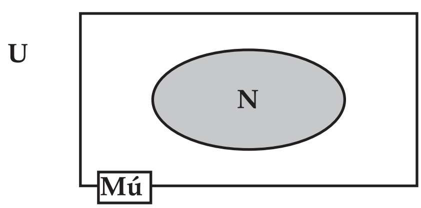
Objective 5: Terms commonly used in Set Theory

a) Empty set

The set that has no elements is called the empty or null set. It is denoted with { }. That is, it is denoted using braces with nothing written inside the braces, or by using the symbol, q. An example of an empty set is a set of students in your class (Grade 6) who are 40 years of age or older.

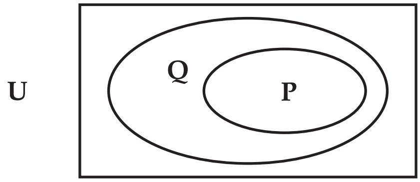
b) Complement of a set

If N is a set, then the complement of the set N (written ú) is the set of all elements in the universal set, U, which are not elements of the set N. The diagram below shows a Universal set, U, containing the set N, and its Complement, ú.



c) Subset of a set

The set P is a **subset** of another set Q (written $P \subseteq Q$) if, and only if, every element of P is also an element of Q. This means that if P is a subset of Q, then every element of set P also belongs to set Q. This means that the set P is contained completely in the set Q. In other words, the set Q contains the set P, so Q is a bigger set than P. We can show this in a Venn diagram, thus:



Objective 6: Summative Evaluation

1. a) Think of examples of the Empty set, Complement of a set, Subset of a set in your everyday life and environment.
   Write down these examples and discuss them with a partner.
   Using your drawing and colouring paper/pencil make a sketch of each type of set you thought of in 1(a).

2. a) Numerical and application exercises
   The two sets D and E are defined as follows:
   D = {1, 3, 5, 7, …}, and E = {2, 4, 6, 8, …}

Based on these sets, answer the following questions:

What type of natural (counting) numbers make up the set D?

What type of natural (counting) numbers make up the set E?

Do the sets D and E have any elements (members) in common, that is, are there any elements that belong to both D and E?

2. b) Let the Universal set be defined as the Cree Nation, which is made up of three different groups, namely, the Woods Cree, the Swampy Cree, and the Plains Cree. Applying your knowledge of set theory to this definition, find the following sets:
   i) The complement of the Plains Cree group.

ii) The complement of the Woods Cree group.
iii) Draw Venn diagrams to show the sets described in 2b (i), and 2b (ii).

3. Consolidation exercises and follow-up assignments.
   a) Use your classroom or home computer to draw sets you define such that these sets have complements and subsets. Using colouring or cross-hatching, show the complement and subset of each set. Print your drawings and bring the print outs to class next week.
   b) As you go home from school, and walk around your community throughout this week, make a list of all objects/things you think can be classified as properly defined sets. Bring your list to class next week for presentation and class discussion.

Note: You should be prepared to explain, and give reasons to convince your classmates that the sets you have listed are all properly defined.

LESSON PLAN FOR GROUP B: THE INTEGRATED (CULTURE-SENSITIVE/ABORIGINAL) CURRICULUM GROUP – EXPERIMENTAL GROUP.

Explanatory note: This lesson for Group B was taught on the same date and for the same teaching duration as stated in the lesson plan for Group A (the Control group). The instructional objectives and source books, were the same for both groups, and are, therefore, not repeated in the lesson plan for Group B. The teaching aids/resources were the same as those listed for Group A, except for the teaching aid/ resource in bullet # 5. In this bullet, samples of sets of things/objects were drawn solely from the students' school for Group A, while samples were drawn from the students' entire community and environment for Group B. To show this contrast, bullet #5 is included at the beginning of the group's lesson plan, thus:

Bullet #5 for Group B: Samples of sets of objects/things gathered from the students' environment. These include sea shells of different sizes, pebbles, stems and leaves of the local "tall grass", labeled drawings of distinct local birds and animals, for example, the peacock, the crow, squirrels, the beaver, several breeds of dogs, log cabins of different sizes, and the students themselves.

Lesson Presentation (For Group B)

Objective 1

Formally define a set as a collection of things, objects, animals, humans, etc.

Elements of a set: The items that make up a set are called the elements or members of the set.

Examples of sets: The set of all parks in Walpole Island community, the set of all male community members, the set of all dogs in the Island. Now, prompt the students to give their own examples.

Objective 2: Properly and improperly defined sets.

Adopting the discussion method, ask the students if they can name all the tall people who work in the *High Banks Park* (Park Keepers) in Walpole Island. It is expected that the students will give names of some people, but they are not likely to agree on all the names listed, since the adjective "tall" is vague. Next, ask the students to say if there is a problem if we define a set as "the set of all tall Park Keepers in Walpole Island". Let them advance a reason for whatever answer they give. From this, generate a class discussion, and ask the students to state what specific height they would regard as "tall". Using this interactive inquiry technique ask the students to give a proper definition of a set involving the Park Keepers, the word tall, and the height they would regard as "tall". Draw their attention to the difference between a properly defined set and an improperly defined one.

Ask students to give more examples of improperly defined sets focusing on objects and things, or people in their environment - the Walpole Island community.

Objective 3: Symbolic representation of sets

a) Listing in brackets/braces

We use opening and closing brackets or braces to enclose the elements (members) of a set. For example, we can write the elements in the set of all Anishnabe-speaking groups of people in Walpole Island community as follows: {**o**, $\underline{\mathbf{o}}$, **p**} where,

o = Odawa people, $\underline{\mathbf{o}}$ = Ojibwa people, and **p** = Pottawatomi people.

Note: that commas separate the elements of the set.

The use of brackets (braces) to show a set is called **set notation**.

b) Member of a set

"Member of" is denoted by $\in$ and read "is a member of", while $\notin$ means "is not a member of". For example, if we define the set A as follows: A = the set of all Anishnabe-speaking groups of people in Walpole Island or A = {**o**, **o**, **p**} then we can write $p \in A$ (p is a member of A), and we can also write $c \notin A$ (c is not a member of A), where c stands for Cree people - an Aboriginal group that does not speak the Anishnabe language.

Objective 4: Pictorial representation of sets using Venn diagrams

Venn diagrams are used to represent/show sets in picture form. The title "Venn" is used in honour of the famous English mathematician, John Venn (1834-1923), who did a lot of work related to Set Theory.

Colouring and shading or cross-hatching are often used to represent and distinguish the various sets in a Venn diagram (Teacher to show examples - by drawing).

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The term 'Universal set' is used to explain and represent a general set that includes all the things that belong to a set. Thus, a universal set consists of a general collection or group of things with subdivisions/subgroups inside it.

Representation of Universal Set

The Universal set, denoted by U, is represented by a rectangle. Hence, all elements within the rectangle belong to (are members of) U. For example, if a Universal set is defined as the set made up of all Aboriginal people in Canada, then we use a Venn diagram to show U, as follows:

U $\boxed{\text{All Aboriginal people in Canada}}$ **U** $\boxed{\text{C A D I M}}$

C = Cree; A = Anishnabe (3 Fires); D = Dene; I = Inuit; M = Metis, etc.

Objective 5: Terms commonly used in Set Theory

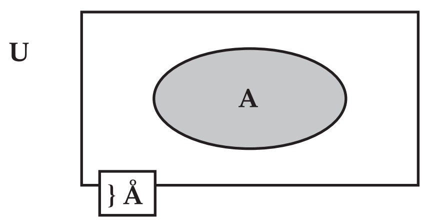
a) Empty set

The set that has no elements is called the empty or null set. It is denoted with **{ }.** That is, it is denoted using braces with nothing written inside the braces, or by using the symbol, q. An example of an empty set is a set of people in Walpole Island who have 2 heads and 7 eyes.

Ask the students to give their own examples of empty sets drawn from their environment.

b) Complement of a set

If A is a set, then the complement of the set A (written }) is the set of all elements in the universal set, U, which are not elements of the set A. The Venn diagram below shows a Universal set, U, containing the set A, and its Complement, }.Å



c) Subset of a set

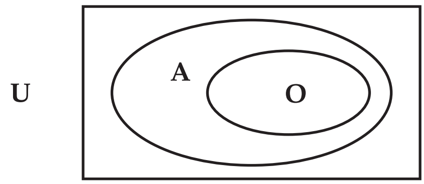
By the term "subset" we mean a "subgroup of" or a "smaller part of"a set.

For example, let us define the set A as follows: A = the set of all Anishnabe-speaking groups of people in Walpole Island, that is A = {**o**, **<u>o</u>**, **p**}, where **o** represents Odawa people, while **<u>o</u>** stands for Ojibwa people, and **p** stands for Pottawatomi people.

We know that the groups Odawa, Ojibwa, and Pottawatomi are smaller groups that make up the large group, Anishnabe, also called the 3 Fires Confederacy. Thus, by our definition of the term "subset", each of these three smaller groups is a subset of the large group (or large set), Anishnabe.

Using symbols in our definition of the term "subset" we can state as follows:

The set O is a **subset** of another set A (written O $\subseteq$ A) if, and only if, every element of O is also an element of A. This means that if O is a subset of A, then every element of set O also belongs to set A. This means that the set O is contained completely in the set A. In other words, the set A contains the set O, so A is a bigger set than O. We can show this in a Venn diagram, thus:



<u>**Note**</u>: In the diagram above, A is a larger set containing the smaller set O. If you think of A as Anishnabe-speaking people, and O as Odawa people, you can easily remember that in your community, O is a smaller group within the larger group, A.

Hence, O is a subset of A, and we write in symbolic form, O $\subseteq$ A.

Similarly, since we know that the two other groups – the Ojibwa and Pottawatomi are smaller groups within the larger Anishnabe group (A), we can also write <u>O</u> $\subseteq$ A, and P $\subseteq$ A, where <u>O</u> = Ojibwa, and P = Pottawatomi. Thus, in place of O in the diagram, we can also put <u>O</u> and P, respectively.

Objective 6: Summative Evaluation

The same questions and exercises given for Group A – the regular (existing) curriculum group which is the Control group - were also used for Group B.

CONTRASTS BETWEEN THE TWO LESSON PLANS

Essentially the Control (regular curriculum) group lesson plan followed the pattern of mathematics teaching and learning in typical mathematics textbooks used in Ontario schools. Examples are given to illustrate concepts but these examples are not usually drawn from the students' schema, culture, and environment. For instance, English alphabets were used to illustrate a Universal set, English vowels and consonants used to show subsets within the Universal set, and complements of sets.

On the contrary, the experimental (culture-sensitive curriculum) group lesson plan zeroes in on the schema and lived experiences of the students as embodied in their communal activities, history, nomenclature, culture, environment, and their day-to-day life. For example, the set of Canadian Aboriginal people was used to illustrate a Universal set, the component groups that make up the Aboriginal population used to show and explain subsets, and complements of sets. With particular reference to the local community (Walpole Island), the Anishnabe (the larger group), and Odawa, Ojibwa, and Pottawatomi (smaller groups) were effectively used in appropriate situations to explain relevant concepts in Set Theory.

Follow-Up Observation

It is instructive to note that at the end of the study, when the two groups were given the same posttest, participants from the experimental group (taught with the culture-sensitive curriculum) readily gave innovative examples of sets from their environment. On the contrary, their counterparts that were taught with the regular curriculum, only gave haphazard examples of what they struggled to remember from their textbooks and class notes. The same pattern was evident in the periodic continuous assessment exercises on various units of instruction and concepts taught in the various segments of the study.

RESULTS AND FINDINGS

As earlier stated, to test the *Entry Behaviour* of the control and experimental groups, the two groups were given the same pretest at the beginning of the study in Grade 5. The results of the pretest are shown in Table 1, while Table 2 gives the ANOVA summary for the pretest scores.

Table 1: Pretest mean scores of participants in instructional groups (N = 28)

Groups	**No. of Participants**	**Curriculum Type**	**Mean**
A (Control)	14	Regular curriculum	33.85
B (Control)	14	Integrated curriculum	35.85
Total	28		34.85

Table 2: ANOVA summary for pretest scores

Source of Variance	Sum of Squares	df	Mean Square	F
Between groups	28.00	1	28.00	0.284
Within groups	2559.43	26	98.44	
Total	2587.43	27		

$p > 0.05$ ($F_{crit.} = 4.23$)

At the end of the study in Grade 6, the two groups were given the same posttest - a mathematics achievement test (MAT) based on the subject-matter content covered during the instructional phases of the study in Grades 5 and 6.

DEVELOPMENT AND VALIDATION OF TEST INSTRUMENTS

Development

The Mathematics Achievement Test (MAT) used as the posttest was developed from the units of instruction covered during the teaching phase of the study. Thus, test items were drawn from the five strands of the Ontario curriculum – Number Sense and Numeration, Measurement, Geometry and Spatial Sense, Patterning and Algebra, and Data Management and Probability. The MAT was in two sections. Section I, the theory part, was made up of 20 short-answer essay questions, while Section II consisted of 50 multiple-choice questions.

Validation of MAT

(i) Content validity

Sprinthall (2003) pointed out that content validity "is based on whether the test items are a fair and representative sample of the general domain that the test was designed to evaluate" (p. 491). With this in mind, the MAT was created to reflect both the subject-matter and objectives of instruction covered in the study. Thus, in establishing content validity, this researcher drew up tables of specifications for both the theory and multiple-choice sections of the test. Test items were drawn with the tables of specifications as a guide, and this ensured that the items were representative of all the areas

– the five mathematics strands – covered in the instructional phase of the study, taking the scope of each strand into consideration. The main instructional objectives of the study were also borne in mind in choosing the test items. Details of the two tables of specifications are shown in Appendices 3 and 4.

(ii) ***Face validity***

To ensure face validity, both sections of the MAT were given to one expert in each of these four areas – curriculum studies (with specific expertise in the Ontario mathematics curriculum), mathematics, mathematics education (a teacher at the elementary level), and measurement and evaluation – for critical appraisal and comments. The critiques of the experts were incorporated into the final versions of the tests.

Reliability Measures

(i) Section I -Scorer reliability

Section I of the MAT consisted of 20 short-answer theory (essay) questions. The scorer reliability for this section was found by having the test papers (posttest) independently scored by two different examiners with the same marking scheme. The two sets of scores thus obtained by each examinee were then correlated using the Spearman's Rank Order Correlation Coefficient procedure. This yielded a high scorer reliability of 0.97 or 97%.

(ii) Section II reliability

Section II of the MAT was made up of 50 multiple choice questions with five options in each question. The Kuder-Richardson (K-R) formula was used for determining the reliability of this section. The reliability coefficient so determined was 0.92 or 92%.

Tables 3–5 give the results of the posttest.

Table 3: Posttest mean scores of subjects in instructional groups (N = 28)

Groups	No. of Participants	Curriculum Type	Mean
A (Control)	14	Regular curriculum	39.86
B (Control)	14	Integrated curriculum	54.79
Total	28		47.33

Table 4: ANOVA summary for posttest scores

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between groups	1560.036	1	1560.036	8.315*	0.008
Within groups	4878.071	26	187.618		
Total	6438.107	27			

* $p < 0.05$ ($F_{crit} = 4.23$)

Table 5: Further descriptive statistics

					95% Confidence Interval for Mean		Min.	Max.
Curriculum type	N	Mean	Std. Dev.	Std. Error	Lower Bound	Upper Bound		
Regular	14	39.8571	11.88960	3.17763	32.9923	46.7220	26.00	67.00
Integrated	14	54.7857	15.29293	4.08721	45.9558	63.6156	32.00	83.00
Total	**28**	**47.3214**	**15.44177**	**2.91822**	**41.3337**	**53.3091**	**26.00**	**83.00**

SUMMARY AND DISCUSSION OF RESULTS

The pretest mean score of Group A (the control group) was 33.85, while Group B (the experimental group) recorded a mean of 35.85. The Analysis of Variance summary in Table 2 indicated there was no statistically significant difference between these mean scores. This finding implies, therefore, that there was no significant difference between the performances of the two groups at the time of commencement of the study in Grade 5. Thus, no group was at an initial advantageous position over the other in terms of its mathematics attainment or readiness. The two groups were, therefore, deemed equivalent at the beginning of the study.

Hypothesis

The study was guided by the null hypothesis that there would be no significant difference between the posttest mean scores of the control group and the experimental group. However, the Analysis of Variance revealed there was actually a significant difference in favour of the experimental group –

the group taught using the integrated (culture-sensitive) curriculum. Thus, the students taught by this method out performed their counterparts in the control group taught with the regular (existing) curriculum. Hence, the null hypothesis was rejected at the 0.05 significance level. Also, the researcher would like to note that the Analysis of Variance test was also significant even at the 0.01 level ($F_{crit.} = 7.72$). So, the null hypothesis of no difference would also be rejected at that level. Thus, the type of curriculum used in teaching mathematics to the students played a significant role in the performance of the students over and above what would be expected by chance. Additionally, further descriptive statistics given in Table 7 indicate that the best overall performing participant who had a score of 83 came from the experimental (culture-sensitive curriculum) group while the maximum score in the control (regular curriculum) group was 67. Similarly, the minimum score of 32 recorded in the experimental group was also higher than the minimum score of 26 in the control group. Hence, from all indications, the students taught with the culture-sensitive curriculum performed better than those taught with the regular curriculum.

Limitations

The unavoidable use of convenience sampling procedures in selecting the research participants for this study may be considered a limitation. However, to minimize the possible effect of this limitation, randomization was used to assign the two Grade 5 classes to instructional groups. Also, as a further check and experimental control aimed at ensuring the equivalence of the groups, the same pretest was administered on the two groups and this revealed that no group was at an initial advantage over the other at the beginning of the study.

The relatively small sample size was also a limiting factor that could not be controlled because that was the entire Grade 5 population in the community school. However, the fact that there was no case of attrition or experimental mortality in the transition from Grade 5 to Grade 6, provided considerable stability in the study. The long duration of the study (four weeks in Grade 5 and six weeks in Grade 6), and the building of instructor permanence into the design of the study ensured a high measure of continuity not just in content presentation, course coverage, and teaching style, but also in teacher-student rapport and the establishment of favourable learning environments in both groups.

RECOMMENDATIONS AND CONCLUSION

Based on the findings of this study, the researcher would strongly recommend that Huffman's (2001) "cultural discontinuity hypothesis", as cited in Piquemal and Nickels (2005, p. 119) be addressed in all schools that have Aboriginal students. This hypothesis postulates that "differing cultural elements between in-school and out-of-school experiences…have a significant effect on young Aboriginal students' school experiences". The curriculum adopted in this study for teaching the students in the experimental (culture-sensitive curriculum) group was aimed at tackling the cultural discontinuity hypothesis. Thus, Aboriginal (specifically, Anishnabe) cultural content was incorporated into the integrated mathematics curriculum in terms of knowledge base – Aboriginal mathematics knowledge culled from the environment and the archival holdings of the Walpole Island Heritage Research Centre, and traditional mathematics knowledge readily put at the disposal of the researcher by community Elders (Knowledge Keepers), and educators. In addition, this study injected classroom experiences similar to the early cultural socialization experiences of Aboriginal learners. For instance, emphasis was placed on learn-as-you-do mathematics learning experiences, and in-class demonstrations and exercises. This mirrors the age-old apprenticeship system of knowledge and skill acquisition popular among Indigenous cultures worldwide, including Canadian Aboriginal people. Also, still in line with the early cultural socialization experiences of Aboriginal learners, end-of-unit quizzes were administered as consolidating exercises aimed at diagnosing learners' strengths and weaknesses, instead of competitive, ranking-oriented school examinations. Furthermore, outdoor mathematics learning experiences were freely utilized, for example, the log house Geometry sessions, and the Data Management and Probability lessons in the *High Banks* park.

The researcher would also recommend that significant efforts be made by all teachers and educational institutions to enable Aboriginal learners experience smooth cultural border crossing (Ezeife, 2003) as they navigate the transition from their life-world culture (acquired from home, peers, and community) to the culture of school mathematics. A smooth cultural border crossing learning experience would enhance "simultaneous collateral learning", a situation "in which learning a concept in one domain of knowledge or culture can facilitate the learning of a similar or related concept in another milieu" (Aikenhead & Jegede, 1999, p. 24). In other words, a smooth cultural border crossing experience can help Aboriginal students "apply what they already know to novel learning opportunities" as suggested by Ignas (2004, p. 52), a suggestion this researcher unreservedly reinforces.

The term "storyline approach" derives from the well-known Indigenous epistemology on the connectivity between stories and learning. Referring to this Indigenous epistemology in their study, Greenwood and de Leeuw (2007) affirm that "teachings flow from stories, that embedded in the acts of telling and listening to stories there exists virtually unlimited potential for learning" (p. 48). Using narratives as a stimulus to gain and sustain students' interest and invigorate learning is a methodology prevalent in Indigenous teaching and learning traditions as supported by the work of Atleo (2009) on Aboriginal Learning Ideology. Thus, these authors encourage the use of stories in teaching, a technique often referred to as the storyline approach (Ezeife, 2002). The present study provided ample storyline learning experiences to the students in the experimental (culture-sensitive curriculum) group. For instance, sharing of the bannock cake – a local delicacy – was used to introduce the relationships among the circumference, diameter, radius, and arc of a circle. The story was told of a group of six children who were given a large bannock cake (which is actually circular in form) to share, and were supplied with strings, measuring tapes, cutting boards, and kitchen knives. The challenge posed to the class was to come up with strategies for sharing the cake such that each of the six children would get an equal piece. Having been given this life-related story, the class was then divided into working groups to strategize, and later articulate their ideas in a general discussion session. From the discussion, linkages were built from the story of the bannock cake to the geometry concepts referred to above, hence transferring ideas from a familiar staple food item in the community to a related mathematics learning experience, using an engaging story. Based on this positive learning outcome, this researcher would recommend the use of appropriate and meaningful stories to invigorate mathematics learning for Canadian Aboriginal students, whenever possible. Dwelling on Indigenous education methodology, Alonge (1982) had emphasized the essential attributes of this methodology. As cited in Ezeife (2001) these attributes include "Oral tradition (listening, watching and doing, Individualised instruction, Group work, Apprenticeship. Teaching materials are real physical objects or challenging philosophical abstractions" (p. 22). Essentially, the Indigenous methodology of education is holistic and environmentally based, drawing from, and interconnected with nature, but not in control of it (Hanson, 1994).

In conclusion, the researcher would briefly touch on the economic dimension of mathematics education, and draw attention to the urgent need for the labour market in every country to adapt to industrial and commercial innovations on the global scene. Since most of these innovations are technologically focused, this is an added reason for the youth to embrace subjects like mathematics and science that would give them a strong foothold in an environment of technological innovations. The researcher's submission is that a culture-sensitive mathematics curriculum developed with the Aboriginal learner's cultural and environmental background as the cornerstone would place such a learner in a self-confident, hope-laden frame of mind as the learner considers his/her "foreground" in a mathematics and technologically oriented society. The term "foreground" as used in this context "refers to a person's interpretation of learning and 'life' opportunities, which the socio-political context seems to make available" (Skovsmose, Alrø, & Valero, 2007, p. 154). Considering the fact that Aboriginal people constitute a sizeable percentage of the Canadian population, it follows that the Canadian economy will benefit from whatever contributions Aboriginal youth can make to the continued growth of the economy. It is, therefore, essential that such youth be fully equipped to make this contribution by preparing them early in life to pursue enabling mathematics-related courses. A timely and early introduction of a culture-sensitive mathematics curriculum, which this study has found to appeal to Aboriginal students, and which produced better results than the regular (existing) curriculum, would hopefully dispel the current math phobia prevalent among Aboriginal mathematics learners. This, in turn, would lead to improved mathematics performance, and hopefully an inclination to pursue mathematics-related careers and engagements in later years, thereby ending the current under-representation of Aboriginal people in scientific, mathematical, and associated technological fields.

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Dr. Anthony N. Ezeife is a Professor of Mathematics and Science Education in the Faculty of Education, University of Windsor.

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APPENDIX 1

INTERVIEW INSTRUMENT FOR COMMUNITY ELDERS AND EDUCATORS

Introduction

It is known that Aboriginal people had a deep knowledge of mathematics and science in the past, and regularly used and applied this knowledge in their daily lives and activities. For example, the Skidi Pawnee were reputed astronomers and were able to predict and interpret the movement of heavenly bodies and stars.

Purpose of Interview

Our discussion in this interview is meant to seek information on how the lives of community members of Walpole Island involve mathematics in today's world, and had involved math in the olden days. Please, tell us what you know about mathematics in the cultural and traditional life of the community. For instance, you could talk about mathematics as it affects the following aspects of life and activities:

Traditional housing

Anishnabe names of types of local/traditional houses could be given. You could talk about the shapes of the houses, how they were partitioned, materials and equipment used in their construction, their elevation (how high or low they were), their positioning – facing/backing the sunrise, capacity (the approximate number of people the houses could hold, their length, width, and height – approximately).

Traditional occupational activities and transportation

This could be discussed under these headings:

Fishing – Local instruments and equipment used for fishing in the past, ice fishing – approximate depth and width of fishing holes, temperature ranges during periods of ice fishing, fishing teams, and so on.

Farming – Sharing of farmlands, approximate sizes of farming plots, how the plots were measured, including the instruments used, how farm products were stored, and so on.

Hunting – Hunting traps and gear, shape of traps – any angles involved in the preparation/setting of traps, and reasons for shaping the traps in a particular fashion, hunting teams and expeditions, etc. Any other occupational activities? Tell us about any other such activity you know.

Transportation **–** Local/traditional means of transportation used in the olden days, their names and how they were built, seasons of the year when they were used.

Folklore **–** traditional stories, beliefs, customs, etc. usually handed down by word of mouth from generation to generation by elders. Any numbers, counting, weights, heights, areas and volumes involved in these stories?

Games – Names of popular Anishnabe games played in the olden days by both young and old people, times of the year they were played, instruments and equipment used to play them, number of people taking part, purpose of the games?

Clothing and Decoration **–** Names, types, styles, and uses of traditional clothes and feathers, ceremonial occasions when used, who is entitled to wear what types of clothes and why? Seasons of the year they were worn? Decorations used in the traditional culture, purpose of these decorations. Any special patterns of art in traditional clothes and decorations?

Eating and Drinking **–** Names, types of foods, and sizes of food rations, sizes of traditional drinking cups, their shapes, etc.

Counting and Record Keeping **–** "Base" system used (that is, after how many numbers does the person counting begin again from a specific starting point of the counting cycle). Note to the interviewer: Here, explain that the current base system in the Western world is the decimal (base ten) system, while the computer uses the base two or binary system.

Time and Time Keeping, Calendar **–** How was time observed and recorded in the culture of the people in the past? Keeping of appointments, instruments and equipment used to keep time, how were they made? How many days were there in the traditional week (or whatever local name by which the 'week' was called)? Month? Year? How were these records kept?

Measurement **–** How were distances, speed, weights, etc, measured? What standards or units were used to record these measurements?

General **–** Please, tell us any Anishnabe story that involves mathematics – numbers, counting, running, bending, angles, weighing of objects, duration of activities, sunrise and sunset, sleeping habits of people and animals, and so on. Whatever you can think of is acceptable to us.

Appreciation: Thank you very much for discussing and sharing your ideas on, and knowledge of, mathematics with us.

Name of person interviewed ______________________________

Interviewed by ______________________________

Date of Interview ______________________________

APPENDIX 2

SAMPLE CATEGORIZATIONS OF ANALYZED INTERVIEWS INTO MATHEMATICS STRANDS, TEACHING TOPICS, AND CONCEPTS

Relevant math content gleaned from interview	Corresponding math Strand	Applicable math topic/concept
Farmers picking strawberry with large bowls.	Measurement	Capacity and Volume – different amounts in containers of different shapes and sizes, for example, the volumes/capacities of household utensils, cans, cups, bottles, and other everyday containers.
Use of "willow" to make a "dream catcher" frame.	Geometry and Spatial Sense	Construction; angles involved in the frame; types and measures of angles.
Beadwork and beads worn by the Anishnabe.	Patterning and Algebra	Patterns in the beadwork, colours and ordering of beads.
Making moccasins - "sometimes requires measuring the feet of someone standing on the hide".	Measurement	Units and standards of units, Conversion between different systems of units - The SI system, fps, etc.
Component groups of the "3 Fires Confederacy", and their common language. "Many", in the Anishnabe language "means a whole bunch of something". For example, "in case of berries, it could be a pail full of berries".	Number sense and Numeration Number sense and Numeration	Set Theory – Set descriptions and symbols/notations, The Universal set, Complements, and Subsets. Counting, basic units of counting, different base systems.
Flowers in the environment. "Sometimes, we picked flowers and counted the petals".	Number sense and Numeration; Patterning and Algebra.	Numeric skills, Naturalistic intelligence (Gardner's Multiple Intelligences); Patterns in the arrangement of the petals.
Hunting: "The rounded tipped arrows are used for hunting smaller game, while the sharpened tips are used for hunting larger game".	Geometry and Spatial Sense.	Angles, Shapes, and Velocity of Motion. (Link the "V" or tip of the arrowhead, which leaves a wake that follows the rest of the arrow to flight of birds in "V" formation - the other birds follow the lead "squad" with less effort).

Housing: "The shape of the lodges is usually circular". "… the construction of the lodges is symbolic. At the centre of the lodge is a hold for the fire, and at the top of the roof is a circle for smoke exit. The doorways of the lodges agree with the four directions - East, West, North, and South".	Geometry and Spatial Sense	Coordinate Geometry - Directions and locations in space. The four cardinal points and the formation of the four quadrants.
Fishing: The technique the Anishnabe use is to make "marsh grass in a circular formation. A hole inside the formation is lined with tunnels; often six or more tunnels are linked to the hole".	Data management and Probability	Probability - its example and application in an everyday life situation. (The Anishnabe technique involves running the fish through several tunnels until they are captured in one. This strategy adopts, and exemplifies the principle of probability).
Burial Traditions: "Burying of a loved one is usually on the 5th day…the body is positioned to the East which symbolizes a new beginning - where the sun rises".	Number Sense and Numeration	The decimal (base 10) system of counting contrasted with the base 5 system. The concept and use of "place holder" in counting. Cycles and rotations. Directions - sunrise and sunset.
Games: "Gaming was a traditional activity, almost like present-day casinos. There were shell games, slide-of -hand tricks, the moccasin game, etc. In the moccasin game, players try to correctly guess in which pouch a specially marked marble is hidden".	Data management and Probability.	Principle of Probability - Games involving chance – such as raffles, lotteries, and bingos. Determination of the odds of winning.

APPENDIX 3

TWO-WAY SPECIFICATION TABLE FOR THE 20-ITEM MATHEMATICS ACHIEVEMENT

TEST (MAT) –THEORY SECTION – ON AREAS OF INSTRUCTION COVERED IN THE STUDY

S/N	Content Areas (Math Strands)	**MAJOR INSTRUCTIONAL OBJECTIVES**					
		Can explain basic terms.	Correctly applies concepts and principles.	Appreciates the role and functioning of mathematics in everyday life.	Interprets data meaningfully.	Works numerical exercises; explains how to, and is able to use manipulative (concrete) resources.	**TOTAL**
1	Number Sense and Numeration			1	1	2	**4**
2	Geometry and Spatial Sense	1	1	2		1	**5**
3	Data Management and Probability	2		2	1		**5**
4	Patterning and Algebra	1			1	1	**3**
5	Measurement		1	1		1	**3**
	TOTAL	**4**	**2**	**6**	**3**	**5**	**20**

APPENDIX 4

TWO-WAY SPECIFICATION TABLE FOR THE 50-ITEM MATHEMATICS ACHIEVEMENT

TEST (MAT) – MULTIPLE-CHOICE SECTION - ON AREAS OF INSTRUCTION COVERED IN THE STUDY

S/N	Content Areas (Math Strands)	MAJOR INSTRUCTIONAL OBJECTIVES					
		Can explain basic terms.	Correctly applies concepts and principles.	Appreciates the role and functioning of mathematics in everyday life.	Interprets data meaningfully.	Works numerical exercises; explains how to, and is able to use manipulative (concrete) resources.	**TOTAL**
1	Number Sense and Numeration	2	2	2	2	3	**11**
2	Geometry and Spatial Sense	2	2	3	2	3	**12**
3	Data Management and Probability	2	2	2	2	3	**11**
4	Patterning and Algebra	1	2	2	1	2	**8**
5	Measurement	1	2	1	2	2	**8**
	TOTAL	**8**	**10**	**10**	**9**	**13**	**50**