NUMERACY IN Haida Gwaii, BC:
CONNECTING COMMUNITY, PEDAGOGY, AND
EPISTEMOLOGY

by
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of the Requirements for the Degree of
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In the Faculty
of
Education

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Abstract

The performance and participation rates of Aboriginal students in mathematics in British Columbia are significantly lower than those of the general student population. The purpose of this study is threefold. First of all, to find out how the community of Haida Gwaii/Queen Charlotte Islands, BC, which consists of Haida and non-Haida people, uses mathematics and numeracy practices in their daily life. Secondly, to find out how such numeracy practices could be integrated into the present curriculum taught in the schools so that students would be interested in learning mathematics. Finally, to explore the different ways of knowing that could increase the participation rate and achievement of Aboriginal students in high school mathematics.

This study is based on interviews of members of the Haida Role Model Program, community members, and educators on the islands of Haida Gwaii/Queen Charlotte Islands. It shows how the community of Haida Gwaii practices numeracy with its unique culture and environment in a way that makes sense to the people living there. The problems they solve are contextual and situated within that community, and provide insights into how the Haida use their knowledge in dealing with quantitative, relational, and spatial aspects of their lives. The challenge is to recognize and acknowledge the embedded numeracy practices of the community and apply the pedagogy to teach school mathematics. If Aboriginal students could see themselves included and represented in the curriculum, then their learning of mathematics is likely to improve.

There is a tension between maintaining culture and evolving culture. There is also a tension about how school mathematics should connect with the daily numeracy practices. Many Aboriginal communities feel that the student performance is usually measured with a different cultural lens. These are artificial polarizations because in essence what the elders and role models are calling for is dual epistemologies: situate the learning in our culture to help them learn, also teach the students to know the Modern ways so that they measure up to the Western standards in order to succeed in the Western world.

Keywords:
Dedication

To my family, thank you for your encouragement, support and love.

To the people of Haida Gwaii thank you for sharing your traditions and wisdom.

To the children everywhere, you are our future.
Acknowledgements and Gratitude

This thesis comes after three decades of teaching and learning in mathematics education. Over these years I have had many teachers, mentors, guides, friends, and colleagues...I thank you.

During my years of studying and working in the Faculty of Education at Simon Fraser University I have been fortunate to have been inspired and supported by many Faculty members and Faculty Associates. In particular, I would like to acknowledge and thank Dr. Tom O'Shea for encouraging me to pursue my doctoral studies and be my pro­tem advisor. Dr. Peter Liljedahl, Dr. Mark Fettes, and Ms. Vonnie, Hutchingson members of my supervisory committee thank you for providing me feedback and guidance. Thank you to LUCID Project, Imaginative Education Research Group (ierg) SFU for providing partial funding for the research.

I also wish to express my deep appreciation and thanks to the people of Haida Gwaii, especially the elders, members of the Haida Role Model Program, and community members. This thesis would not have been possible without their contributions. I hope that I have represented their voices respectfully, truthfully and honorably.

I wish to acknowledge and thank the teacher informants and staff from School District No. 50 (Haida Gwaii/ Queen Charlotte Islands) who made themselves available for the purposes of this study.

Last but not the least thanks to my extended family especially my wife Nancy and my daughters Aekta and Sarekha for their continued love, encouragement and support.
# Table of Contents

Approval ........................................................................................................ ii
Abstract ....................................................................................................... iii
Dedication ..................................................................................................... iv
Acknowledgements and Gratitude .............................................................. v
Table of Contents ......................................................................................... vi
List of Figures ............................................................................................. x
List of Tables ............................................................................................... xiv

**CHAPTER ONE - A Starting Point** ................................................................. 1
  Personal Interest ....................................................................................... 2
  Background ............................................................................................. 3
  Organization of the Thesis ........................................................................ 8

**CHAPTER TWO - Multiple layers of Numeracy** ......................................... 11
  Introduction ............................................................................................. 11
  Numeracy the Entity (Definition) .............................................................. 11
  Numeracy the Embodied Disposition (Being Numerate) ......................... 14
  Numeracy the Practice ............................................................................ 16
  Numeracy the Language .......................................................................... 18
  Numeracy the Cultural Activity .............................................................. 20
    Counting .............................................................................................. 21
    Measuring ........................................................................................... 21
    Designing and Building ....................................................................... 22
    Locating ............................................................................................... 22
    Explaining ........................................................................................... 22
    Game Playing ...................................................................................... 23
  Numeracy: Socio-Cultural Constructs ...................................................... 23
  Ethnomathematics .................................................................................. 23
  Socio-Cultural Theory ............................................................................ 27
  Situated Learning ..................................................................................... 28
  Indigenous Cultural Context ................................................................... 29
  NCTM Principles and Standards for School Mathematics ....................... 31
  Summary ................................................................................................. 32

**CHAPTER THREE - Indigenous and Modern Epistemologies in the Learning of Mathematics** ........................................................................... 35
  Introduction ............................................................................................. 35
  Indigenous Epistemology ........................................................................ 37
    Gregory Cajete ..................................................................................... 37
    Oscar Kawagley .................................................................................... 40
    Willie Ermine ....................................................................................... 41
List of Figures

Figure 1. What is Numeracy? ........................................................................................................... 12
Figure 2. Aspects of Ethnomathematics .......................................................................................... 24
Figure 3. An Indigenous Curriculum Mandela for Science from a Native American Perspective (Cajete, 1999, p 204). Used with permission .......... 39
Figure 4. Aerial view of Haida Gwaii. Used with permission ......................................................... 80
Figure 5. Map of Haida Gwaii. Used with permission .................................................................. 81
Figure 6. Historical Sign near Tlell, about the Queen Charlotte Islands ........................................ 82
Figure 7. Tlell Stone Circle ........................................................................................................... 85
Figure 8. Balance Rock near Skidegate .......................................................................................... 86
Figure 9. Haida Nation Flag Representing the Two Clans: Eagle and Raven ................................. 87
Figure 10. Distinct Logos Representing each Clan Shown on the Sides of a Truck in Skidegate .................................................................................. 88
Figure 11. Chief Skidegate ........................................................................................................... 89
Figure 12. Elder, Weaver, and Teacher, Mary Swanson, with her Daughter, Crystal Robinson, a Social Worker, Weaver, and Healer, and her Granddaughter, Shane, a Recent High School Graduate ........................................ 91
Figure 13. Elder, James Young, in Skidegate, meeting with the other Elders ................................. 91
Figure 14. Family Tree showing how a Person would become a Chief ........................................... 92
Figure 15. Punnett Square shows the different Chances of Inheriting a Disease ............................ 93
Figure 16. Haida Art depicted in the Logo for School District No. 50 ........................................... 95
Figure 17. Symmetrical and Asymmetrical Haida Art depicted on a Totem Pole and on a Vest ......................................................................................................................... 96
Figure 18. Primary Formline Ovoid and U-Shape ......................................................................... 97
Figure 19. Bilaterally Symmetrical Ovoid Shapes .......................................................................... 98
Figure 20. Ovoids and U-shapes Carved on the Sides of Totem Poles ........................................... 99
Figure 21. James Sawyer at Work in His Studio ............................................................................ 101
Figure 22. Canadian 20 Dollar Bill Depicting Bill Reid’s Artworks: The Raven and the First Men, and The Spirit of Haida Gwaii ................................. 102
Figure 23. Bill Reid’s Carving in Yellow Cedar of The Raven and the First Men, displayed at the UBC Museum of Anthropology ........................................... 103
Figure 24. Bill Reid’s The Spirit of Haida Gwaii ........................................................................... 105
Figure 25. Dancing and Singing on National Aboriginal Day in Old Masset .................................. 106
Figure 26. A Copper Shield, Once belonging to Albert Edward Edenshaw, Portraying his Female Grizzly Bear Crest ................................................................. 108
Figure 27. Beadwork around a Feather Quill ............................................................................... 109
Figure 28. Frieze Pattern Recognition Chart ................................................................................. 111
Figure 29. A Beadwork Pattern is first drawn on Graph Paper and then Tessellated onto a bottle ....................................................................................................................... 112
Figure 30. Five-Sided Box with Cover made of Beadwork .............................................................. 112
Figure 31. Bentwood Box made by Christian White ....................................................................... 113
Figure 32. The Making of a Bentwood Box ................................................................................... 114
Figure 33. Bentwood Box made by James Sawyer ......................................................................... 116
Figure 34. Circular Design carved by Ernie Burnett onto the Side of a Box ........................................ 116
Figure 35. Traditional Dancing and Story-Telling with Full Regalia ........................................ 118
Figure 36. Section of the Design for Irene’s Blanket, drawn by Tyson Brown ......................... 119
Figure 37. Putting Together the Ultra Suede Pieces for the Blanket ........................................ 120
Figure 38. Irene’s Four Button Border Pattern on her Blanket .................................................. 120
Figure 39. Various Blankets worn by Haida Graduates at the Haida Graduation Ceremony .......... 122
Figure 40. Traditional Haida Canoe in Skidegate ................................................................. 123
Figure 41. Wedge-Spreaders were Installed to Keep the Shape of the Canoe .............................. 124
Figure 42. Traditional Haida Warrior and Other Paddles of Different Sizes and Shapes ............ 127
Figure 43. Wooden and Fiberglass Haida Canoes in Christian White’s Workshop .................... 127
Figure 44. The Sound of a Drum also Depends on the Tension and its Assemblage on the Back ................................................................. 128
Figure 45. Drumming a Traditional Beat at a Ceremonial Event .............................................. 129
Figure 46. Drums, Depicting Various Forms of Haida Art ...................................................... 130
Figure 47. Nika Collison, Dancing with her Drum .............................................................. 130
Figure 48. Christian White Carves a Scaled Model before Carving the Actual Piece of Art ........ 131
Figure 49. Different Tools are used to Transfer the Measurements onto the Argillite Mask ........................................................................ 132
Figure 50. A Wooden Mask, Carved in the Haida Tradition .................................................. 132
Figure 51. Haida Bracelet Carved by Charles Edenshaw ........................................................ 133
Figure 52. James Sawyer, Carving a Gold Shield .................................................................... 134
Figure 53. Designs are Created on Tracing Paper before being made into Silver Bracelets by James Sawyer ........................................................................ 135
Figure 54. Knives, Wedges, Chisels, and Drills are commonly used in wood-working .......... 136
Figure 55. Adazes are used to Plane Rough Wood until the Surface is Flat ............................... 136
Figure 56. Different Measuring Tools used by Reg Davidson for Carving a Totem Pole ............ 138
Figure 57. Remains of a Traditional Longhouse built with Cedar Beams and Planks at the Ancient Village of Tanu ................................................................. 138
Figure 58. Front View of Christian White’s Tluu Xaada Naay Canoe Peoples’ House ............. 139
Figure 59. Buildings at SHIP and the Haida Heritage Centre are Replicas of Traditional Longhouses ........................................................................ 140
Figure 60. Making a Rectangle with the Golden Ratio .......................................................... 141
Figure 61. Post and Beam Joints Used in Building a Traditional Haida Longhouse .................. 142
Figure 62. A Frontal Pole and a Memorial Pole ..................................................................... 143
Figure 63. Each Pole is Unique with its Cultural Style, Carving, and Story ............................ 144
Figure 64. This Pole has Three Watchmen at the very Top, who are Guardians, looking out for Danger from the Land, Water, and Supernatural World ................................. 145
Figure 65. A Frontal Pole, Carved by Norman Price and then Erected in Front of his House at Skidegate .............................................................................. 147
Figure 66. Starting with a Scale Drawing of 18:1 and using a Variety of Tools to Carve the Actual Totem Pole .............................................................................. 148
Figure 67. Outline of an Eye is Sketched before Carved with a Chisel ........................................ 148
Figure 68. Ben Davidson, Carving a Totem Pole at Skidegate with an Apprentice .................... 150
Figure 69. Raising of Totem Poles at the Haida Gwaii Heritage Centre, being built at Qay'llnagaay, near Skidegate .................................................. 151
Figure 70. View of the Six Poles at Haida Gwaii Heritage Centre at Qay'llnagaay ........... 153
Figure 71. Ancient Haida Mortuary Poles in the Village of SGang Gwaay Linagaay (Ninstints) .......................................................... 154
Figure 72. Blanket of a Haida Graduate with the Number 10, a Significant Number in the Haida Culture ............................................. 156
Figure 73. Fusion of Cultures. A Blanket of a Recent Haida Graduate (who was a Basketball Star), depicts Number 23 (Michael Jordan’s number) .................................................. 158
Figure 74. Is the Tide Coming In or Going Out at North Beach? .................................. 160
Figure 75. Example of How the Tides Visually Match a Sine Function .......................... 161
Figure 76. Rippled Ponds are Formed by the Receding Tides at North Beach ................. 162
Figure 77. Seaweed on the Banks and Rocks on the Bottom of a Channel Reveal Different Water Levels .............................................. 163
Figure 78. January Sunrise near Queen Charlotte Harbor Lights Up the Sky with Red Hues ................................................................. 165
Figure 79. Changes in the Contrast and Color of the June Sunset at North Beach near Masset .............................................................. 166
Figure 80. Different Materials, including Cedar Bark Strips, are used for Weaving ............ 167
Figure 81. A Basket, Woven with Spruce Roots ...................................................... 167
Figure 82. Weaving with Double Twining is Tighter than Single Twining ..................... 168
Figure 83. A Small Basket, made with a Plain Weave using Cedar Bark ....................... 169
Figure 84. Weaving with Different Designs and Patterns ........................................... 169
Figure 85. Cedar Bark Hat Woven by Christine Carty .............................................. 170
Figure 86. A Bag Contains the Sticks and the Cedar Bark Mat for the Stick Game .......... 172
Figure 87. A Die with a Cross-Hatched Side and an X-Pattern .................................... 173
Figure 88. Old Growth Rainforest in Haida Gwaii .................................................. 174
Figure 89. Gwaii Haanas National Park Reserve and Haida Heritage Site Map ............... 177
Figure 90. An Abandoned Pier where Sitka Spruce was Logged to Build Planes during the Second World War ........................................... 178
Figure 91. Logs Piled to be Transferred to Saw Mills or for Other Use ......................... 180
Figure 92. Side View of Logs, showing the Tree Rings ............................................. 181
Figure 93. A Measuring Stick for Determining the Volume of Lumber ......................... 182
Figure 94. Stacked Firewood, Approximately One Cord ........................................... 182
Figure 95. Using a Tree Scale Stick to Measure Tree Diameter ................................. 183
Figure 96. Measuring the Height of a Tree in 16 Foot Logs ...................................... 184
Figure 97. Logs are Transported to a Saw Mill to be Cut into Specific Sizes ................. 184
Figure 98. Accurate Measurements are Made before a Lathe or Other Machines are Used ................................................................. 185
Figure 99. Arthur Pearson, Cutting a Slot on a Beam .............................................. 186
Figure 100. The Height of Each Stair Must be Equal ............................................... 187
Figure 101. A House under Construction in Skidegate ............................................ 188
Figure 102. A Cabin and a Fence made with Different Recycled Materials .................... 188
Figure 103. Like Cars, Boats have Numerical Identification and Licenses that are Monitored by Police Patrol Boats ................................. 190
List of Tables

Table 1. Numeracy Grade 7 results and participation of the Foundation Skills Assessment (FSA) for BC .......................................................... 6
Table 2. Principles of Mathematics 12 participation and success rates in BC from 1995/96 to 2003/04 the last nine years .................................................. 7
Table 3. Interconnectedness between Epistemologies ........................................................................................................ 50
Table 4. Comparison of Parallel Worldviews adapted from (Knudtson and Suzuki, 1992, p. 13-15) ........................................................................... 53
Table 5. Haida Role Models and Community Members who were Interviewed .......... 64
Table 6. Data Collection Time-Line ...................................................................................................................................... 66
Table 7. Tide Tables for Masset, BC (54.0167° N, 132.1500° W) July 2006 ............ 161
CHAPTER ONE - A Starting Point

Slogans such as: “Mathematics for all,” “Everybody counts in math,” or “Do math...and you can do anything!” are idealistic and far from the reality. For many years, the achievement and participation rate of Aboriginal students in mathematics in BC has been significantly lower than those of the general student population. This study investigates factors in community, school, and personal life that could influence the success rates of Aboriginal students in school mathematics and math-related disciplines.

Devlin (2000) found many people saying they ‘can’t do math,’ and compared the idea to running a marathon. He asserted that the key to being able to run a marathon (or to do mathematics) was in the individual’s ‘will’. That will, motivation, or determination comes to different people at different times depending on their personal circumstances. To stay motivated about learning mathematics can be a challenge for many people, especially when students are trying to fit into multiple worldviews. As an example, Dr. Edward Doolittle, a Mohawk from the Six Nations in Ontario, received his PhD in mathematics and is currently Assistant Professor in the Department of Mathematics and Statistics at the University of Regina. Dr. Doolittle, one of the top fifty young alumni from the University of Toronto, discussed his 20-year challenge to fit in as an Aboriginal and as a Mathematician in a personal email communication:

I am not sure how my success is viewed by others in the Aboriginal culture to which I have committed myself. Respect for learning and academic achievement is not automatic in my culture; respect has more to do with what one does with one’s abilities rather than with the abilities themselves. I am comfortable enough with my level of achievement most of the time, but I feel that others may not understand, and may measure
achievement in different ways. Sometimes I feel that I'm not Indian enough for the Indians, not Mathematician enough for the Mathematicians. No doubt some of that feeling is just standard human feelings of alienation, but some of it is due to my peculiar history.

I guess in summary I might say that I have had a 20-year long identity crisis initially sparked by my guilt at accepting education funding for Status Indians when I didn't feel like an Indian, and exacerbated all the way by experiences and feelings of alienation from both Aboriginal and non-Aboriginal cultures. Throughout most of my life I have felt like I don't fit in anywhere. Fortunately that feeling is more or less over. Perhaps I'm lucky it only took me twenty years to know who I am, to know what is right and wrong, and to have the self-confidence to be able to follow my heart. (Edward Doolittle)

Like Dr. Doolittle, I am following my heart and have embarked on this study. To begin, I provide a brief outline about my interest and motivation to do this study.

**Personal Interest**

I am an educator with a keen interest in mathematics education. For the past 30-years, I have taught at a variety of levels from elementary to secondary, to pre-service teachers, to graduate students at the university. I have been an author, software developer, textbook reviewer, and host of the award-winning television series, *Math Shop*. I have also been the president of the BC Association of Mathematics Teachers (BCAMT) and have made presentations at many local, national, and international conferences. During my presidency at the BCAMT in 1999, and through the opportunity to meet students and teachers across BC and in other parts of Canada, I realized the importance of finding possibilities for closing the achievement and participation gap for Aboriginal students.

I am not of Aboriginal ancestry, but have been interested in the Aboriginal people since I immigrated to Canada almost 40 years ago. I believe that we all must
acknowledge, respect, and honor the Aboriginal people of Canada. As a Sikh of Indian ancestry, growing up in Canada, I remember the elders in the Sikh community using the phrase *thaek* to describe Aboriginal people. The term literally means: “children of your father’s elder brother.” In a metaphorical sense, it means that the Aboriginal people are the keepers of the land, knowledge, and local traditions. In this land of immigrants, it is disconcerting to see so many Aboriginal people not attain their dreams and goals to work in a particular profession, because they have not passed certain mathematics courses. This has been especially true in professional careers such as teaching, medicine, engineering, etc., where the doors to higher education may have been closed due to the student’s failure in mathematics courses. As a mathematics educator, I am passionate about ethnomathematics and the situated nature of numeracy, and as I embarked on this study, I wanted to see if students’ abilities to learn mathematics could be increased if the context, and personal and cultural relevance was meaningful. My hope is to also see if a situated understanding can assist teachers in finding ways to make the school mathematics curriculum and pedagogy more meaningful for Aboriginal and non-Aboriginal students.

**Background**

The proliferation of research documents, government reports, and task force papers in recent years acknowledges the disturbingly low educational success rates for Aboriginal students. While a few isolated programs demonstrate exceptional successes, we need to ask and seek answers to the question: “How can the participation rate and achievement of Aboriginal students be increased in high school mathematics?” This question is not new and has been asked by the members of Aboriginal communities, educators, and policy-makers across the country for many years. Aboriginal voices have
been consistent and strong in demanding a change in the education for their children

(Indian Control of Indian Education, 1972; Gathering Strength, Vol.3, 1996; Task Force
on First Nations Education, 1999; Barriers to Equal Education for Aboriginal Learners,
2001; How are We Doing? Demographics and Performance of Aboriginal Students in BC
Public Schools, 2004, 2005; Education Action Plan, 2005). Over the years, many
national, provincial, and local Aboriginal education studies have indicated the inability of
public schools to meet the needs of Aboriginal learners, especially in mathematics
education. To continue with the status quo would be an injustice to the Aboriginal
children who, historically, have been denied an opportunity to develop to their full
potential. Aboriginal parents want their children to have a strong identity and also want
them to participate fully in the economic lives of their communities.

Aboriginal parents want education to prepare them to participate fully in
the economic life of their communities and in Canadian society. But this is
only part of their vision. Presenters told us that education must develop
children and youth as Aboriginal citizens, linguistically and culturally
competent to assume the responsibilities of their nations. Youth that
emerge from school must be grounded in a strong, positive Aboriginal
identity. Consistent with Aboriginal traditions, education must develop the
whole child, intellectually, spiritually, emotionally and physically. (Royal
Commission on Aboriginal Peoples, 1996, pp. 433-4)

In the Demographics and Performance of Aboriginal Students in BC Public
School, (2002, 2005, and 2006), and the Report Card on Aboriginal Education in British
Columbia (2005 and 2006), the performance of Aboriginal students in BC for the last
nine years was reported to have increased, though it remains at a significantly lower level
than that of non-Aboriginal students.
• By grade 7, Aboriginal students lag behind their non-Aboriginal classmates by about 20% in their performance of the Foundation Skills Assessment (FSA) in numeracy.

• By grade 10, the gap widens and only 47% of Aboriginal students meet the expectations in numeracy, compared to 77% of non-Aboriginal students.

• Over the last nine years, only 5-7% of Aboriginal students have written and passed the Principles of Mathematics 12 provincial exam, compared to 25-27% of non-Aboriginal students.

• In the same period, 38% of Aboriginal students completed their grade 12, and graduated from secondary school, while 77% of non-Aboriginal students graduated.

Table 1 shows the trends for the Numeracy Grade 7 results for the Foundation Skills Assessment (FSA) for BC. Table 2 compares the Principles of Mathematics 12 participation and success rates in BC for the last nine years. Both the participation and success rates of Aboriginal students across the country have similar patterns, even though the exact figures cannot be substantiated as the data from different provinces is not available due to the Freedom of Information Act.

---

1 The Foundation Skills Assessment (FSA) is an annual province-wide assessment of British Columbia students' academic skills administered each spring to Grade 4 and 7 students in public and provincially funded independent schools. It provides a snapshot of how well BC students are learning foundation skills in Reading Comprehension, Writing, and Numeracy.
Table 1. Numeracy Grade 7 results and participation of the Foundation Skills Assessment (FSA) for BC

<table>
<thead>
<tr>
<th>Year</th>
<th>1999/00</th>
<th>2000/01</th>
<th>2001/02</th>
<th>2002/03</th>
<th>2003/04</th>
<th>2004/05</th>
<th>2005/06</th>
</tr>
</thead>
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<tr>
<td>Prov. Participation Non Aboriginal</td>
<td>94</td>
<td>93</td>
<td>92</td>
<td>93</td>
<td>92</td>
<td>92</td>
<td>88</td>
</tr>
<tr>
<td>Prov. Participation Aboriginal</td>
<td>87</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>81</td>
<td>81</td>
<td>76</td>
</tr>
<tr>
<td>Prov. Meets Non Aboriginal</td>
<td>81</td>
<td>83</td>
<td>84</td>
<td>85</td>
<td>84</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td>Prov. Meets Aboriginal</td>
<td>54</td>
<td>58</td>
<td>61</td>
<td>64</td>
<td>63</td>
<td>63</td>
<td>67</td>
</tr>
</tbody>
</table>
Table 2. Principles of Mathematics 12 participation and success\(^2\) rates in BC from 1995/96 to 2003/04 the last nine years.

From large-scale testing like the FSA, concrete evidence is available about the disparity between the success rates of Aboriginal and non-Aboriginal students in numeracy. Clearly, more questions are being asked without answers. To improve this complex situation, multiple approaches are necessary. In the next section, I outline the organization of the thesis according to a framework of gathering, analyzing, and interpreting the data obtained from the interviews.

\(^2\) Success Rate is the students who received a grade of C- or better.
Organization of the Thesis

In Chapter 2, I argue that Numeracy is multiple layered and requires the ability to integrate mathematics, situated and contextual problem solving, and communication skills. Socio-cultural constructs of numeracy are defined and extrapolated from theoretical constructs of ethnomathematics, socio-cultural theory and situated learning to the context of indigenous learners. This chapter provides some of the key conceptual foundations for the thesis as a whole.

In Chapter 3, I explore the distinctive features and roots of Indigenous and modern epistemologies. I present the frameworks for Indigenous and modern epistemologies separately and conclude the chapter with a synthesis of building epistemological bridges. The literature review also uncovers some of the complexities of knowing mathematics, and the foundation of modern mathematics. This chapter exists as part of embracing the complexities of responding to different worldviews that many Indigenous students straddle when they learn mathematics.

Chapter 4 outlines the theoretical and practical aspects of the methodology for the study. Beginning with some of the pilot projects I conducted, I discuss how my research was located in a specific community having a substantial Aboriginal population. After a number of meetings, phone conversations, and emails, I decided that the most suitable place for me to conduct this study would be in Haida Gwaii, BC, which is affiliated with School District #50 (Haida Gwaii/Queen Charlotte). I also describe how the research participants were chosen, being comprised of role models, elders, professionals, educators, and community members. I end this chapter with my research questions and
the three facets to be informed by the study. First of all, how does the community of Haida Gwaii use mathematics and numeracy practices in their daily life? Second, how can such numeracy practices be integrated into the present curriculum taught in the schools so that all students will be interested in learning mathematics? Finally, I explore different ways of knowing that could increase success rates of Aboriginal students in school mathematics and math-related disciplines.

The results and analysis of the data is presented in the next three chapters of the thesis. Within each of these chapters, a number of conceptual categories are used into which the observed phenomena are grouped. The categories are descriptive and multidimensional and form the preliminary framework for the analysis. In Chapter 5, my aim is to humanize our view of mathematics and expand on the mathematical thinking of a specific community. The people of Haida Gwaii are described by how they “Do the math” in their daily lives. Many connections are shown between the types of problems people solve in their daily lives and the mathematical concepts that are taught in school mathematics. These connections are examined in conjunction with the concepts of situated learning, community of practice, and ethnomathematics.

Chapter 6 provides details about some of the issues in teaching and learning, through the “Honoring the Voice of Educators-Change Agents”. What works, and what needs to be changed to improve the quality of teaching and learning are analyzed through the lens of community connection, pedagogical implications, and relevance. A rich math community begins with the classroom community, but must also include the greater school community, the home and family community, and the outside community.
Chapter 7 articulates the voice of Role Models, elders and community members. Different people focus on different aspects of the issues and offer their points of view based on their personal experiences in the community. Many students find it difficult to make connections between concepts of mathematics which they learn in school with what they are using in their daily lives. By mediating meaning and different ways of knowing for Aboriginal students and showing them how traditional and contemporary cultural activities have many mathematical concepts embedded within them, they can be motivated to learn. In Chapter 8, I draw on the results, analyses, and conclusions from previous chapters to synthesize conclusions of the study as a whole, and provide answers to the research questions.
CHAPTER TWO -
Multiple layers of Numeracy

Introduction

Numeracy means different things to different people. In this chapter I will argue that numeracy is multiple layered that requires the ability to integrate mathematics, situated and contextual problem solving, and communication skills. Numeracy is multiple layered: it is an entity, an embodied disposition, a language, a practice, and a cultural activity. Current school reform initiatives acknowledge the importance of connecting school mathematics with students' own experiences in social and cultural contexts. Overall, this chapter presents some of the key conceptual foundations for the thesis as a whole.

Numeracy the Entity (Definition)

Various definitions of numeracy share an emphasis not on mastering specific mathematical content but on the ability to use mathematical knowledge and problem solve. The BC Ministry of Education, for example, has adapted the following definition:

Numeracy can be defined as the combination of mathematical knowledge, problem solving and communication skills required by all persons to function successfully within our technological world. Numeracy is more than knowing about numbers and number operations.

(BCAMT, 1998, p.1)

According to the BCAMT numeracy involves the functional, social, and cultural dimensions of mathematics. Numeracy is the set of math skills needed for one's daily functioning in the home, the workplace, and the community. Beyond daily living skills,
numeracy is now being defined as the mathematical knowledge that empowers citizens for life in their particular society (Bishop, 1993). ABC CANADA Literacy Foundation (2005) defines numeracy on its web site as follows:

![WHAT IS NUMERACY?](http://www.abccanada.org/math_literacy/)

**Figure 1. What is Numeracy?**

Such a definition is limiting as it does not take into consideration spatial perception, symbolic reasoning, or graphical representation. In order for today's students to be prepared to succeed as productive members of a society that is profoundly influenced by technology and mathematics it is essential that they have some competence in the area of mathematics. Numeracy is not a case where either one is proficient or not, rather individuals' skills are a continuum of different purposes and levels of accomplishment with numbers.

Hughes, Desforges, Mitchell, & Carre (2000) consider numeracy as more about the ability to use and apply rather than just knowing. Evans (2000) regards numeracy as the ability to process, interpret and communicate numerical, quantitative, spatial, statistical, even mathematical, information, in ways that are appropriate for a variety of
contexts, and that will enable a typical member of the culture or subculture to participate effectively in activities that they value.

The International Life Skills Survey defines *quantitative literacy* in a comprehensive manner as follows:

An aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication capabilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work. (ILSS, 2000)

The Organisation for Economic Co-operation Development (OECD) in their Programme for International Student Assessment (PISA) adopts a similar definition, but calls numeracy *mathematical literacy*:

An individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded mathematical judgments and engage in mathematics in ways that meet the needs of that individual's current and future life as a constructive, concerned and reflective citizen. (PISA, 2000)

The Mathematics Council of the Alberta Teachers' Association (2004) and other organizations have often interchanged the terms *mathematical literacy* and *numeracy*. The term numeracy tends to be more commonly used in the United Kingdom, Australia, and Europe, while the term mathematical literacy is more commonly used in North America and South Africa (Clarke, Cheeseman, Sullivan, & Clarke, 2000; Wright, Martland, Stafford, & Stanger, 2002). Generating a concise but complete definition for either term is a difficult task. "Numeracy is not the same as mathematics, nor is it an alternative to mathematics. Rather, it is an equal and supporting partner in helping students learn to cope with quantitative demands of modern society" (Steen, 1990, 13
In some definitions, numeracy is seen as contextualized and situated, and takes into account one's culture, the culture of others, and daily living. Consideration must be given to real-life situations, be it generative computational skills, interpretive skills, or decision making skills (Gal, 2000). Steen (2001) identifies five different dimensions of numeracy, depending on the situation:

- Practical - for immediate use in the routine tasks of life;
- Civic - to understand major public policy issues;
- Professional - to provide skills necessary for employment;
- Recreational - to appreciate games, sports, lotteries;
- Cultural - as part of the tapestry of civilization.

Regardless of the source and difference, however, there exists a common theme in all the definitions, namely, the ability to use, interpret, and communicate mathematics in context. Simply put, numeracy is ‘Math in Action’.

**Numeracy the Embodied Disposition (Being Numerate)**

What does it mean for a person to be numerate? Withnall (1995) states that a numerate person is one who possesses the math skills required for everyday functioning in the home, the workplace, and the community. However, such skills are “not a fixed entity to be earned and possessed once and for all” (Steen, 1990, p. 214). The Queensland School Curriculum Council (2001) numeracy position paper defines a numerate person as one who is confident in using her own and others’ mathematical know-how to deal with everyday situations. The British Columbia Association of Mathematics Teachers in its
brochure on numeracy, suggests that a numerate individual should possess a variety of mathematical skills, knowledge, attitudes, abilities, understanding, intuition, and experience, all of which could be expressed as the number sense, the spatial sense, the statistical sense, and the sense of relationship (BCAMT, 1998). According to the Australian Association of Mathematics Teachers (1997), to be numerate is to use mathematics effectively to meet the general demands of life at home, paid work, and participation in community and civic life. Johnston (1994) argues,

to be numerate is more than being able to manipulate numbers, or even being able to succeed in school or university mathematics. Numeracy is a critical awareness which builds bridges between mathematics and the real world, with all its diversity... In this sense...there is no particular level of mathematics associated with [numeracy]: it is as important for an engineer to be numerate as it is for a primary school child, a parent, a car driver or a gardener. The different contexts will require different mathematics to be activated and engaged in" (p. 34).

A numerate person does not need to possess or lack a set of discrete skills, but have the 'practices and dispositions' or 'skills and abilities' perceived to be needed to meet the numeracy demands of a situation.

In the *BCAMT K-12 Survey*, 99% of the respondents agreed or strongly agreed that numeracy should be valued as a necessary lifelong skill. Though there was some disagreement about the minimal attributes of a numerate person, all agreed that a numerate person should be able to solve problems and confidently negotiate through necessary life skills (BCAMT, 2004). Such skills are usually driven by issues that are important to one's place of residence and employment.
Numeracy the Practice

Cajete (1999, p.162-179) suggests a model with multidimensional approaches that is centered with creativity as a learning process, and with the perspective of science as a cultural system of knowledge. Such a model can also be extrapolated to numeracy the practice where students could learn through creative processes and culturally meaningful communication.

The following curriculum model is adapted from Cajete (1999) which recognizes and provides for the integration of the intuitive and rational thought processes. A process which would include metaphoric thinking, problem solving, exploring, innovating, and transforming.

1. An understanding and application of the metaphoric thought process. Metaphoric thinking is closely linked with the process of imaging in creativity. Metaphors allow for expansion and elaboration of creative insights such as synthesis, intuition, and the process of relationships.

2. The understanding and application of appropriate strategies that address the brain patterned learning styles of students. Characteristics and potential of the “whole” brain need to be addressed. The mutual and reciprocal interrelationship between the right and left brain processes needs to be reinforced.

3. Teaching for creativity in science and mathematics by exposing students to creative problem-solving techniques and facilitating their awareness of their own creative abilities and potential.
4. The development and application of situational learning contexts where there is a specific interface between science, mathematics and culture. The identifying of mathematics with the cultural identity of the student is a basic intent of this curriculum approach. Contexts, situations and phenomena in the immediate environment, the home, community or school are all sources for curriculum content.

5. The facilitation of opportunities for student growth and development in their abilities to deal with and adapt to changing environmental influences by setting up a scientifically challenging situation that stimulates creative problem-solving. Establishing learning situations that are experientially based and help students develop their inquiry skills.

6. An understanding and application of interdisciplinary perspectives concerning science, culture, and creativity. Activities involving drawing, construction, or artistic exemplification of science or math concepts allow for a fuller expression of culturally-related ideas and for more complete involvement in the learning process.

The above model characterizes teaching and learning, as cyclic, multi-dimensional, multi-directional, and in a constant state of flux. Culture is intimately connected with the nature and expression of the scientific and mathematical thought process. Such a model would develop a contemporary, culturally based educational process founded upon traditional values, orientations, and principles, while simultaneously using the most appropriate concepts, technologies, and content of mathematics education. Cajete's curriculum model would connect with the NCTM Principles and Standards which calls for a common foundation where all students should actively build new knowledge from experience and proper knowledge to be able to
understand and use Mathematics. Teachers can help students to recognize that science and math are both creative processes and cultural systems of knowledge.

**Numeracy the Language**

Steen (1990) implies that numeracy has the same relationship to mathematics as literacy has to language. Each represents a distinctive means of communicating with others depending on the cultural context. There is some tension between narrow and broad interpretations of literacy and numeracy—particularly between their practical benefits and cultural effects—as they must be taught in a realistic context to sustain motivation and to ensure mastery. Just as the term literacy, defined in the Compact Oxford English Dictionary as the ability to read and write, implies the everyday use of letters in the process of communication, numeracy must involve the everyday practical use of numbers. Moreover, the way in which we use these two words influences the way we think.

Literacy is the cornerstone of education. It includes not only reading and writing skills, but the fluency with which one is able to communicate in a language. Literacy has become a cross-curricular concept with shared responsibilities. It is considered the key to lifelong learning where families and communities must be supported and encouraged to promote it. Most areas of the curriculum make demands on students’ mathematical knowledge, understanding, abilities, and skills. Hence, numeracy is an intersecting set of literacy practices. A student’s level of numeracy is a significant component of his or her literacy level. Like literacy, numeracy is a set of cultural practices that reflect the particular values of the social, cultural, and historical contexts of society. Without the
ability to understand basic mathematical ideas, one cannot fully understand polls from contested elections to sports statistics, from stock scams and newspaper psychics to diet and medical claims, sex discrimination, insurance, lotteries, and drug testing (Paulos, 1998).

The distinction between numeracy and mathematics creates a curricular and pedagogical challenge for all educators who have a role in developing an individual’s numeracy (AAMT, 1997). While numeracy is related to mathematics, for reasons already given, the two terms are not synonymous or equivalent. Having mathematical knowledge such as the system of ideas involving numbers, patterns, logic, and spatial configuration contributes to being numerate, but such knowledge in isolation is not sufficient for learners to become numerate. Numeracy and mathematics should be complementary aspects of the school curriculum, since both are necessary for life and work, and one overlaps the other.

Numeracy is a socially based activity that requires the ability to integrate math and communication skills (Withnall, 1995). Since language is a function of both thought and culture, the ability to use and communicate with mathematics is important. Mathematics has its own culture as well; it possesses a language and a set of norms. It should be embedded in cultural activities that involve everyday tasks and solve everyday problems (Nunes, 1992). People of different cultures and different eras have engaged in mathematical activities to solve the problems they encountered in their daily lives. For example, they devised numbering systems, counted objects, constructed homes, and designed works of art based on mathematical principles. Perhaps they didn’t give the
name mathematics to these activities or attach the title mathematician to the people who invented the concepts, but the basic strands of number, spatial, statistical, and patterns that we practice today have resulted from their efforts.

During the field work of this study in Haida Gwaii a number of elders and community members indicated that they didn’t use mathematics in their daily lives. However, as the interviews progressed it was evident that they did use mathematical activities such as: counting, measuring, designing, locating, and explaining. This will be discussed in detail in Chapter 5.

**Numeracy the Cultural Activity**

Bishop (1988) asserts that mathematics is present across cultures as a human activity, a statement supported by numerous other authors (Ascher, 1991; D’Ambrosio, 1985; Joseph, 1991; Nunes, 1992; Powell & Frankenstein, 1997; Zaslavsky, 1991). Bishop et al. go on to argue that different cultures use mathematics in different ways. The abstraction and the symbolic characteristics that we commonly associate with mathematics have not appeared in every culture. Rather, common mathematics is frequently of an informal nature and part of indigenous knowledge. This can be seen in the mental math used by bazaar merchants in the Middle East, the navigational practices of South Pacific islanders, or the carving of a totem pole in Haida Gwaii. Indisputably, “an enormous range of mathematical techniques and ideas has been developed in all parts of the world” (Bishop et al., 1993, p. 6).
Bishop (1988) identifies six activities as mathematical practices found in every culture: counting, measuring, designing, locating, explaining, and game playing. Bishop’s classification scheme, which is elaborated below, could be used to connect school mathematics curricula with cultural practices to form the basis of what we might consider numeracy across cultures.

**Counting**

From the beginning of time people have needed a way to keep a record of their possessions. Folklore tells us that counting emerged from one-to-one correspondence with objects found in the natural environment. The ordered number names correspond to the objects of the count. The most elementary counting system was probably “one, two, and many” (Bishop, 1988, p. 23). Children usually learn basic number names before starting school. Different cultures have used different number systems of a cyclic pattern and varying cycle length, or different counting systems for different kinds of objects.

**Measuring**

This activity involves the use of certain units found in the environment. At one time, parts of the body provided a convenient standard unit of measure. Developmentally, measurement begins with a comparison between two objects, then extending to many objects and dimensions. Common measured attributes are length, area, volume, weight, temperature, speed, and duration.
Designing and Building

Different cultures have different design traditions: carving, basketry, garments, buildings, weaving, pottery, patchwork, etc. Characteristic designs with fine workmanship and ornate patterns can be found in many indigenous cultures. The essence of design is to combine the functional with the aesthetic: carving a tree stump into a totem pole or making a cooking pot out of clay.

Locating

Most societies have developed ways to code and symbolize their position within the spatial environment. Finding and knowing one's position in space is essential for directed movement from one place to another. Locating includes the notions of forward and backward, the directions of the compass, left and right orientation, routes between places, and points of reference (absolute or relative).

Explaining

Formally or informally, people try to make sense of things and issues. The success of this undertaking depends on organizing and interpreting data. Some explanations appear as logical commentaries, often formal and abstract, as in mathematical proofs, or stories of origin. Others may be informal, such as giving someone directions to their destination, or telling oral histories. Whatever the situation, mathematical notions commonly appear in explanations that people share with one another.
Game Playing

People in most cultures play games, develop and solve puzzles, and pose riddles. Many games use patterns, strategies, as well as geometric shapes and structures. Some games of chance and some gambling games can be found across different cultures around the world. These activities have sets of rules, guidelines, or parameters which the players must observe. Interestingly, some people see mathematics itself as a game that requires following rules and formulating strategies to reach conclusions.

Bishop (1988) has attempted to bridge mathematics in school and culture by connecting a student’s experience with mathematics to his or her everyday experiences. In the next section socio-cultural constructs of numeracy are defined and extrapolated from the theoretical constructs of ethnomathematics, socio-cultural theory, and situated learning to the context of Indigenous learners.

Numeracy: Socio-Cultural Constructs

Ethnomathematics

In the introduction to the UNESCO publication, Significant influences on children’s learning of mathematics, Bishop et al. (1993) make a bold statement that “there is no sense in regarding mathematics learning as abstract and culture free...[since] the learner cannot be abstract and context free (i.e. free of societal influence)” (p. 1). Ethnomathematics has been identified as the study of mathematics that takes into consideration the culture in which mathematics arises (Ascher, 1991; Bishop, 1988; D’Ambrosio, 1985; Zaslavsky, 1991). D’Ambrosio (1990) also defines ethnomathematics in the following way: “Resorting to etymology, the term
ethnomathematics is introduced as the art or technique (tics) of explaining, understanding, coping with (mathema) the socio-culture and natural (ethno) environment” (p. 22). Ethnomathematics could also be regarded as the pedagogy of understanding content knowledge within a cultural context. I have represented this idea visually as a set of intersecting circles in the Venn diagram below.

**Culture and Context**

![Venn Diagram](image)

**Figure 2. Aspects of Ethnomathematics**

Ethnomathematics seeks to identify the diverse ways in which cultural groups quantify, compare, classify, measure, and explain day-to-day phenomena in their own environment. D'Ambrosio (1985) defines cultural groups broadly, including such considerations as language, codes of behaviour, myths, symbols, work, and political and religious values. In a subsequent work (1990), he acknowledges the need to consider a holistic view of mathematics that includes one’s culture, the culture of others, language, and the algorithms we use and combine to construct individual abilities or even disabilities in mathematics. Ethnomathematics, in essence contributes to bringing the
human dimension back into mathematics. It has typically been defined as the study of mathematical concepts in cohesive social groups, with an emphasis on small-scale or indigenous cultures. Working in many different areas of the world, Ascher (1991), Barton (1996), Closs (1986), D'Ambrosio (1990), Eglash (1999), Gerdes (1991), and Zaslavsky (1973), have provided mathematical analyses of a variety of indigenous practices, while drawing attention to the role of conscious intent in these practices. These authors have described cultural activities from a mathematical point of view demonstrating the idea that much human activity has, from the earliest times, been mathematical in form – that mathematical activity is not the preserve of mathematicians.

Barton (1999) claims that the use of ethnomathematics as a theoretical tool can be seen as a practical way of acknowledging the reflexivity of [the] relativistic viewpoint: it is the differing conceptions of the field which make it a valuable tool in ongoing political and educational debates. We acknowledge that our own conceptions are context-derived, but use that knowledge to continue our work (p. 34).

Powell and Frankenstein (1997) challenge the Eurocentric paradigm prevalent in mathematical education with respect to curricula and pedagogy. They focus on the following specific challenges to the Eurocentric myth:

- Ethnomathematical knowledge;
- Uncovering distorted and hidden history of mathematical knowledge;
- Considering interactions between culture and mathematical knowledge;
- Reconsidering what counts as mathematical knowledge;
- Ethnomathematical praxis in the curriculum;
• Ethnomathematical research.

Mathematics is a collection of progressive discoveries and inventions from cultures around the world during different times. We can gain a much deeper understanding of the subject if we think of mathematics as the development of structures and systems of ideas involving numbers, patterns, logic, and spatial configuration and then examine how different cultures develop and use mathematics. Ethnomathematics, unlike the school mathematics, is both context-relevant and problem-specific thus provides the necessary linkage between the everyday cultural practices of mathematics and the teaching of school mathematics. Ethnomathematics provides a framework in which to consider how the dominant Eurocentric or Western discourse has influenced our ability to see and represent the many significant contributions that other cultures, including Indigenous cultures, have made in the field of mathematics (Powell & Frankenstein, 1997). According to Ascher (1991),

A critical issue is that, as it stands, much of mathematics education depends upon assumptions of Western culture and carries with it Western values. Those with other traditions are, as a result, often turned away by the subject or unsuccessful in learning it. And, for them, the process of learning mathematics, particularly when unsuccessful- can be personally debilitating as it detracts from and conflicts with their own cultural traditions, conceptual categories and world view. (p. 195)

In the last decade, many scholars have acknowledged the need to adopt a socio-cultural perspective in the study of mathematics and mathematics education (FitzSimons, 2002). Ethnomathematics can be applied as a socio-cultural framework for the learning and teaching of mathematics. A socio-cultural perspective of mathematics would offer a different lens through which to view student success, curricular content, historical contributions, and educational practices.
The learning of mathematics has often been associated with a belief that mathematics is a boring, difficult, and dry subject. This socially constructed attitude towards mathematics creates anxiety and phobia, which promotes innumeracy. Paulos (1988) defines "innumeracy" as an inability to deal comfortably with the fundamental notions of number and chance. Innumeracy could lead to individual decisions and broader policy decisions made on the basis of badly understood statistics, data, patterns, and mathematical principles. Teachers need to be aware of the complexity of cultural and social contexts in which their students become numerate. According to Vygotsky's socio-cultural theory (1986) and Lave and Wenger's situated learning knowledge (1991), learning is constructed in a social context.

Socio-Cultural Theory

The key to Vygotsky's socio-cultural theory (1986) is the belief that we learn from others in an environment that is culturally based. Vygotsky emphasizes the need for a child to interact with those who have more experience and knowledge, usually older children or a teacher. Vygotsky uses the term zone of proximal development to describe the teachable range between the student's current knowledge and the knowledge that the student is expected to acquire. Vygotsky also believes that children have their own mathematical understanding and beliefs based on their experiences, but it is the teacher's role to influence students to reach higher levels of thinking and knowing. Finally, students are more able to solve problems with assistance from an adult or a more able peer than they are on their own.

What lies in the zone of proximal development at one stage is realized and moves to the level of actual development at a second. In other words, what
the child is able to do in collaboration today he will be able to do independently tomorrow. (Vygotsky, 1986, p. 206)

Thus, the zone of proximal development is defined by both the student’s psychological developmental level and the social environment. Group interaction, with its social and linguistic components, is critical to the development of mental operations. Hence, language is a vital instrument for the development of thought, particularly since children tend to internalize the talk heard in a group situation.

When we view the learning of mathematics or numeracy through the Vygotskian lens, we see that students use their play experiences to develop their understanding of everyday concepts. Their rich cultural environment provides them with a stimulating area for meaningful learning. This educational process needs to be replicated in the mathematics classroom, where social interaction should be integrated with the teaching of formal mathematical concepts. The language of schools is culturally specific, and teachers should not assume that all students have the same Eurocentric cultural background or context for understanding concepts.

**Situated Learning**

Lave and Wenger (1991) argue that learning as it normally occurs is a function of the activity, context, and culture in which it occurs (i.e., it is situated). Social interaction is a critical component of situated learning—learners become involved in a community of practice, which embodies certain beliefs, attitudes, skills, and practices to be acquired. The meanings we make through our participation or practice in the communities within which we interact, are necessarily negotiated. Since social circumstances and
relationships are constantly changing, so must the relationships adapt to these changes. As individuals participate in more than one community of practice, so do different communities interact with each other.

Classroom learning activities could involve multiple communities of practice. As the beginner or novice moves from the periphery of this community to its centre, he or she becomes more active and engaged within the culture and hence assumes the role of the expert or elder. Lave and Wenger (1991) call this process *legitimate peripheral participation*. "Thus the concept of legitimate peripheral participation obtains its meaning, not in a concise definition of its boundaries, but in its multiple, theoretically generative interconnections with persons, activities, knowing, and world" (p.121). Hence, school mathematics is a form of situated learning, which needs to take place within a context. The context needs to be mathematically meaningful to the learner, and the curriculum should make sense of the local social and cultural situations.

*Indigenous Cultural Context*

Aikenhead (2002) points out that Aboriginal or Indigenous student bring with them a diverse cultural background. Their way of knowing and learning is influenced by what they have learned from their families, friends, elders, and teachers. Some students also carry the burden of social issues such as poverty, dysfunctional families, substance abuse, and racism. Central to ethnomathematics is the tenet that indigenous children should be advantaged by their own cultural identity and language. Indigenous students have the potential to see the world from at least two very different points of view: the dominant culture and their own culture. By linking indigenous and other worldviews of
mathematics in the classroom, teachers can develop strategies for effectively teaching their students' multiple perspectives in numeracy (Cajete, 1986, 1999; Kawagley, 1995).

Since students learn in a variety of ways and at different rates, it is also important to synthesize the interrelationship between creativity, culture, and some of the multiple intelligences. Literature in the field suggests that most Indigenous communities use informal learning systems: Indigenous children learn from family and community members through modeling and imitation (Cajete, 1986, 1999; Kawagley, 1995). More accurately, traditional approaches to learning in indigenous communities rely heavily on situated learning / legitimate peripheral participation. However, in contemporary Indigenous communities these processes are only partially still functional where the learning is largely oral, with storytelling being one of the ways to convey important concepts. Often elders or other community mentors are the chief conveyors of traditional or cultural knowledge, which is a lifelong endeavour (Nichol, R., & Robinson, J., 2000).

According to the *Principles and Standards for School Mathematics* (2000), "mathematics is one of the greatest cultural and intellectual achievements of humankind, and citizens should develop an appreciation and understanding of that great achievement, including its aesthetic and even recreational aspects" (p. 4). The NCTM *Principles and Standards for School Mathematics* (2000) document advocates a broader and more meaningful mathematics curriculum that is responsive to changing societal priorities and to changes in instructional practice that meet the needs of a far greater proportion of the student population than has been true in the past.
NCTM Principles and Standards for School Mathematics

National Council of Teachers of Mathematics (NCTM) released the *Curriculum and Evaluation Standards for School Mathematics* in 1989. These standards were updated with a renewed interest in educational standards and re-released in 2000 as *Principles and Standards for School Mathematics*. In both the documents the idea was to shift away from isolated facts and memorization of procedures, and move towards conceptual understanding and problem solving. The six Principles and ten Standards constitute a vision to guide educators as they strive for the continual improvement of mathematics education in classrooms, schools, and educational systems.

The six Principles for school mathematics address overarching themes of: Equity, Curriculum, Teaching, Learning, Assessment, and Technology. These Principles can influence the development of curriculum frameworks, the selection of curriculum materials, instructional decisions in the classroom, integration of technology, the design of assessments, and the establishment of ongoing professional development for teachers.

The ten Standards describe what mathematics instruction should enable students to know and do. They specify the understanding, knowledge, and skills that students should acquire from pre-kindergarten through grade 12. These ten Standards are divided into two groups titled Content and Process. The five Content Standards (Number and Operations, Algebra, Geometry, Measurement, Data Analysis and Probability) explicitly describe the curriculum or the content students should learn in their mathematics classes. The five Process Standards (Problem Solving, Reasoning and Proof, Communication, Connections, and Representation) are interwoven throughout the curriculum to provide a context for learning and teaching mathematical knowledge.
The NCTM *Principles and Standards* calls for a common foundation where students are able to understand and use Mathematics:

- For life
- As part of a cultural heritage
- For the workplace
- For the scientific and technical community

(NCTM, 2000, p.4)

Partnerships need to be developed with families, other caregivers, and community members to promote numeracy and change societal attitudes towards mathematics to reflect the fact that mathematics is inherent in everyday living and it enables us to solve a variety of situated and contextual problems. NCTM's equity principle states that "equity does not mean that every student should receive identical instruction: instead, it demands that reasonable and appropriate accommodations be made as needed to promote and access attainment for all students" (NCTM, 2000, p. 12).

**Summary**

Numeracy isn’t just about mathematics, which is an abstract construct; it is about mathematics situated in culture. Numeracy has multiple layers and should be linked and contextualized. Familiar contexts can make mathematics more accessible to those who have been alienated from it. Relevant learning experiences should be designed to challenge the learner’s understanding and extend his or her knowledge to a personal context. Learning activities should be culturally valid and educationally sound. Teachers
need to select culturally oriented learning activities that can be used in the study of appropriate topics in mathematics.

D'Ambrosio (2007) reminds that he first used the word ethnomathematics in 1977 as a conceptual word. It was designed to have a broad idea “to understand how knowledge is generated, how it is organized and how it is diffuse in different cultural environments. Once we recognize influence of culture in knowing and doing, we are within the scope of the Program of Ethnomathematics” (p. 3). As already mentioned, the framework of ethnomathematics can also be used to identify the mathematics that exists in a cultural activity. However, there is tension when the term ethnomathematics is used in such a way. Does the mathematics exist in the observed activity, or is it in the person observing the activity? The answer to this question is not clear. In some activities the mathematics is explicitly present; in other activities the mathematics is only identifiably present because of the impositions of the observer. However, it is not my intention to answer these questions. My intention is to identify cultural activities that can have curricular mathematics associated with them - whether that mathematics exists explicitly or only by my imposition - so that curricular mathematics can be made to appear more culturally relevant to the students of Haida Gwaii. In so doing, I will identify cultural activities as being numeracy activities.

Different definitions emphasize different aspects of the term numeracy. For the purposes of this study my working definition of numeracy will be as follows:

Numeracy is the set of mathematical skills needed for one’s daily functioning in the home, the workplace, and the community. It is the
willingness and capacity to solve a variety of situated and contextual problems that could be functional, social, and cultural.

Today's mathematics curriculum from pre-kindergarten to Grade 12 is in most cases limited to the major successes of the Eurocentric world. Students of Indigenous and multicultural heritage frequently face the challenge of learning in an environment that may undervalue or ignore their cultural backgrounds. *Principles and Standards for School Mathematics* (NCTM, 2000) calls for a common foundation of mathematics to be learned by all students. It also advocates the need to learn and teach mathematics as a part of cultural heritage and for life. Achieving this goal requires a paradigm shift in the way mathematics is taught and the introduction of culturally inclusive curricula and pedagogy. Trentacosta (1997), in the NCTM Yearbook *The Gift of Diversity*, presents a vision of how classroom practices can embrace and celebrate diversity as well as ensure a powerful mathematics program for all students. Learning activities should build upon a student's prior knowledge and present mathematics in an exciting and inclusive way. Context combined with content should direct teaching in the ongoing cultural quest for knowledge. Partnerships need to be developed with educators, elders, parents, policymakers, and others in the community to promote numeracy and change societal attitudes towards mathematics.
CHAPTER THREE -
Indigenous and Modern Epistemologies
in the Learning of Mathematics

Introduction

How do children construct their knowledge of mathematics? Educational theorists and philosophers have attempted to answer the above question for centuries, and the debate continues. The very word mathematics is derived from the Greek word mathema to mean “learning, study, science.” There are many different definitions of the word mathematics. Devlin (2000), for example, states that “mathematics is the science of order, patterns, structure, and logical relationships” (p. 74). Whatever the definition, there are different beliefs how children construct their knowledge. Some believe that mathematics should be studied in order to better understand other objects within our world, and knowledge can be gained through reasoning. Others view mathematics as the result of the study of those objects where knowledge is gained through sensory experiences. There is also the belief that all knowledge is "constructed" through human perception and social experience. Educators have tackled this issue with a range of ideas and theories including: cognitive, socio-cultural, constructivist, behaviorist, multiple intelligences, and cooperative learning.

This chapter is a literature review uncovering some of the complexities of knowing mathematics, and the foundation of modern mathematics. Teaching mathematics is one thing but learning mathematics is another thing. Improving the learning of mathematics is connected with epistemology. This chapter exists in part as a way to embrace the complexity that comes from responding to the different worldviews.
that many Indigenous students straddle when they learn mathematics. The word *Indigenous* in this chapter and throughout the document can be interchanged with the terms: Aboriginal, Native Indian, First Nations, Native or Aborigine. The word *Modern* in the context of this chapter represents the Western or Eurocentric ways of knowing. This chapter discretely presents some of the distinctive features, roots, and frameworks for Indigenous and Modern epistemologies. The frameworks are established by answering the following questions. What are some of the distinguishing characteristics in each of the worldviews? What are some of the foundations of modern mathematics taught in schools today? In the final section the question of whether it is possible to integrate these worldviews within a single educational approach will be addressed.

The modern epistemology of mathematics constructed with Cartesian-Newtonian ways of knowing used to be the only reality discussed in academic circles. Tarnas (1991) shows how the Cartesian-Newtonian worldview of linear, cause-effect logic exerts a strong influence throughout western thought not just in scientific thinking and methodology but also throughout subsequent philosophy. Recently, educators and elders of Indigenous knowledge have engaged in a critique of Modern epistemological tyranny and the oppressive educational practices that follow it (Battiste & Barman, 1995; Cajete, 1999; Davison, 2002; Kavanagh, 2006). It is important to acknowledge that Modern pedagogy is not necessarily oppressive, just as Indigenous pedagogy is not necessarily empowering.

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3 It is important to note that one does not make an assumption that the term *Modern* equates to advanced or sophisticated, and the term *Indigenous* equates to primitive. Each term represents a different worldview, and there is no single unified Indigenous worldview.
Indigenous civilizations have been compared with the knowledge generated by Modern mathematics. Some educators are starting to challenge this status quo epistemology to make sense of the interconnected social, physical, and spiritual ways of knowing.

**Indigenous Epistemology**

Knowledge is the condition of knowing something with familiarity gained through experience or association. The traditional knowledge of northern aboriginal peoples has roots firmly in the northern landscape and a land-based life experience of thousands of years. Traditional knowledge offers a view of the world, aspirations, and an avenue to ‘truth’, different from those held by non-aboriginal people whose knowledge is based largely on European philosophies. (Department of Culture and Communications, Government of the Northwest Territories, 1991, p.11)

The work of Cajete (1994, 1999), Kawagley (1995), Ermine (1995), and Semali and Kincheloe (1999) provide perspectives on Indigenous worldviews and knowledge. Each author explores different aspects of the debate on Indigenous knowledge both in the west and elsewhere. It is difficult to encompass the whole meaning of Indigenous knowledge; each time we try to reconstruct Indigenous knowledge into another language we rewrite its meaning. This, along with its deconstruction, strip a rich tapestry from Indigenous knowledge, as it is interwoven with thought, experience, language and relationships that characterize Indigenous cultures.

*Gregory Cajete*

Cajete (1994) uses the metaphor of tracking and the symbol of concentric circles to provide a visual representation of the interconnectedness of knowledge. “Knowledge grows and develops outwards in concentric rings. Concentric rings can also form the basis of learning, how to track ideas and intuitions; how to observe fields of knowledge;
and how to see patterns and connections in thought and natural reality" (p. 123). He also represents the integrated concentric rings of relationships among seven courses in the "Curriculum Mandala." The seven courses are founded on the shared metaphor and meanings of sacred directions among Native American tribal groups. Each of the circles represents rich sources from which to originate discussion of the nature and dynamic expression of creative thought based on metaphoric representations of Native American perceptions of the natural world.
Cajete (1999) states that the goal of basic education is to provide self-knowledge, "seeking life through understanding the creative process of living, sensitivity to and awareness of the natural world, knowledge of one's role and responsibility in the social order and receptivity to the spiritual essence of the world" (p. 54). The contexts through which knowledge is gained are "through experiential learning (learning by doing and..."
seeing), storytelling (learning by listening, imagination), ritual/ceremony (learning through initiation), dreaming (learning through the unconscious and imagery), the tutor (learning through apprenticeship), and artistic creation (learning through creative synthesis)" (p. 55).

Oscar Kawagley

Oscar Kawagley is a Yupiaq Inuit who, as an Indigenous person and Western-trained science educator and researcher, integrating respectful knowledge of the reciprocity of nature, and his own education in science as it is taught in Western schools. Kawagley (1995) outlines how all learning and knowledge should start with what the student and community know and are using in their daily lives. To help students begin to understand these phenomena, Indigenous knowledge is connected with the five basic elements of the universe: earth, air, fire, water, and spirit. The sacred gifts of each must be understood, as well as the human activities that contribute to the sustainability or destruction of these life-giving gifts. To be holistic, the curricular activities must include Indigenous language and culture, language arts, mathematics, social studies, arts and crafts, and sciences. All must be interrelated as all of Earth is interrelated.

In using the five elements of life to teach, it is extremely important to assure that each element is a gift to the life-giving forces of the living Earth. The teacher must be careful to explain that those gifts are absolutely necessary for life on Earth to continue. Yupiaq people honor and respect these gifts in their rituals and ceremonies, incorporating all five elements in mutually reinforcing ways.
Yupiaq knowledge is based on a blending of the pragmatic, inductive, and spiritual realms. Mystical knowledge cannot be gained merely by observation, which is the main basis for rational knowledge. To obtain mystical knowledge, observation must be coupled with the participation of the whole being (mind, body, and soul) and with the universe. Culture influences our state of mind; stories and the imagination affect the attitudes and values of the mind (Kawagley, 1995).

Willie Ermine

Aboriginal or Indigenous epistemology requires an acceptance that knowledge exists in many forms, including the tangible and intangible. “Those who seek to understand the reality of existence and harmony with the environment by turning inward have a different incorporeal knowledge paradigm that might be termed ‘Aboriginal epistemology’...The inner space is that universe of being within each person that is synonymous with the soul, the spirit, the self, or the being” (Ermine, 1995, p.103). Indigenous Peoples do not seek understanding, nor convey cultural teachings within the group through objective processes. Rather, knowledge is provided so that the learner must integrate the intangible elements of self within the comprehension process. One’s personal set of kinship, experiences, relationships, knowledge of community practices, spirituality and history are all part of Aboriginal epistemology. Indigenous Knowledge comprises a complex system of reciprocity that must be understood by the learner in order to maintain equilibrium within the world. Indigenous Knowledge differs from region to region and is grounded in the particular environment and culture from which it has emerged.
Semali and Kincheloe (1999) outline the dilemma faced in defining Indigenous knowledge, because the context varies for millions of the world's Indigenous peoples. Central to the postmodern and postcolonial debates is "the origin of knowledge and the manner in which it is produced, archived, retrieved and distributed throughout the academy" (p. 4). Semali and Kincheloe (1999) urge caution and care with respect to who should be talking about Indigenous knowledge. The appreciation of Indigenous epistemology can provide Western peoples with "another view of knowledge production in diverse cultural sites," while at the same time situating Western knowledge in its own cultural setting, rather than a universal one. Studying Indigenous knowledge fosters "greater awareness of neo-colonialism and other Western social practices that harm Indigenous peoples," and serves as a reminder that "traditional knowledge has been lost and world views have been shattered."

**Framework for Modern Epistemology**

The framework for modern epistemology has been influenced by many educational theorists and philosophers. These forefathers of modern epistemology include John Locke, Jean-Jacques Rousseau, John Dewey, Jean Piaget, and Lev Vygotsky. Their respective theories are defined, and their ideas create contradictions and tensions, which are very much part of the modern experience.

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4 In this section the works of five male educational theorists is identified, but there are other like Immanuel Kant and David Hume who have also been influential about European mathematical and scientific thinking. The works of Descartes and Newton are discussed later in the chapter.
John Locke

John Locke (1632 - 1704) revived Aristotle’s notion that all knowledge and learning originate in experience. His concept of learning was that the child’s mind is a blank tablet (tabula rasa) that gets shaped and formed by his/her own experiences. He promoted natural learning methods that took into account an individual student’s temperament, interests, capabilities, and environment. The mind makes connections through the senses and creates simple ideas from experience; these simple ideas combine to form complex ideas.

In *Some Thoughts Concerning Education* (1693), Locke posited that skills and knowledge are continuously learned by example and practice instead of by memorizing rules and principles. To have a sound mind in a sound body, a gentleman needs to develop the following: virtue, wisdom, breeding, and knowledge. Hence, Locke considered good morals and good manners more important than knowledge. “Learning must be had, but in the second place, as subservient only to greater qualities” (Locke, 1996, p.113). The knowledge taught should be usable and practical: for example, learning your own language, and foreign languages.

Jean-Jacques Rousseau

During the Age of the Enlightenment, Jean-Jacques Rousseau (1712 - 1778) wrote the novel *Emile* claiming that “God makes all things good; man meddles with them and they become evil.” Therefore, he insisted on educating children in a natural way. He asserted that since man possesses an inherent natural goodness, his nature should be developed as it exists originally. Rousseau advocated that people should learn naturally,
with their natural gifts, and not be influenced by established cultural, moral, and religious teachings.

Emile, the main character, learned about life through his experiences. He celebrated the concept of childhood and felt that children should be allowed to develop naturally. “The education of a man begins at birth, before speaking, before understanding, he is already learning” (Rousseau, 1979, p. 62). Rousseau argued that the impetus for learning is provided by the growth of the person (nature). He suggested that learning is developmental, and he devoted a book to each of the following stages in Emile: Infancy, The Age of Nature, Pre-adolescence, Puberty, and Adulthood. Rousseau’s ideas emphasized that more attention should be paid to the education of the individual, or child-centered education.

John Dewey

John Dewey (1859-1952) is considered one of the forefathers of constructivism. Constructivist theories of learning and teaching are based on the belief that students construct their own meaning and understanding from direct experience with content that is linked to their prior knowledge. Dewey’s educational theory encompasses the psychological and the sociological. The psychological entails that a child is born with its instincts and its individual needs and desires, in addition to its natural capabilities. The sociological involves the society around the child: i.e., what society wants the child to achieve in activities such as reading, writing or practical skills. Dewey felt that without a balance of the two sides, the process cannot truly be called education (Dewey, 1944).
Dewey therefore proposed that knowledge is attained in a community or social context with social and community-based subjects. One’s life, personality, and experience all come from what a person does and how others relate to him or her.

Jean Piaget

Jean Piaget (1896 – 1980) was the first to state that learning is a developmental cognitive process, and the students create knowledge rather than receive knowledge from the teacher. He recognized that students construct knowledge based on their biological, physical, and mental stages of development. Piaget (1966) outlines four developmental stages of growth: sensorimotor (birth - 2 years), preoperational (ages 2 – 7), concrete operations (ages 7-11) and formal operations (ages 11 – adulthood).

The child, through physical interaction with his or her environment, builds a set of concepts about reality and how it works. As physical experience accumulates, the child starts to conceptualize and create logical structures to explain his or her physical experiences. This is followed by the ability to problem solve and engage in conceptual reasoning. During all developmental stages, the child experiences his or her environment using whatever mental maps he or she has constructed so far. From Piaget’s work on the nature of children’s intellectual development progressive educators sought to learn how to apply these insights to educational practice principles, based on genetic epistemology, look carefully at how knowledge develops in children (Egan, 2002).

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5 Egan (2002) outlines that the essays and works of Herbert Spencer (1820-1903) had a crucial role in the formation of progressivism, and influenced much of modern day schooling.
Lev Vygotsky

The key to Vygotsky’s (1896-1934) socio-cultural cognition theory is the concept that we learn from others in an environment that is culturally based. Knowledge and learning are constructed in a social context. He emphasized a child’s need to interact with others who have more experience and knowledge, usually older children or the teacher. Vygotsky (1986) referred to the Zone of Proximal Development to describe the teachable range between what a student currently knows, and the new learning that he or she is expected to acquire. He felt also that children have their own understanding and beliefs based on their experiences, but that it is the teacher’s role to influence students to higher levels of thinking and knowing. Students would be more able to solve problems with an adult’s assistance or from a more able peer than they would on their own.

Integration of Ideas

How do children learn to construct their knowledge? Depending on which educational theory one subscribes to or which educational stakeholder is raising the question, different tensions come to the forefront. Recent psychological, neuroscience, cognitive and educational research establishes the importance of learning with understanding, learning in context, and taking into account different learning styles. However, there are still many other issues that need to be overcome. These issues are being multiplied with the explosion of knowledge, powerful new communication and information technologies, and the changing role of society. “Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students’ learning” (NCTM, 2000, p.24). Tools such as calculators and
computers are not to be used as a replacement for basic understanding; rather, they can and should be used to foster understandings and intuitions.

In some ways, all of the theorists agree that knowledge is gained through some form of reasoning and sensory experiences. Students need to be engaged both physically and mentally in their learning experiences. By using hands-on, minds-on learning opportunities, they can learn in context. Physical actions and hands-on experiences may be necessary for learning, especially for younger children, but they are not sufficient. We also need to provide activities which engage the mind as well as the hands.

Locke, Rousseau, and Piaget have generalized about learning being age dependent. As children grow up, they tend to move from one stage to the next. On the other hand, Dewey and Vygotsky have attributed individual differences to be a function not only of age, but also of personal interests, abilities, and characteristics of the current learning environment.

The experience that students bring to the classroom, the ways they interpret their learning experiences, and the knowledge, skills, and attitudes with which they leave the classroom will all vary. We need to acknowledge that students have multiple abilities, learn with different learning styles and create meaning with multiple intelligences. In schools today the progressivist ideas have become central to educational thinking where attention is given to a child’s nature, particularly to their modes of learning and stages of development (Egan, 2002). Vygotsky extended the developmental theory of the individual’s cognitive abilities to include the notion of social-cultural cognition: that is, the idea that all learning occurs in a cultural context and involves social interactions.
Foundations of School Mathematics

Many of the topics in school mathematics today are rooted in the epistemological works of mathematicians outside Europe before the 14th century. The learning outcomes in the document *Common Curriculum Framework for K-9 Mathematics* (2006) are organized into four strands: Number, Patterns and Relations, Shape and Space, and Statistics and Probability. Mathematics related to the above strands was transmitted to Western Europe across many geographical and cultural boundaries such as India, China, and Egypt. The Egyptians and Babylonians were well versed in the basic operations of arithmetic, algebra, and geometry. The ancient Chinese, the Mayans, the Indians—all were competent mathematicians, with advanced numeration systems. Modern mathematics on the other hand is linked to European advances of the seventeenth century: the analytic geometry of Fermat (1629) and Descartes (1637); the differential and integral calculus of Newton (1666, 1684) and Leibniz (1673, 1675); combinatorial analysis (1654), and particularly the mathematical theory of probability of Fermat and Pascal; the number theory (1630-65) of Fermat; the dynamics of Galileo (1591,1612) and Newton (1666, 1684), and the law of universal gravitation (1666,1684-7) of Newton (Marks, 1964, p.134).

Descartes and Fermat are credited for the development of analytical geometry. The roots that gave geometry a two thousand year domination of mathematics began to erode during the course of the seventeenth century. The invention of algebra meant that various problem-solving algorithms were now available to solve complex problems. The development of notation meant that the supremacy of geometry was challenged. The union of the algebraic and geometric methods resulted in the invention of analytical geometry.
The differential and integral calculus of Newton and Leibniz provided a method for investigating continuity in all its manifestations. All continuous change problems, such as in dynamics or in the flow of heat and electricity could now be solved with the use of differential and integral equations. The ideas from algebra and analytic geometry were used to develop a meaningful understanding of the methods and intentions of differential and integral calculus. In calculus courses, even today, topics such as definition of the limit, simple function approximation, and approximation of definite integrals are taught. Such topics find their roots to the works of Newton and Leibniz. In recent years there has been more emphasis on applications which involve data, developing the idea of a mathematical model, and using sequences to study discrete dynamical systems.

Games of chance have been played for generations as it is human desire to get something for nothing; efforts to understand this activity led European philosophers and mathematicians to modern notions of chance and risk. Fermat and Pascal’s collaboration started after Pascal asked Fermat’s advice on a game of chance problem in 1654. Their solutions of probability problems led to the development of the probability theory we know today (Marks, 1964, p.157). This mathematical theory of probability is not only taught in schools today but is basic in all statistical analysis from stock-market trends and insurance to Gallup polls and biometrics.

Today’s mathematics curriculum from pre-Kindergarten to Grade 12 includes most of the topics outlined above. Several different kinds of mathematical knowledge are needed to effectively teach the above topics: knowledge about the mathematical ideas; knowledge about how curriculum is unique at each grade level; knowledge about the
challenges students are likely to encounter in learning these ideas; knowledge about how
the ideas can be represented to teach all students; and knowledge about how students’
understanding can be assessed (NCTM, 2000).

Interconnectedness of Epistemologies

It is not the intention of this chapter to argue that we should abandon one or the
other worldview. Rather it is to suggest that it would be useful for us to connect the
features of each epistemology in the journey of learning. The table below elaborates my
interpretation of the interconnectedness between the epistemologies through the topics of
Language, Visualization, Context, Learner Diversity, Integration, and Creativity. These
six topics are my adaptation from the NCTM (2000) Principles, Gardner’s (1983)
Indigenous Curriculum Mandala. These topics highlight some of the elements involved in
the relationships among formal and informal learning in Indigenous and Modern ways.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Indigenous</th>
<th>Modern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language</td>
<td>Myths and Oral Lore</td>
<td>Symbolism</td>
</tr>
<tr>
<td></td>
<td>Learning occurs more frequently in informal, unstructured situations through observation and imitation rather than verbalization. Indigenous cultures are strongly auditory, as shown by their strong oral traditions, metaphorical thought process and story telling.</td>
<td>Mathematics is a language: a way of communicating ideas. Students build links between their informal, intuitive notions and the abstract language and symbolism of mathematics.</td>
</tr>
<tr>
<td>Visualization</td>
<td>Visual Images</td>
<td>Spatial Sense and Patterns</td>
</tr>
<tr>
<td></td>
<td>Visual images, symbols, rituals and diagrams are used to acquire new information and understandings. Information is</td>
<td>Visualization and understanding of measurable objects and their units, systems, and processes are created with the use of patterns and</td>
</tr>
</tbody>
</table>

Table 3. Interconnectedness between Epistemologies
<table>
<thead>
<tr>
<th>Topic</th>
<th>Indigenous</th>
<th>Modern</th>
</tr>
</thead>
<tbody>
<tr>
<td>transmitted primarily through observation.</td>
<td>orientation. Students use their ability to create mental pictures and use sense of patterns and orientation.</td>
<td></td>
</tr>
<tr>
<td>Context</td>
<td>Community Life</td>
<td>Representation</td>
</tr>
<tr>
<td>Counting, locating, measuring, designing, playing and explaining are central to all indigenous cultures and to mathematics. Contexts, activities, situations and phenomena in the immediate environment, the home, community or school should be used as sources for mathematical content.</td>
<td>Representation refers both to process and product. Representations should be used to model and interpret mathematical ideas. Mathematical ideas could be represented in concrete, pictorial, symbolic, and algebraic forms.</td>
<td></td>
</tr>
<tr>
<td>Learner Diversity</td>
<td>Learning Styles</td>
<td>Multiple Intelligences</td>
</tr>
<tr>
<td>Application of appropriate strategies that address the brain pattern of indigenous students should be used. Auditory learning, observation skills, and memory by means of storytelling, oratory, and experiential learning are still part of the informal education of many Indigenous students.</td>
<td>Mathematics instruction should be done in multiple ways which help students develop confidence in their ability to reason and justify their thinking in multiple ways.</td>
<td></td>
</tr>
<tr>
<td>Integration</td>
<td>Holistic Worldview</td>
<td>Connections</td>
</tr>
<tr>
<td>Indigenous Worldview is holistic or integrated. Everything is interrelated and all relationships are important. Perspectives are interdisciplinary concerning math, culture, and creativity.</td>
<td>Models are used to represent and interpret physical, social and mathematical phenomena. Recognize and interconnect mathematical ideas within mathematics, other subjects, and applications.</td>
<td></td>
</tr>
</tbody>
</table>
Teaching creativity in mathematics by exposing students to creative problem solving techniques. Establish learning situations that are experientially based in cultural traditions and help students develop their inquiry skills.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Indigenous</th>
<th>Modern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity</td>
<td>Cultural Traditions</td>
<td>Problem Solving</td>
</tr>
<tr>
<td></td>
<td>Teaching creativity in mathematics</td>
<td>Problem Solving is the key to</td>
</tr>
<tr>
<td></td>
<td>by exposing students to creative</td>
<td>mathematics instruction.</td>
</tr>
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<td></td>
<td>problem solving techniques.</td>
<td>Students learn the skills of</td>
</tr>
<tr>
<td></td>
<td>Establish learning situations that</td>
<td>effective problem solving in</td>
</tr>
<tr>
<td></td>
<td>are experientially based in cultural</td>
<td>a variety of contexts and</td>
</tr>
<tr>
<td></td>
<td>traditions and help students</td>
<td>build new mathematical</td>
</tr>
<tr>
<td></td>
<td>develop their inquiry skills.</td>
<td>knowledge through it.</td>
</tr>
</tbody>
</table>

Summary: Building Epistemological Bridges

The complexities that come into play when two fundamentally different worldviews converge present a great challenge. In an analysis of the beliefs and practices of Indigenous people from around the world, Knudtson and Suzuki (1992) identified the following characteristics as distinguishing these peoples' worldviews from the predominant beliefs and practices in Western society.
Table 4. Comparison of Parallel Worldviews adapted from (Knudtson and Suzuki, 1992, p. 13-15)

<table>
<thead>
<tr>
<th>Indigenous Worldviews</th>
<th>Modern Worldview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spirituality is imbedded in all elements of the cosmos.</td>
<td>Spirituality is centered in a single Supreme Being.</td>
</tr>
<tr>
<td>Humans have responsibility for maintaining harmonious relationship with the natural world.</td>
<td>Humans exercise dominion over nature to use it for personal and economic gain.</td>
</tr>
<tr>
<td>There is a need for reciprocity between human and natural worlds. Resources are viewed as gifts.</td>
<td>Natural resources are available for unilateral human exploitation.</td>
</tr>
<tr>
<td>Nature is honored routinely through daily spiritual practice.</td>
<td>Spiritual practices are intermittent and set apart from daily life.</td>
</tr>
<tr>
<td>Wisdom and ethics are derived from direct experience with the natural world.</td>
<td>Human reason transcends the natural world and can produce insights independently.</td>
</tr>
<tr>
<td>The universe is made up of dynamic, ever-changing natural forces.</td>
<td>The universe is made up of an array of static physical objects.</td>
</tr>
<tr>
<td>The universe is viewed as a holistic, integrative system with a unifying life force.</td>
<td>The universe is compartmentalized in dualistic forms and reduced to progressively smaller conceptual parts.</td>
</tr>
<tr>
<td>Time is circular with natural cycles that sustain all life.</td>
<td>Time is a linear chronology of &quot;human progress.&quot;</td>
</tr>
<tr>
<td>Nature will always possess unfathomable mysteries.</td>
<td>Nature is completely decipherable to the rational human mind.</td>
</tr>
<tr>
<td>Human thought, feelings and words are inextricably bound to all other aspects of the universe.</td>
<td>Human thought, feeling and words are formed apart from the surrounding world.</td>
</tr>
<tr>
<td>The human role is to participate in the orderly designs of nature.</td>
<td>The human role is to dissect, analyze and manipulate nature for own ends.</td>
</tr>
<tr>
<td>Respect for elders is based on their compassion and reconciliation of outer- and inner-directed knowledge.</td>
<td>Respect for others is based on material achievement and chronological old age.</td>
</tr>
<tr>
<td>There is a sense of empathy and kinship with other forms of life.</td>
<td>There is a sense of separateness from and superiority over other forms of life.</td>
</tr>
<tr>
<td>The proper human relationship with nature is viewed as a continuous two-way, transactional dialogue.</td>
<td>The relationship of humans to nature is viewed as a one-way, hierarchical imperative.</td>
</tr>
</tbody>
</table>
Most Indigenous peoples' worldviews seek harmony and integration with all life, including the spiritual, natural, and human domains (Knudtson and Suzuki 1992). These three realms permeate traditional worldviews and all aspects of epistemology. On the other hand, modern epistemology promotes a rationalist and dualistic knowledge production that analyzes and objectifies in a linear form.

Cajete (1999) in his book *Igniting the Sparkle: An Indigenous Science Education Model* describes a culturally responsive science curriculum. The curriculum integrates Indigenous (Native American) traditional values, teaching principles, and concepts of nature with those of Modern (Western) science. Every Indigenous culture has an orientation to learning that is metaphorically represented in its art forms, its way of community, its language, and its understanding of itself in relationship to its natural environment. Indigenous peoples have historically applied the thought process of creative science within cultural contexts, taking a holistic approach. In most schools, science is taught from a Western cultural perspective that is preoccupied with abstract formalizations and technical operationalization. Both worldviews relate to the social organization of science. The fundamental difference being that the Indigenous worldview takes place in a community context and serves the good of all; in the Modern worldview it takes place in specialized settings that is separate from everyday life. Thus, there is a mismatch between cultural perspectives that results in many young Indigenous students becoming alienated from science and mathematics.
CHAPTER FOUR
An Overview of Research Methodology and Questions

Aboriginal Context

This chapter outlines the theoretical and practical aspects of the methodology selected for the study. In the early stages of my study, I naively believed that I could conduct a few clinical interviews with Aboriginal students or email a questionnaire at the university and then be able to extrapolate my findings for all Aboriginal learners. Nevertheless, my assumption was incorrect. Aboriginal people in Canada are descended from the original inhabitants of North America. They speak more than fifty distinct languages, there are more than 600 bands, several thousand distinct communities, and more than a million urban Aboriginal people all contribute to the diversity of Aboriginal people in Canada (Royal Commission on Aboriginal Peoples, 1996). There are differences in historical experiences and contemporary circumstances among the groups. Each First Nation has its own unique history, heritage, culture, language, traditions, and beliefs. The Métis people have a unique new culture which is a blend of traditions from Aboriginal and European ancestry. The Inuit are also different as their culture was shaped by the demands of the northern environment.

Being a non-Haida, I made every attempt to practice an Indigenous methodology which was culturally appropriate, and followed the ethical practices of respect, relationships, and reciprocity as part of my research. The implementation of the ethical practices will be further discussed in the sections on selecting the research participants and the conducting of interviews. In the document *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (2005) Section 6, “Research Involving
Aboriginal Peoples" under the sub section on "good practices," researchers are asked to consider the following in their research:

- To respect the culture, traditions and knowledge of the Aboriginal group;
- To conceptualize and conduct research with Aboriginal group as a partnership;
- To consult members of the group who have relevant expertise;
- To involve the group in the design of the project;
- To examine how the research may be shaped to address the needs and concerns of the group;
- To make best efforts to ensure that the emphasis of the research, and the ways chosen to conduct it, respect the many viewpoints of different segments of the group in question;
- To acknowledge in the publication of the research results the various viewpoints of the community on the topics researched; and
- To afford the community an opportunity to react and respond to the research findings before the completion of the final report.

To make a long-term difference for Aboriginal students, a professional community of educators must be brought into being that has forged strong ties with the Aboriginal community and is committed to a different way of thinking about and doing education. Recently, (Fettes, 2005; Lipka & Adam, 2006) have conducted research in Aboriginal communities which has greater appreciation for connectedness and relationships. Fettes (2005) has been heading a five-year research project titled “Learning for Understanding through Culturally Inclusive Imaginative Development” (LUCID). This project brings together researchers in the Faculty of Education at Simon Fraser University, and school district-First Nation partnerships in three regions of British Columbia. LUCID teachers’ approach enables the flexible and meaningful incorporation
of First Nations cultural knowledge and practices in ways that enrich standard academic objectives. Lipka & Adam (2006) have studied the mathematical activities of Yup’ik people of southwest Alaska for many years. They have investigated how the Yup’ik peoples knowledge of problem solving, spatial relationships, estimation, measurement, and the interpretation of physical phenomena have enabled them to live for thousands of years in southwest Alaska.

This qualitative study bridges between the ethnomathematics context of the community and school.

Qualitative research is multi method in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them. (Denzin & Lincoln, 1994, p. 2).

This study will explore how the community of Haida Gwaii practices numeracy with its unique culture and environment in a way that makes sense to the people living there. The problems that the community solves are contextual and situated within that community, and provide insights into how Haida people use their knowledge in dealing with quantitative, relational, and spatial aspects of their lives. Supplemental mathematics activities based on school mathematics curriculum and Haida knowledge have been included in Appendix 8 and 9.

As I fully immersed in the community for six weeks, my research was qualitative in nature where description was balanced by analysis and interpretation. Since ethnography has it roots planted in the fields of anthropology and sociology, and the goal of ethnographic research is "to understand another way of life from the native point of
view" (D'Ambrosio, 2007), this research is indirectly ethnographic but closer to 'situated learning' and 'community of practice' (Lave & Wenger, 1991; Wenger, 1990).

**Pilot Projects**

As mentioned above, I had planned on interviewing Aboriginal students at Simon Fraser University (SFU) who were recent high school graduates and had successfully completed Principles of Math 11 or 12, or Applications of Math 12, but the coordinator of the First Nations Student Center was unable to provide names of potential participants. After consulting my senior thesis supervisor, Dr. Peter Liljedahl, I decided to change the group of participants and do a pilot project with a different group. Prior to approaching this new group, I obtained ethics approval from SFU (Appendix 1). From the Indigenous Peoples Teacher Education Module (IPTEM) at the Faculty of Education (SFU), 14 students were given survey questionnaires which explored their beliefs about learning and teaching mathematics. Of these student teachers, 6 were also interviewed for 20 to 30 minutes. These approaches provided me with feedback on my initial set of questions and highlighted some of the emerging issues. The survey questionnaire and the results are included in Appendixes 3 and 4.

I had another idea to send a set of questions by email to a number of Aboriginal role models in Canada (engineers, scientists, educators, and professionals of Aboriginal ancestry) to find out about their mathematical success, and also about their views on what it takes for Aboriginal students to be successful in mathematics. I compiled a list of 50 role models from the list of participants at the 2005 Canadian School Mathematics Forum and searched various Web sites. I then managed to find email addresses for 25 of the role models and sent them emails with my questions (listed in Appendix 6). This idea was a
total failure; as I only received three replies, from those who I had met at the CMS Forum in Toronto. Clearly, I needed to have research participants from a specific Aboriginal community, and needed to develop a rapport and sense of trust with them.

I needed to be located in a specific community having a substantial Aboriginal population that would enable me to identify and document various forms of numeracy practices and mathematical thinking in that community. School mathematics is a form of situated learning that should be mathematically meaningful for the learner, and the curriculum would have to make sense of the local social and cultural situations.

**Selecting Research Participants**

In the summer of 2005, when I presented my proposal as part of my comprehensive examination to a group of Masters students’ in the Learning for Understanding through Culturally Inclusive Imaginative Development (LUCID) Project at SFU, a new opportunity arose. Dr. Mark Fettes, Assistant Professor at SFU, who is responsible for the overall direction and coordination of the LUCID Project, suggested that I consider doing my study with one of the three First Nations participating in the project: the Haida, Stó:lō, and Tsimshian First Nations, and their corresponding BC School Districts 50, 33, and 52. Since the goals of the LUCID Project are to explore the potential of imaginative education in improving academic and other educational outcomes in BC public school districts with high numbers of Aboriginal students, working with one of the three districts seemed like a natural fit. After some face-to-face meetings, phone conversations, and email correspondence with Vonnie Hutchingson, Director of Haida Education, School District #50 (Haida Gwaii/Queen Charlotte), I decided to do my study at this location. School District #50 (Haida Gwaii/Queen
Charlotte) serves a student population of about 750 students in 7 schools. Most of the teachers are non-Aboriginal, and more than half the student population belong to the Haida nation.

Vonnie Hutchingson was a key person for my research. She was involved with the LUCID Project and personally knew many of the elders, role models, and community members in Haida Gwaii. In working for the school district, she also knew most of the teachers and many of the recent graduates. After our preliminary meetings, she assisted in the wording of the consent form (Appendix 2) so that it would be acceptable to the Haida Education Council and School District #50. She was a great resource person during the research as she provided critical feedback and leads on selecting the research participants. She was also interviewed as a research participant and later became a member of the supervisory committee. In her multiple roles, she not only guided the research but made sure that the research was ethical, respected the culture, traditions and knowledge of the Haida people and the community.

All participants in the study first gave their informed consent. Actual names of Haida Role Model Program members, elders, and other community members are used in the study. To honor the individuals who agreed to be interviewed for this research, their names and description have been included in Table 5. This was done with the permission of the participants so that the readers can connect with 'real people doing mathematics'. On the other hand educators were identified as Teacher A to H to maintain their anonymity. All recordings and transcripts of interviews were kept secure by the researcher and available only to the participants of that specific interview. Only through
the grace of the participants was I able to do the research and learn about the activities, and the context of the activities.

**Elders Focus Group**

After obtaining approval from the Haida Education Council, two focus groups were held with the elders: one in Skidegate at SHIP (Skidegate Haida Immersion Program), in the south; and the other in Old Masset at the Day Care Centre, in the north. Reed (1999) identifies elders as men or women who have lived through many experiences to gain knowledge and wisdom. They are usually recognized in their communities as being wise individuals, and people seek them for guidance, help, or advice. Each focus group was attended by six elders and researchers from SFU and UBC, where all the participants sat in a circle. In these circles the elders told a variety of stories which embodied the tradition of oral story telling.

The meeting with the elders was arranged by Vonnie Hutchingson. She contacted the elders who were able to attend on the specific days. Three professors from UBC who attended these meetings talked about the Transformative Education for Aboriginal Mathematics Learning (TEAM) project. Their project was a partnership with Haida Gwaii and three other regions in BC. Their aim was to work with students and teachers in the elementary schools to explore ways of teaching that are culturally responsive and prepare students to be successful with mathematics in a range of contexts that open possibilities for future study or careers. On the other hand, my research was with members of the *Haida Role Model Program*, educators at the high schools, and other community members in Haida Gwaii.
Each elder was asked to focus on three things: first, to talk about how they use mathematics in their daily life. Second, how their daily practices could be integrated into the present day curriculum taught in the schools. Lastly, how could schools assist the Haida students who have not performed well in mathematics? Many of the elders felt that it was important to know mathematics, but could not see the connection between mathematics and their daily lives. Many of them also had a difficult time articulating how they could help students do better in mathematics in school, as their experiences in school had been negative for a variety of reasons. The elders were very knowledgeable, carriers of culture, and willingly talked about their experiences, though mostly in general terms. Due to the specific nature of the study, I realized that working with the elders needed specialized skills and would take a lot of time to establish relationship based on openness and sharing. At this point, I began looking for other community members who could be interviewed and respond to my specific questions.

**Research Participants in Haida Gwaii**

To pursue my research questions, I thought it would be beneficial to study two distinct groups of participants in Haida Gwaii. The first group had to be a cross-section of the community, so that I could document their use of numeracy and mathematical thinking. After some brainstorming with Dr. Mark Fettes and Ms. Vonnie Hutchingson, the starting point for this group was clearly the members of the *Haida Role Model Program*, which consists of elders, professionals, and community members who go to schools and assist teachers in integrating Haida knowledge and perspectives with the school curriculum. The Role Models provide a vital connection between the school district community and the Haida community. Since the Role Models had been
previously screened and identified by the school district, I felt that this group would representative of the community. Lisa Shoop, Haida Education Assistant, SD # 50, contacted many of the participants from the program and arranged for interviews. Even though I stayed at Haida Gwaii for six weeks during my fieldwork I was unable to get a chance to interview many of the people listed in the program. The group was a great starting point, and as I interviewed, observed, interacted with them; they often suggested other community members to be interviewed. In total, I interviewed 33 members of the community which are listed in Table 5 below in alphabetical order.
Table 5. Haida Role Models and Community Members who were Interviewed

<table>
<thead>
<tr>
<th>Name</th>
<th>Expertise/Profession</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marvin Alton</td>
<td>Parks patrol officer</td>
<td>Queen Charlotte city</td>
</tr>
<tr>
<td>Jason Alsop</td>
<td>Swan Bay Rediscovery assistant</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Dick Bellis</td>
<td>Carver and tour guide</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Christine Bentley</td>
<td>Fisheries and Aquaculture officer</td>
<td>Queen Charlotte city</td>
</tr>
<tr>
<td>Cecil Brown</td>
<td>Business student</td>
<td>Old Masset</td>
</tr>
<tr>
<td>Diane Brown</td>
<td>Haida language teacher and traditional medicine practitioner</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Judson Brown</td>
<td>Public safety, law enforcement and resource manager with Parks Canada.</td>
<td>Queen Charlotte city</td>
</tr>
<tr>
<td>Christine Carty</td>
<td>Weaver and accountant</td>
<td>Masset</td>
</tr>
<tr>
<td>Shane Collinson</td>
<td>Canoe and paddle maker</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Nika Collison</td>
<td>Curator, historian, Haida language and culture interpreter, singer, dancer, weaver, and carver</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Ben Davidson</td>
<td>Carver</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Kim Davidson</td>
<td>Carpenter</td>
<td>Old Masset</td>
</tr>
<tr>
<td>Reg Davidson</td>
<td>Haida singer, dancer, carver, and print artist</td>
<td>Old Masset</td>
</tr>
<tr>
<td>Sam Davis Jr.</td>
<td>Crab fisherman and charter boat captain</td>
<td>Old Masset</td>
</tr>
<tr>
<td>Tanu Gamble</td>
<td>Social Science researcher</td>
<td>Queen Charlotte city</td>
</tr>
<tr>
<td>Philip Gladstone</td>
<td>Boat builder and charge hand mechanic</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Guujaaw</td>
<td>Haida singer, dancer, carver, and traditional medicine practitioner. President of Haida Nation</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Vonnie Hutchinson</td>
<td>Director of Haida education</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Anissa Jones</td>
<td>Nurse</td>
<td>Queen Charlotte city</td>
</tr>
<tr>
<td>Frank (Herb) Jones</td>
<td>Teacher, tree faller and bullbucker</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Elder Roy Jones</td>
<td>Elder, fisherman, Haida culture and historian</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Bernard Kerrigan</td>
<td>Jewelry maker, teacher, carver, and lawyer</td>
<td>Old Masset</td>
</tr>
<tr>
<td>Irene Mills</td>
<td>Singer, dancer, weaver of button blankets and textiles, carver, head worker, and designer.</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Elizabeth Moore</td>
<td>Weaver and chief councilor for the Masset Village Council</td>
<td>Old Masset</td>
</tr>
<tr>
<td>Bobbi Parnell</td>
<td>Counselor for Adult Education</td>
<td>Masset</td>
</tr>
<tr>
<td>Willis Parnell</td>
<td>Recreation Director</td>
<td>Masset</td>
</tr>
<tr>
<td>Arthur Pearson</td>
<td>Logger, fisherman, and master sewer</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Norman Price</td>
<td>Carver</td>
<td>Skidegate</td>
</tr>
<tr>
<td>Danny Robertson</td>
<td>Swan bay Rediscovery director, school district support worker, and boat captain</td>
<td>Queen Charlotte city</td>
</tr>
<tr>
<td>James Sawyer</td>
<td>Carver, artist, and jewelry maker</td>
<td>Old Masset</td>
</tr>
<tr>
<td>Eld Mary Swanson</td>
<td>Elder, weaver, and teacher</td>
<td>Old Masset</td>
</tr>
<tr>
<td>Christian White</td>
<td>Professional artist, carver, Haida dancer and singer.</td>
<td>Old Masset</td>
</tr>
<tr>
<td>Elder James Young</td>
<td>Elder, fisherman, Haida culture and historian</td>
<td>Skidegate</td>
</tr>
</tbody>
</table>
The second group was the educators from School District No. 50. Since one of my research questions was to see how the mathematics school curriculum and pedagogy can be more meaningful for Aboriginal students in grades 7-9, I interviewed all secondary and middle school math teachers. I also interviewed educators in the school district who taught other subjects but who were also involved in leadership roles in professional development, union issues, or outdoor education. I interviewed five teachers in the South (Queen Charlotte City and Skidegate), and five teachers in the North (Old and New Masset).

Denzin and Lincoln (1994) mention that when the researcher uses multiple means for collecting data, it increases the likelihood of consistent results. This data collection process also permits the researcher to ask questions or investigate themes that emerge from field data as it is being collected, and to confirm the findings with participants. As I interviewed the Role Models, I asked for their recommendation as to who else should be interviewed. I followed many of their leads and in some cases, had to reschedule my whole day to take advantage of the new opportunities. The fieldwork for the study took place over two stages during a six month period, when I went to the community of Haida Gwaii to either give workshops or conduct interviews (see Table 6). Each of my five visits to the islands lasted from a couple of days to three weeks. Some of my field notes from two days of research are included in Appendix 7 and provide the context and some insight about how a day of research might progress in the different communities. The first day describes a visit to the Queen Charlotte/ Skidegate area in the south, and the second day describes a visit to the Old Masset/ Masset in the north.
Table 6. Data Collection Time-Line

<table>
<thead>
<tr>
<th>May-Dec 2004</th>
<th>Jan-Apr 2005</th>
<th>May-Aug 2005</th>
<th>Sep-Dec 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Completed directed reading course</td>
<td>• Obtained ethics approval from SFU</td>
<td>• Wrote comprehensive exams</td>
<td>• Emailed survey to Aboriginal Role Models across Canada</td>
</tr>
<tr>
<td>• Finalized thesis proposal</td>
<td>• Revised questionnaires for all participants</td>
<td>• Summarized results from Fieldwork, Stage 1</td>
<td>• Met Dr. Cynthia Nicol, Dr. Jo-ann Archibald, and Dr. Heather Kelleher from the TEAM-Learning project at UBC who will be doing a three-year collaborative project in Haida Gwaii</td>
</tr>
<tr>
<td></td>
<td>• Fieldwork, Stage 1 (prepared survey questionnaire on numeracy beliefs and conducted short interviews with student teachers from IPTEM at SFU)</td>
<td>• Oral presentation made to the LUCID Masters cohort about the purposes, methodological intention, and the theoretical foundation of my research</td>
<td>• Met Vonnie Hutchingson to plan the Fieldwork</td>
</tr>
<tr>
<td></td>
<td>• Co-facilitated the Working Group on Mathematics Education in Aboriginal communities at the Canadian Mathematics Society (CMS) Forum in Toronto</td>
<td>• Made contact with Vonnie Hutchingson, Director of Haida Education, School District #50 (Haida Gwaii/Queen Charlotte) at the IERG International conference in Vancouver</td>
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Giving Back

Before beginning the study, I grappled with a couple of questions regarding how I would be “Giving Back” to the community. What will interview participants get in return for sharing their time and insights? How will the community benefit in some way from

66
the results of the study? Smith (1999) provides a coherent and detailed alternative perspective for those researching in fields related to indigenous populations. Smith proposes an Indigenous methodology, specifically Kaupapa Maori research as "research that is culturally safe which involves mentorship of elders, which is culturally relevant and appropriate while satisfying the rigour of research, and which is undertaken by a Maori researcher, not a researcher who happens to be Maori" (p.186). Being a non-Haida, I made every attempt to practice such an Indigenous methodology where I would be mentored by the elders, role models, and others in the community during my research. When I participated in community events and activities I made sure that I learned from members of the local community about cultural traditions and expectations. I would continually interact formally and informally with the elders and community members to learn about and build upon the expertise of the local cultural knowledge.

"Giving Back" to the teachers, schools, and the school district was a natural fit for me. As I have extensive experience and expertise in presenting workshops on the mathematics curriculum and pedagogy to teachers, I consulted with Vonnie Hutchingson about the needs of the district. One of the goals in the accountability contract of School District No. 50 is "Improving Student Achievement in Numeracy". I gave a series of workshops over a three-month period, and offered to do more workshops in the future as needed. Denzin and Lincoln (1994) state that 'reflexivity' is a form of self-monitoring, a form of data analysis, and a further method of establishing credibility by showing others, that your interpretations of the data are reasonable. Reflexivity is concerned with the researcher's responses to the various stages of the qualitative research process.
Conducting the workshops would not only enable me to give back, but also provide the community an explicit account of my data collection, analysis and results.

First in the series of workshops was a double study session on a book, *The Teaching Gap,* which was attended by ten, K-12 teachers from across the district. *The Teaching Gap* describes the process of "lesson study" through which Japanese teachers research and test ways to continually improve instruction in their math classes. Lesson study is a professional development process in which teachers systematically examine their practice by working together to plan, teach, observe, and critique lessons.

The next workshop was for K-7 teachers in which I provided an overview of Pearson's *Mathematics Makes Sense* program. The program is based on the most current research about how students learn, and takes a problem-solving approach which is balanced with purposeful practice of skills and reinforcement of concepts. This workshop was attended by 13 teachers, and after the workshop, the teachers were able to take sample resources with them, which were donated by Pearson Education Canada.

Secondary math teachers also wanted to find out about intervention strategies they could use with students who were weak in basic math skills, and strategies for preparing students for writing the provincial exams in grades 10 and 12. I prepared materials and presented two separate workshops to meet the teachers' request. In the first workshop, I compiled a variety of instructional strategies from *Math 44: Teaching for Proficiency,* to create a balanced classroom math program that will help students achieve mathematical proficiency. The second workshop provided an overview of Examination Preparation packages that could be used with the students to prepare for their exams and show them
how to approach questions to optimize their answers. Unfortunately, both of these workshops were poorly attended so I emailed an electronic copy of the material I had prepared to all math teachers in the district.

To answer my second question (How will the community benefit in some way from the results of the study?), I plan to publish Chapter 5 of the study ("Numeracy Practices in the Community of Haida Gwaii") in an electronic and print format and have it available to the public. This document will have different topics containing background information, stories from the field, and have appropriate colored digital photographs showing numeracy practices. This document is intended to benefit students, teachers, and community members, not only in Haida Gwaii but also in other communities where people seek answers to the age old question, “When are we ever going to use math?”

**Semi-Structured Interviews**

Bogdan and Biklen (1992) state that qualitative interviews may be used either as the primary strategy for data collection, or in conjunction with observation, document analysis, or other techniques. Patton (1990) writes about three types of qualitative interviewing: 1) informal, conversational interviews; 2) semi-structured interviews; and 3) standardized, open-ended interviews. Most of the interviews I conducted were semi-structured in nature, but had other aspects, depending on the interview. I posed specific and open-ended questions to encourage participants to respond from their own experiences and beliefs. All interviews were digitally taped and later transcribed. A $25.00 stipend was provided from the Role Model Program for some of the participants, in particular, the elders. The interviews lasted from five minutes to an hour, depending on the availability of the participants and their willingness to respond to the different
questions. The length of the interviews varied depending on the topic or the depth in which the participants told their stories. The longer interviews occurred when the participants told personal stories and could speak at length about related topics. The specific questions asked in the interviews are included in Appendix 5. The length of the interviews varied depending on the topic or the depth in which the participants told their stories.

**Validity and Reliability Checks**

Since the start of the research the Haida Education Council, Haida Nation, School District No School District #50 (Haida Gwaii/Queen Charlotte), and the Faculty of Education, SFU have been consulted to make sure that the able listed “good practices” were adhered to. Since the act of conducting research is value-driven, I made sure that the questions to be asked in the interviews had been reviewed by my committee, consisting of Dr. Liljedahl, Dr. Fettes, and Ms. Hutchingson.

A research report consists of a series of validity claims: claims that the data or field records produced are true to what occurred, claims that the analysis performed on the data was conducted correctly, and claims that the conceptual basis of the analytic techniques used is sound (Carspecken, 1996, p.57).

When I did the interviews in the south, I was fortunate to have daily debriefing sessions with Vonnie Hutchingson that provided me with valuable feedback through the peer debriefing, and that assisted me in the process of member checking, giving higher internal validity. As I conducted the interviews, I also checked the transcribed interview data for consistency with the interviewee’s words. When interviewing I was the facilitator, and used open-ended “lead-off” questions. I listened actively, and was encouraging, with non-leading inputs and follow-up questions because I wanted them to
talk about their experiences and beliefs. I also reviewed my field notes, which were running descriptions of settings, people, activities, and timelines. In addition to field notes, I also took photographs of most of the interviewees and the different activities connected with their lives. Permission to use the photographs in Chapter 5 “Numeracy Practices in the Community of Haida Gwaii” was obtained from the respective participants, and the sources were acknowledged. When all the interviews were complete, each participant was emailed or mailed a document containing portions of the transcript which would be quoted in the body of the dissertation. Though the participants had consented to be included in the study, they were asked to review and approve their quotes. Based on the feedback, transcripts and quotes were revised as needed. Vonnie Hutchingson also shared the pertinent parts of the dissertation with the Haida Education Council and sought and received their approval. She also attained the blessings from the President of the Council of Haida Nation, and the chiefs from Skidegate Band and Old Masset Band Councils.

**Analysis of Data**

The primary data for this study consists of excerpts from the interviews. Patton (1990) stated that “the raw data of interviews are the actual quotations spoken by interviewees. There is no substitute for these data” (p. 347). Therefore, I digitally tape-recorded all interviews and produced verbatim transcripts. Bogdan and Biklen (1992) define qualitative data analysis as "working with data, organizing it, breaking it into manageable units, synthesizing it, searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others" (p. 145). The transcripts from the 43 interviews I conducted involved hundreds of pages, I needed to be efficient
and thorough in analyzing the data. I read and re-read some of the transcripts a few times to look for emerging patterns. Then, I developed an “open coding” system which enabled me to develop three distinct chapters as part of the analysis.

The open coding process, while procedurally guided, is fundamentally interpretive in nature, where researchers "must include the perspectives and voices of the people" whom they study (Strauss & Corbin, 1994, p. 274). Open coding is performed during a first pass through recently collect data. In this process I located themes and assigned initial codes or labels in a first attempt to condense the mass of data into categories. I then slowly read field notes, historical sources, reference materials, or re-read the data, looking for critical key categories, or themes, which were then noted. Next, I created preliminary concepts or labels as fields in a data base and inserted data that fit into that particular category/code. As I analyzed and classified the data I was open to creating new themes and to changing these initial codes in subsequence analysis. In short, open coding brought themes to the surface by breaking down, examining, comparing, conceptualizing, and categorizing from deep inside the data. The discrete categories identified in open coding were compared and combined in new ways as I began to analyze data for the different chapters. The purpose of coding was to not only describe but, more importantly, to acquire new understanding of rich deep embedded mathematics content, especially in Chapter 5. Although the stages of analysis are described here in a linear fashion, in practice they occurred simultaneously and repeatedly for the different chapters. During the process some of the initial categories identified were revised, leading to re-examination of the raw data. Finally, I translated the coding into chapters, sections, and sub sections so that they could be easily read and understood by others.
The first analysis was to look at the people on Haida Gwaii and how they “Do the Math” in the daily lives. Chapter 5 “Numeracy Practices in the Community of Haida Gwaii” looks at how the community in Haida Gwaii practices numeracy with their unique culture in a way that makes sense to the people who live there. The cultural activities identified as numeracy practices were chosen as they could have curricular mathematics associated with them. Some practices may have very rich deep embedded mathematics content, while others may not be that deep but could be culturally relevant to the students of Haida Gwaii. The practices included are by no means complete or exhaustive. I would call these to be representative situated practices.

The second was to discuss the issues of teaching and learning, presented in Chapter 6, “Honoring the Voice of Educators-Change Agents”. The third was to articulate the voice of the community members which is presented in Chapter 7, “Honoring the Voice of Role Models and Community Members”. Within each chapter, I created a number of conceptual categories into which the observed phenomena was grouped. The categories which were derived from emergent themes were descriptive and multi-dimensional, and formed a preliminary framework for analysis. Words, phrases, ideas or events that appeared to be similar were grouped into the same category. These categories were gradually modified or replaced during the subsequent stages of analysis (Carspecken, 1996). This also helped me to form tentative hypotheses, develop insights, and come to some conclusions. Carspecken (1996) states that theorizing helps to alter, challenge, or refine an existing ideological perspective. Analysis across the interviews and feedback from my supervisory committee helped me to move the study further from describing and interpreting data to concluding.
Limitations

One of the limitations that must be acknowledged in this study is that some of the Role Models and community members that I wished to interview were not available during the time I was in Haida Gwaii. Considering the number of researchers that are constantly doing research in Haida Gwaii in a variety of fields, one has to wonder about the impact this has on the residents. It seemed to me that when we did the focus groups with the elders, they were cautious about how they responded. It was not easy to establish trust with this group during the short period I was there. I am told that some researchers in the past had not followed due process; consequently, the interviewees were misquoted and misrepresented. Being a non-Haida, and not having lived on the islands was somewhat limiting when I interviewed the elders, that is why I chose to have members of the Haida Role Model Program as participants in the research. Vonnie Hutchingson, who personally knew all the members of the Haida Role Model Program, made sure that before I interviewed them they had been properly informed about me and my work. This enabled me to have a trusting and open relationship with the group. Many Aboriginal artists and artisans create works inspired by the traditional knowledge of their community. “The meaning embodied in our art might be guessed at by identifying figures depicted in it, but the full history of a piece can only be deciphered through the knowledge held in our oral histories” (Collision, 2006, p.63). Some oral stories are owned by a group and they may be only told by them in a private gathering. Some of the explanations and stories told in Chapter 5 may seem limiting as the artist might not have the permission to share them with outsiders.

On the other hand, my expertise was recognized in the educational community so
that trust was less of an issue when I interviewed teachers. Originally, I had also hoped to interview Aboriginal students from Haida ancestry that were completing Principles of Math 11 or 12, or were recent high school graduates who had successfully completed these courses. Selecting students who were enrolled in the academic Math 12 courses was challenging as they were busy preparing for their exams at the end of the school year. Finding recent graduates was also challenging as many of them were working off island, especially those whose parents lived in Masset. Since the interviews with students were limited, I decided that the student group would not be part of the study.

**Research Questions**

I wanted my research questions to inform me of three things. First of all I wanted to find out how the members of the community of Haida Gwaii use mathematics and numeracy practices in their daily lives. In order to do this I would need to interview members of the community which I have discussed earlier in this chapter. I knew people of different cultures and different eras have engaged in mathematical activities to solve the problems they encountered in their daily lives (Nunes, 1992). Lave and Wenger (1991) mention that many activities are learned through mutual engagement in a joint participation, called a *community of practice*, where the participants are involved in a set of relationships over time in a context of lived experience (p. 98).

Secondly, I needed to find out from educators how such practices could be integrated into the present school curriculum so that Aboriginal students would be interested in learning mathematics. What needs to change within the classroom so that
familiar situations could assist students attach meaning to the concepts of school mathematics curriculum.

Finally, I wanted to explore how different ways of knowing can increase the participation rate and achievement of Aboriginal students in high school mathematics. Over the years, the following reports and documents have made recommendations on how to improve numeracy for Aboriginal learners: Year 2000: A Framework for Learning, 1990; Gathering Strength, 1996; Task Force on First Nations Education, 1999; Report of the Mathematics Task Force, 1999; The Principles and Standards for School Mathematics, 2000; WNCP Mathematics Research Project: Final report, 2004; Report card on Aboriginal education in British Columbia, 2005; Aboriginal Report-2005/06 How are we doing? BC public schools, 2006. Recommendations from some of the above listed documents were discussed in Chapter 1. Reports alone do not bring about change. However, there have been some positive changes over the last thirty years; most Aboriginal children still experience school as largely disconnected from the realities and aspirations of their home communities.

Research Question One

What forms of numeracy practices and mathematical thinking are present within the community life of Haida Gwaii, particularly by participants in the Haida Role Model Program?

There are many ways in which a community engages in mathematical thinking and numeracy practices. In this study the above question pertained to members of Haida Role Model Program and other community members. This program and particulars about the participants are discussed in detail in the chapter on methodology. Although the
question gets to the heart of the research it has its limitations as many participants don’t see themselves involved in mathematical thinking in their daily lives. However, as one starts to look for examples in the daily practices, one finds mathematics is a part of cultural heritage and used for life (NCTM, 2000). Data from this part of the research are presented on Chapter 5.

Additional questions were asked in the interview which gave insight into the community’s views and attitudes on mathematics and other social issues. It might be as important to change perceptions and discourse in the community as it is to change school practices. The response to these questions is discussed in the Chapter 7 titled “Honoring the Voice of Role Model and Community Members in Haida Gwaii”.

Research Question Two

How can numeracy practices be drawn to engage students, particularly Aboriginal students, with the prescribed mathematics curriculum?

This question takes into consideration the intersection of mathematics and culture, and how ‘informal’ community-based mathematics can influence ‘formal’ school mathematics. There is increased awareness of the importance of context, ownership and mathematical subjectivity in the development of ‘mathematical meaning’ (Bishop, 1985). Teachers’ beliefs and practices need to be explored, and how they change as they learn about and use students’ culture and mathematical thinking in culturally sensitive ways in their practice. Davison (1992) strongly encourages teaching mathematics to students from Aboriginal cultures through hands-on instructional methods, as opposed to abstract non-contextual ways. To remedy the situation, he suggests that, wherever possible, mathematics concepts should be presented in a culturally relevant manner, using
situations that the students find interesting. Above all, the presentation of mathematical ideas needs to be consistent with how all students learn. This view of learning is founded on the three fundamental principles of learning:

- learning requires the active participation of the student;
- people learn in a variety of ways and at different rates;
- learning is both an individual and a group process.


Interviewing educators and analyzing the pedagogical practices that have worked with Aboriginal students could provide some answers as to how mathematical community practices can engage students to learn the prescribed curriculum in engaging culturally relevant ways. Additional questions were also asked of this group in order to get a better understanding of their pedagogy. The response to these questions is discussed in the Chapter 6 titled “Honoring the Voice of Educators-Change Agents”.

Research Question Three

How could different ways of knowing increase the success rates of Aboriginal students in school mathematics and math-related disciplines?

Choosing participants who are successful could be challenging since “the definition of success is complex and unique to each individual and community, but it almost always involves children being self-confident, understanding their own culture and traditional values, and having a positive self-identity” (Kavanagh, 2006, p. 20). Glanfield (2007) outlines that learning occurs best when it is acquired in a meaningful context based on student’s existing knowledge, and enhanced through socially supported interactions within a community of practice. The above question was pursued with
members of the Haida Role Model Program elders, and other community members. The response to this question is discussed in Chapter 8 under the section “Epistemological Considerations”.

Summary of Research Questions

The overall purpose of the study is to investigate ways in which the participation rate and achievement of Aboriginal students in high school mathematics may increase. The three research questions connect community, pedagogy and epistemology. Though the research questions pertain to the learning and teaching of mathematics for Aboriginal students, some of the issues, concerns and attitudes are applicable for all students. In the chapters that follow the answers to these questions will be pursued through different voices: Role Models, Educators, and Community Members. The questions cannot be explored in isolation, however, given the voices might be different they are all from the same community. As such, I hope some of the findings from this study can offer insights to other communities, teachers, and researchers on how to improve within their local contexts.
CHAPTER FIVE -
Numeracy Practices in the Community of Haida Gwaii

Introduction

Haida Gwaii, meaning, “Islands of the People,” is the ancestral home of the Haida people. This collection of islands is also known as the Queen Charlotte Islands. These islands, situated off the northern coast of BC and south of Alaska, are a unique mix of wilderness, plants, animals, and cultural heritage. The location of the islands can be determined by a Global Positioning System (GPS) or by looking at a map between 52 and 54 degrees North latitude, and between 131 and 133 degrees West longitude (Turner, 2005).

Figure 4. Aerial view of Haida Gwaii. Used with permission.
The Haida have inhabited these islands for thousands of years, and have depended on the land and the sea for their livelihood. Today, with depleting natural resources and a changing technological world, the people on these islands find themselves at a crossroads. Their lifestyles are changing economically, but they are determined to maintain their culture, heritage, and way of life.

Haida history dates back thousands of years; some of the historical highlights of the post-contact period are briefly outlined here. In 1774, the Haida paddled their great
dugout canoes to greet the first-recorded European explorers. In 1778, Captain Dixon, an English explorer, named the islands “Queen Charlotte Islands” after Sophie Charlotte, the wife of the King of England, George III (Turner, 2004). Queen Charlotte was also the name of one of Captain Dixon’s ships. Around 1862, several smallpox epidemics ravaged the Haida villages and approximately 95 percent of the Haida population was wiped out by the disease. The census, conducted in 1885 by the Hudson’s Bay Company, counted only 800 Haida. This population dropped to 588 in 1915. More recently, according to the 2001 census, 5,000 people (both Haida and non-Haida) live primarily in seven population centers on the islands.

Figure 6. Historical Sign near Tlell, about the Queen Charlotte Islands.

In this chapter, the daily lives of the people on Haida Gwaii are examined through the concept of situated learning, numeracy and ethnomathematics. Ethnomathematics is mathematics embedded in cultural activities, in the workplace, home, community, and in
aspects of everyday tasks to solve problems (Nunes, 1992), as discussed in detail in Chapter 3. The term Numeracy in this chapter will be used as defined in Chapter 2:

Numeracy is the set of mathematical skills needed for one’s daily functioning in the home, the workplace, and the community. It is the willingness and capacity to solve a variety of situated and contextual problems that could be functional, social, and cultural.

Many books have been written on Haida Gwaii, focusing on diverse topics such as: art, birds, culture, language, myths, plants, politics, sea life, stories, and so on. As mentioned above, the focus of this chapter is to outline some of the mathematical practices in the community of Haida Gwaii. According to the Alaska Native Knowledge Network (1999) the underlying purpose of mathematics is to use pattern recognition skills to solve problems. Students should learn to try several problem-solving strategies, in a flexible way, in searching for solutions, and be able to perform complex mathematical reasoning by extending the logic from simple patterns and models to more complex situations. Hence, students should be able to apply mathematical concepts and processes to situations within and outside of school, in a community of learners.

In the following sections, traditional, cultural and contemporary practices are shown to have mathematical ideas imbedded that are far more substantial and sophisticated than is generally acknowledged. This is by no means a complete or exhaustive depiction of the community; one could say that it is only a representative sample. Each section starts with some background information to provide the needed context, followed by personal stories that show how people actually use mathematical ideas in their daily lives. These mathematical ideas can include number, logic, measurement tools, exact or estimated computations, physical patterns, geometric relationships, or spatial configuration. Seeing how mathematical and numeracy practices
are a part of one’s heritage not only informs and motivates students from Haida heritage, but all students, who will be able to see how mathematics is used to go fishing, building a house, calculating costs, weaving baskets, making garments, etc. Although the sections are presented independently, some overlap between different sections occurs. I have also included colored photographs, where appropriate, to provide visual representations of that section.

**On Shaky Ground**

Many of the rock formations on the islands of Haida Gwaii originated from seismic and volcanic activities. Parks Canada (2004) documented that the largest earthquake in Canada took place in Haida Gwaii in 1949, registering 8.1 on the Richter Scale. Queen Charlotte Fault is the place where the North American continent meets the Pacific plate. The movements of the tectonic plates has caused mountains to lift, rocks to compress, and earthquakes to occur with magnitudes of greater than 5.0. Different rock formations from the islands can be seen outside Crystal Cabin Gallery in Tlell called the Tlell Stone Circle. This outdoor revolving rock display includes rocks from the Jurassic, Cretaceous, and Triassic periods.
To understand the cause of an earthquake, scientists need to find the epicenter, which is located directly above the focus of the earthquake. Seismologists use mathematics to find the epicenter and the magnitude of earthquakes are used to determine their severity. Triangulation is commonly used to find the epicenter, where three seismometers are used as the centers of three different circles, each having a radius that matches the distance from the seismometer to the epicenter. By drawing the three circles around each seismometer, their point of intersecting is the epicenter of the earthquake.

In 1935 Charles Richter defined the magnitude of an earthquake to be $M = \log \frac{I}{S}$ where $I$ is the intensity of the earthquake (measured by the amplitude of a seismograph reading taken 100 km from the epicenter of the earthquake) and $S$ is the intensity of a "standard earthquake". The magnitude of an earthquake is a measurement of energy released, and is measured on a Richter Scale, usually with readings between 2 and 9. Earthquakes of magnitude 8.0 or greater are very rare and can cause a lot of damage.
Richter Scale magnitude (M) measurements are logarithmic base 10, so that an earthquake of magnitude 9.0 would be 10 times stronger than an earthquake of magnitude 8.0. Similarly, an earthquake of magnitude 9.0 would be $10^4$ or 10,000 times more powerful than an earthquake of magnitude 5.0.

Another evidence of the island’s geology is a massive boulder located on a beach just north of Skidegate called balance Rock. This rock rests on a small base and the elements of nature have not toppled it over the centuries. It has become a symbol for Haida Gwaii’s struggle to find the balance between economy and the environment, the balance of cultures, the balance of rights.

![Image of Balance Rock](image)

*Figure 8. Balance Rock near Skidegate*

**Structure of Haida Nation**

Preamble to the Constitution of the Haida nation:

Our culture and our heritage are born of the respectful and intimate tie we have with the earth and the sea. Like those of the forest, our people’s roots are entwined and adversity will not suffice to fell us. We owe our existence to Haida Gwaii. It is on these islands, where our ancestors lived before us and where they died, that we will live until such time as they send us the sign to join them in the next world. The living generation accepts the responsibility to pass on down our heritage to the generations that follow it. (Parks Canada, 2004, p. 41)
Haida society is based on a matrilineal system, where the heritage is usually passed down through the mother. Property, titles, names, emblems, crests, masks, stories, representations and even songs, are among the hereditary privileges of the Haida. Hence, the stories are the intellectual properties of the people who tell them. At present, some 40 lineages are represented, which are divided into two “clans” or social groups, the Eagle (Gidins) and the Raven (Kaay xil). Each Haida is either an Eagle or a Raven, like their mother. In the past, an Eagle person married a Raven and the clan lineages were preserved. Today, the people from both clans live in various places on Haida Gwaii and in different parts of the world. The highest concentration of communities is around Skidegate and Old Masset. The ancestors from the Raven clan find their roots in the northern part of the island, specifically, Skincuttle Inlet and Naikoon. The Eagle clan’s origins are tied to the area around Cumshewa Inlet (Parks Canada, 2004). Some of the crests that may be used by the Eagle clan are: eagle, cormorant, beaver, dogfish, dragonfly, starfish, abalone, and black whale. The Raven clan can use crests such as:
raven, grizzly bear, killer whale, wolf, mountain goat, tree, and star (Adams &
Markowsky, 1988).

Figure 10. Distinct Logos Representing each Clan Shown on the
Sides of a Truck in Skidegate

Photo by author included with permission
Adams and Markowsky (1988) outlined three types of chiefs: town, family, and house, each having different roles with varying degrees of influence and power. In most cases, the chief acted as a group’s representative when negotiating with other groups. In the past, the Haida class systems were based on wealth and rank, which were finalized at potlatches. The chiefs’ position was his rank and the social structure determined the rank of others. To maintain the position, the chief had to be generous in the gifts that were
given away at potlatches. When a chief passed away, his wealth was passed on to his nephew (his sister’s son).

The elders play an enormous role in preserving the Haida history, language, ancient art forms, and other traditions. Each of the elders have their own personal history and strengths that can be a rich resource for students. The elders’ experience can also be useful in explaining everyday cultural practices in a context that could be connected to intuitive and embedded mathematics. Elders, with their interpretive and creative approach through story-telling, can teach indigenous knowledge that is connected to the local community of practice.

In the knowledge of my people, the Elders and the children are as one in the Circle of Life. The Circle represents the unity of the earth, moon, sun, and stars, the four cycles of the seasons, and life as we are born, as we age and die, to be reborn. The Elders are the holders of knowledge, the teachers of our culture, songs, heritage and survival and are held in high esteem and respect. The children, our future, represent the carriers of this knowledge that never grows old. (Royal Commission on Aboriginal Peoples. 1996, p.2)

As mentioned in Chapter Four, some of the elders in the community are also part of the Haida Role Model program that visits schools to teach Haida culture and history with oral and visual stories. Through story-telling, a maternal grandmother (known as Nonnie/Nuni) would pass along values, beliefs, traditions, and language to her grandchildren.
Passing the Genes

Within the Eagle and Raven clans, genealogy and inheritance are passed to the descendants through the mother. In looking at the Haida family tree in (Figure 14), the arranged marriages with the opposite clan preserved the lineages and controlled intermarriages to produce a “stable” population, long before modern principles of genetics were shown by Gregor Mendel in 1866.
The value of studying genetics is in understanding how we can predict the likelihood of inheriting particular traits. Also, it can help us to explain and predict patterns of inheritance in family lines. One of the easiest ways to calculate the mathematical probability of inheriting a specific trait was invented by an early-20th century English geneticist named Reginald Punnett. His method of Punnett Squares is used to predict typical outcomes if parents have specific genes. With larger numbers of offspring, the results of inheritance approach closer to the predicted outcomes. Punnett Squares (Figure 15) can be used as a predictive tool when a couple is considering having children. Let us assume, for instance, that both a mother and a father are carriers of a particularly unpleasant genetically inherited disease, such as cystic fibrosis. Naturally, they will be concerned about whether or not their children will be healthy and normal. In this example, let us define "A" as the dominant normal gene and "a" as the recessive
abnormal gene, that is responsible for cystic fibrosis. As carriers, both parents will be Aa. This disease only affects those who are recessive (aa). The Punnett square (Figure 15) clearly shows that at each birth, a 25% chance exists that the child will be normal (AA); a 50% chance exists that a child will be healthy (Aa), a carrier like the parents; and a 25% chance exists that a child will be recessive (aa), who will probably die later as a result of the condition.

This is a simple graphical way of discovering the potential combinations of genotypes that can occur in children, given the genotypes of parents. The Haida bloodlines appear to have been maintained across the clans through marriages between individuals of opposite clans, to give rise to a stable gene pool. There was some latitude in passing the lineage depending on the circumstances.

**Haida Art**

In the Haida language, no word exists for “art”, yet art is embedded in all aspects of the people’s lives. Nika Collison, the curator of Haida Heritage Centre in Skidegate, in *Raven Travelling* (2006), describes the role played by art in Haida society:
Haida art fulfills many roles; it is this social function that is its truest responsibility. Whether painted, carved, tattooed, woven or appliquéd, the “art of the clan” signifies lineage, rank and history through the depiction of crests and oral histories and through finely made objects (p. 59).

Guujaaw, Haida carver and political leader, in Raven Travelling (2006), describes art as “trimmings of a culture.” Culture to the Haida Nation and many other First Nations is seen as the life-ways, or their relationship to the land, and the art including song and dance are ways of expressing that relationship. Art described as a ‘trimming’ does not demean the importance of Art, rather captures the fact that art in this scene is a part of life, a way to express that relationship to the land and the sea.

This is to say that an artist has got to know the stories about the land and beings of the forest, the sky and the sea that we share this land with. Songs and dances condense those stories in a rhythmical fashion while masks are made with the intention of being expressed in dance. A totem pole is a deliberate action to prompt the ceremonies that bring out the prerogatives of song and dance. The ceremonials support an economy of prestige gained through the distribution, rather than the accumulation of wealth. (Guujaaw)

Reg Davidson, a world renowned Haida carver and artist in Old Massett, expresses the idea that art is mathematical:

I always wonder what is Haida culture? To me it’s just a way of life. It’s everything. Art is all mathematical. When I do a pencil drawing I first draw to scale, usually 10:1 scale. This is an easy scale to use; you just add a zero to it. I sometimes also use 7:1 scale. I will do two or three sketches until I like what I want. What seems to keep the Haida so strong is the art. It’s all over the world. (Reg Davidson)
Haida art is distinctive and recognized around the world. The most common Haida artistic motif is the symmetrical flat design, made from a complex pattern of components. Symmetry is a fundamental organizing principle in nature and in culture. The analysis of symmetry allows for understanding the organization of a pattern, and provides a means for determining change. By varying the relationships within patterns, where symmetry is expected, otherwise predictable and repetitive patterns are transformed into great works of art. On the other hand, asymmetry is both the absence of symmetry, and a fundamental basis for symmetry. A motif or design may be asymmetrical, or symmetrical. Through Haida art, spatial sense could be taught to students by investigating relationships, drawing, measuring, visualizing, comparing, transforming, and classifying two- and three-dimensional shapes.
Robert Davidson, a world renowned Haida artist, describes the basic principles of Haida art in *Raven Travelling* (2006), as being comprised of two main formlines: the ovoid shape and the U-shape. One needs to know proportion, balance, and composition, and how the positive space plays with the negative space. Ovoids and U-shapes are always compressing and expanding, to create visual tension. This formline has also been practiced and perfected by artists from the Tlingit, Tsimshian, Nisga’a, Gitksan, Haisla, and Heiltsuk nations of the Pacific Northwest for centuries (Gilbert and Clark, 2001). The master artist reveals the rules of the formline to the apprentice, during the long years of apprenticeship, when the new artists copy existing work and begin to create their own.

Although many artists trace the basic shapes from templates, some parts are drawn freehand to bring out the artist’s creativity. Ovoids, ranging in shape from circles to elongated rectangles with rounded corners, are mainly used for eyes and face outlines. The U-shape, split U-shape, and S-shape, or their variations, can be reduced, stretched, enlarged, or elongated to fill a larger space or depict a certain detail. Primary areas are
outlined with black lines, and then filled with secondary forms, which are usually painted red or black.

**Figure 18. Primary Formline Ovoid and U-Shape**

Drawing an ovoid shape is an art in itself:

To draw an offset circle and call it an ovoid is simple enough for anybody to do but to put the kind of strength and tension into it would require some understanding of it. Like most things, once you understand the rules of art, then you have more ability to stray and the possibilities are endless. To create an optimal ovoid shape is sort of like martial arts, you have to work at perfecting it. From there, any design is weighted with numerous ovoid shapes and lines for optimum strength, always challenging the creator (artist) to move to perfection. (Guujaaw)

Bilateral symmetry is commonly used in many forms of ovoid, U-shape, split U-shape, and S-shapes. The symmetry can be seen along a vertical line through the art. For example, a butterfly will have a pattern on one wing, and an image on the other wing, which a direct reflection. Many animals have body forms that are symmetrical, in that their bodies could be divided into matching halves by drawing a line down the center. Nevertheless, some animals are not symmetrical at all, and their bodies cannot be divided into similar halves with a straight line. Gilbert and Clark (2001) have identified the north
coast art style ovoid as being curved, with slightly concave formline at the bottom. The top of the ovoid is moderately convex and thicker than the bottom. Ovoids vary in structure from almost rectangular shapes that can be stretched or shrunk to give varying shapes in the same formline design.

Source: Learning by Designing (2001) included with permission

Figure 19. Bilaterally Symmetrical Ovoid Shapes
The integration of Ovoids, U-shapes, split U-shapes and S-shapes, and variations of these shapes in different art forms shows the development of mathematical arguments about geometric relationships. According to Nika Collison, a curator at the Haida Museum,
Outside of its social function, Haida art is about balance and pleasing the eye and some of that comes naturally but other times you need to think that the bottom figure needs to be three inches and the next one needs to be two inches and the next one needs to be 1.5 inches.

Haida art form has four common characteristics: balance, unity, symmetry, and tension. Like mathematics, these characteristics have to be integrated with specific rules and principles of form and design.

Artists learned to do art in a variety of ways. Traditionally, an apprentice artist worked with a master and would proceed through a series of levels over a number of years. The mentor relationship used to exist between a nephew and his maternal uncle. An artist would start by simply copying the work of their mentor and then slowly become more creative and imaginative and develop their own distinctive personal artistic style. Arthur Pearson, a logger, and James Sawyer, an artist and a jewelry maker, spoke about their experiences.

Basically as a kid I used to go watch my uncle carve argillite, which is black stone they used to carve and it just progressed from there. I’d fool around the chunk he threw away, and I always saw that I didn’t want to do this but I wanted to do a different form so I went to drawing instead because argillite is very dirty. I just went to paper and started drawing. Usually it was using a pencil for guidelines because you could never ever say I am going to keep this all the way through and really you can’t. Your eye doesn’t follow your pencil; your pencil follows your eye. So you always think what size you are dealing with and you try to get the same size again, but if you try and go out and do it on a different level, it will change. You never can keep it the same. (Arthur Pearson)

Doing the design for the paintings—I usually just start out by doing sketches until I find something that I like and then sort of expand on it. But even within the paintings I’ll always start sort of in the center of the design, do one design on half of it symmetrical and flip it over, copy it out. I’ll usually start in the body of the animal that I’m doing and then add on
the wings or the claws—whether it be a bear or an eagle—so I’ll have the stomach done first and then add the legs and the arms or add the wings and the claws and the tail feathers and then after I flip it over so that it’s a symmetrical design, then I’ll add the head on it and make it proportionate to what I’ve drawn. I don’t like making things with a body that’s half the size of the head. I like making the art proportionate. I remember when I first started learning my dad told me if you were ever going to do birds or eagles make sure after you are done your design it looks like the bird can fly without hanging it’s head. So it doesn’t have a 50 lb. head on a 10 lb. body. (James Sawyer)

Reviving Haida Art: Bill Reid

Herem (1998) calls Bill Reid the most famous and influential Northwest Coast artist of our time. Reid was a man of many skills and a broad vision, and his work, especially his monumental bronzes, cut a unique and celebrated path into the international world of public art. Like the great cedar trees of Haida Gwaii, his work is considered monumental. Two of Bill Reid’s masterpieces The Raven and the First Men and The Spirit of Haida Gwaii are depicted on the current Canadian 20 dollar bill. Each masterpiece has its own story which is deeply influenced by the supernatural, and
represents the Haida people with regards to who they are and where they came from. An ancient Haida saying, “everything depends on everything else,” is a reminder that you cannot separate Haida art from their way of life. Haida oral histories are intellectual property, owned either individually or collectively, and cannot be used by others without permission of the owner.

Illustration for the new $20 note by Jorge Peral, Art Director, Canadian Bank Note Company Ltd. included with permission

Figure 22. Canadian 20 Dollar Bill Depicting
Bill Reid’s Artworks: The Raven and the First Men, and The Spirit of Haida Gwai
**The Raven and the First Men** is Bill Reid’s sculpture carved from a laminated block of yellow cedar on display at the UBC Museum of Anthropology, in Vancouver, BC. In the book, *The Raven Steals the Light*, Bill Reid and Robert Bringhurst tell the story of the Raven arriving at Rose Spit after the great flood that had covered the earth. The Raven, one of the most powerful of mythical creatures, hears a sound from the giant clamshell and uses its trickster’s tongue to free the creatures from within, who were the original Haida, the first human. In 1971, Rose Spit at the northern tip of Graham island was declared an ecological reserve and named Naikoon Provincial Park.

![Image of The Raven and the First Men sculpture](Photo by author included with permission)

**Figure 23.** Bill Reid’s Carving in Yellow Cedar of The Raven and the First Men, displayed at the UBC Museum of Anthropology

*The Spirit of Haida Gwaii*, Bill Reid’s largest and most complex sculpture, is displayed at three different places and is also depicted on the Canadian 20 dollar bill. The white original plaster is on view at the Canadian Museum of Civilization in Gatineau, Québec, at the river end of the Grand Hall. Reid constructed a 1/6-scale clay model of *The Spirit of Haida Gwaii* in the spring of 1986. He then enlarged the Haida canoe
carrying 13 mythological Haida figures to a full-scale clay model, before the sculpture was cast in plaster over an armature of steel rod and mesh for further refinement.

From the original white plaster, a bronze casting was completed and installed in 1991 at the Canadian Embassy in Washington, DC. This sculpture was given a glossy black patina to give the appearance of argillite and is known as the “The Black Canoe”. *The Spirit of Haida Gwaii* is a monumental sculpture in bronze: 6.05 m long, 3.9 m high, 3.5 m wide, and weighing 4,900 kg. The Canadian Embassy describes the work as follows:

The canoe contains both Raven and Eagle, women and men, a rich man and a poorer man, and animals as well as human beings. Is it fair, then to see in it an image not only of one culture but of the entire family of living things? Not all is peace and contentment in this crowded boat… But whatever their differences, they are paddling together, in one boat, headed in one direction.

“The Jade Canoe” was completed in 1994 and installed in the international terminal of the Vancouver International Airport. This is a second casting of *The Spirit of Haida Gwaii*, painted in dark emerald green to evoke the gem, jade, found in BC. Bill Reid describes the sculpture as follows:

There is certainly no lack of activity in our little boat, but is there any purpose? Is the tall figure who may or may not be the Spirit of Haida Gwaii leading us, for we are all in the same boat, to a sheltered beach beyond the rim of the world as he seems to be or is he lost in a dream of his own dreaming? The boat moves on, forever anchored in the same place.
Bill Reid’s art incorporates patterns and relationships derived from ideals of balance and symmetry. Viewers can enjoy the sculptures from an artistic or geometric perspective. A variety of media, including paper, wood, plastic, metal, argillite, jade, and copper are used. The sculptures invite communication, representation, connections, and reasoning – some of the processes used in the learning and teaching of mathematics.

**Potlatch Ceremony and Economy**

The potlatch was the most important Haida ceremony and accompanied the progress of high-ranking people through the social order, to mark the giving of names, marriages, and deaths. This ceremony enabled the Haida to preserve their traditional laws and pass on the heritage of rights and properties. Many of the elaborate Haida artistic traditions, including wood and metal carving, songs, dance and theatre, weaving and button blankets, developed around the potlatch.

When the Indian Act was revised in 1951, an earlier ban on potlatch was lifted, to allow the celebration and raising of totem poles to be legal once again. Nika Collison
speaks about this period when the Haida were systematically prohibited from practicing their culture and traditions. Today, the Haida have managed to preserve their culture and many of the celebrations and traditions.

There was a time when our people were silenced — they were forbidden to speak their language, they couldn’t have a potlatch, and they couldn’t do the art that was part of their everyday life. Through the Indian Act, the residential school system and the church; we were forbidden to speak our language, we couldn’t wear the traditional clothes that identified us. Somehow our ancestors survived and prospered. They secretly carried on with a lot of our traditions—songs, oral histories, carving, art, and our potlatch systems. What I find just as fascinating and actually mind-blowing is that the knowledge of our art survived and has to develop. (Nika Collison)

![Photo by author included with permission](image)

**Figure 25. Dancing and Singing on National Aboriginal Day in Old Masset**

Many years of preparation were required to amass the food to feed invited guests and the wealth to distribute gifts for those who witnessed the potlatch. Up to 1,000 people were part of this multi-day ceremony. Since written records were not kept, the host had to estimate the number of people who would attend and then calculate the number of gifts needed. They had to provide and arrange for an extravagant feast, organize and sequence the presentations of dance and storytelling. Even today, when such special events take place, the family coordinates and carries out the whole ceremony on its own, including
invitations, cooking, preparation of gifts, entertainment, accommodation, and clean up. The different kinds of gifts that were given at the potlatch are explained in later sections of this chapter.

In the potlatch system, the copper shields by themselves are not worth a lot of money, but their use in traditional ceremonies and in potlatches can give their owners great wealth. Copper was the ultimate symbol of wealth among the native peoples of the Northwest Coast as, like gold, it reflects the brilliance of the sun. Copper shields symbolized power, prestige, and wealth; they were tokens of the banking system and the value of the copper shields increased each time they were given away. Today, we talk about interest rates and the rise and fall of the dollar, but in the traditional Haida economy, the copper shield was the currency and was used to measure prosperity.

In the Haida culture, your status and your wealth is actually determined by the distribution of wealth as opposed to the accumulation of wealth and that is through the potlatch system which is our legal system. That is where chieftainships are taken or crests are displayed, and we still practice our potlatches today. So when you see a copper that’s missing a piece out of it—that copper has been broken to distribute it to others (an act done only in extreme circumstances), and is actually more valuable than one intact. (Nika Collison)

Back in the old days, our society was based on the potlatch system which was declared illegal. At that time the potlatch system was basically the bank of this coast. The copper shields were the tokens of that banking system and just like nowadays we talk about interest rates and we talk about the rising price of gold, the rising price of oil, and in the old days it was these copper shields that gained value out of their existence. Nowadays we have paper or electronic money, which gains interest in a bank. In the old days the copper shields used to accumulate interest as its token value would rise. I’ve also seen a few examples of whole totem poles that had marks carved in the back and those marks signified the blankets that were actually used as a payment for the carving. (Christian White)
Over the years the value of copper was measured in blankets, which was later given a value in Canadian dollars. The wealth exchange in connection with the contemporary coppers is now in the form of cash, not blankets.

Figure 26. A Copper Shield, Once belonging to Albert Edward Edenshaw, Portraying his Female Grizzly Bear Crest

*T'aaguu*, the copper is more than a mystical geometric form. It is a challenging work of metallurgy whose function is central to a complex economic system. The measure of wealth can see incorporeal properties more valuable than material holdings. Where prestige is the prize gained through the distribution rather than the accumulation of wealth, and influence is attained through respect. (Guujaaw)

**Symmetry and Beadwork Patterns**

After contact, European and Russian glass beads became one of the items traded for sea otter pelts and other furs, for many years. Valued for their bright color and
versatility, European glass beads became a sought-out item, especially at potlatches. Early beadwork was in the form of cuff bracelets, but can now be seen in a variety of forms and items.

When you do beading you have to figure out, not only in this case fitting on a feather, how many beads are going around and then you can see there are different rows so it’s probably like 10 beads on top and then 10 that go in between but then you have to work out your pattern. So that’s a lot of math. (Nika Collison)

![Photo by author included with permission](image)

**Figure 27. Beadwork around a Feather Quill**

Irene Mills an artist in Skidegate explains the process of doing beadwork around a feather quill.

Teaching people how to bead whether it’s flat or whether it surrounds a quill or needle or feather—you need to figure out patterns and the shape that you want. Those are really good examples of how to work math into things that you want to do.

Patterns have different geometric shapes. Beadwork around this feather is circular. So first you have to figure out the thickness of what it is you are going to bead—how many beads will go on. You can figure this out and then you can draw your pattern. Some people will do only one color, which is fine. But again, it’s teaching kids how to do, you know, flower
patterns and really simple patterns. When you do beadwork, you sometimes make a pattern on the graph first and then transfer it. (Irene Mills)

The basic operations of addition, subtraction, multiplication, division are also integrated with the counting of the beads in different configurations. Ratios and fractions are used as the number of beads of one color is compared to the total number of beads. Measurement, using standard and nonstandard units, can also explored in beadwork. The four kinds of rigid motion can be done with beadwork: reflection through a line, rotation, translation, and glide-reflection symmetry.

Every strip pattern can be designed from one or more of these four kinds of rigid motions, being applied to a single design unit. A pattern consisting of repeated copies along a line, in a single figure or block is called a Frieze pattern (McDonald & Weston, 2001). Frieze patterns can be classified mathematically by the types of symmetries they possess, and the classification gives rise to seven symmetry classes. Examples of each of the seven symmetry classifications can be found in a variety of Aboriginal arts and crafts. The following list of classifications can be used to identify the seven Frieze patterns:

Pattern 1: Translation
Pattern 2: Glide reflection
Pattern 3: Two parallel reflections
Pattern 4: Two half turns
Pattern 5: A reflection and a half turn
Pattern 6: Horizontal reflection
Pattern 7: Three reflections
Tessellations are repeating patterns of distinct interlocking shapes. The word "repeating" means that the tessellation can be broken down into identical sections. These sections repeat throughout the design. Devlin (2000) states that there are exactly seventeen different ways to repeat a fixed pattern indefinitely to cover the whole plane (p. 82). Many of these intricate and interesting tessellations are also found in Haida art and beadwork.
Irene Mills explains how she begins by drawing a pattern on graph paper, and once she is sure the pattern will wrap around, she does the beadwork on a bottle:

So here’s the top and then I changed it so then I could take this pattern and then bring it down and then I graphed it again. I missed one row so my pattern didn’t work so I had to re-graph it and add in an extra row and then figure out how I could make sure that my pattern stayed consistent on the corners as well. By counting the beads I slowly worked on the sides to figure out if I could get the pattern I want. (Irene Mills)
Bentwood Boxes

Originally, bentwood boxes were made from one piece of cedar that was steamed and bent. The boxes used to be about two feet high and were used to store important goods such as food, clothing, and even toys like miniature canoes. The wood was softened with heat and moisture and then bent to form a four-sided shape. Wooden pegs or laces were used to secure the two ends. Then, the box shape would be attached to a bottom piece of wood, which had been grooved on its edges to fit. The top, which was optional, would also be grooved to fit the sides. Some boxes were painted and others were elaborately carved, but most were left undecorated. The designs on the boxes were usually based on crests of the clan.

Christian White, an experienced artist and carver, explains that the size of a Bentwood box depends on the availability of the material. Mother Nature determines the width and the height of the boxes. The width, where the plank comes off a log, is slightly different for each layer, since the builder moves inward from the circumference, and the pieces gets wider. The pieces are trimmed to different sizes and the sides of a box are made from a single plank of cedar. After beveling the edges so that they can be bent to
The shape of a box, the plank is steamed, bent, tied, sewn, and then nailed together. The base and lid are also constructed to fit tightly into the bottom and top, thus, creating a watertight box. The boxes are constructed for use to transport dried goods in a canoe or to carry ceremonial regalia. The boxes that are made for a canoe are usually light and uniform in size, and become part of the canoe deck, providing floatation, because they are watertight.

![Diagram of bentwood box construction](http://www.civilization.ca/aborig/grand/gh12eng.html)

**Figure 32. The Making of a Bentwood Box**

The design and construction of a Bentwood Box utilizes a variety of mathematical skills. The making of the boxes integrates traditional and modern ways of understanding how tools can improve our lives. Graphical symmetry is used when the design of the moiety is transferred onto the box. Christian White has made several boxes over the years.
and explains that, even with modern measuring devices such as a square, tape measure, compass, pencils, etc. it is still a challenge to make a box that is square on all four sides.

There are three cuts in the box. There's one end that has a lap joint and you join the box to the end of the wood—but you'd think all those measurements would be the same but because of the way the grooves are cut into the box each side has a variance of about 3/8th of an inch. Sometimes a ¼ of an inch. Because it would always turn out to be like one corner would be square, then ¼ inch would kind of jut out and one side would seem longer. So it did take quite a bit of trial and error to figure this out.

Each of these cuts—they're not just a V-cut—it's actually a cut that is ½ inch or so wider. You have to add the thickness of the wood wide plus one side of the undercut. The reason for this is that you have to cut the whole bottom of the groove, which is between 1/16th and 1/8th of an inch—say 2mm thick—just a few fibers. Cutting the groove in such a manner lets all the fibers stay in one direction without cracking the wood. So, when the wood is steamed it can be folded around the undercut and bent to a 90-degree corner. (Christian White)

Bentwood boxes are made in various shapes and sizes, depending on their function. In Appendix 8, an activity is included that investigates the design of a box so that its volume is optimized, using the same amount of material. Figures 33 and 34 show two Bentwood boxes that have been decorated in different ways on their box faces.
Button Blankets

Button blankets have been used by a number of First Nations in the Pacific Northwest for hundreds of years as a representation of family lineages and crests. The crests depict various animals such as Raven, Killer Whale, Beaver, and Eagle, as well as
other legendary creatures. Each proclaims the rank or social status of the owners and their hereditary rights, obligations, and powers. Lineage is matrilineal in Haida culture, so women pass their crests to their children along with their family's status and privileges. Each family owns its own crests which are directly inherited. Button robes were only to be worn at special events such as the raising of a totem pole, a potlatch, or to cover the coffin of its owner. Afterwards, the blanket would be passed on to the heir of the deceased. At one time, the blankets were mostly used for trade, but today, they are also used for ceremonial purposes. In addition to their traditional role at potlatches, the blankets are gaining more acceptance as part of the educational and political activities. Aboriginal people still value the blankets as a means for portraying historic rights and privileges, communicating a shared identity, and designating the wearer's place in today's ever-changing world.

The button blankets used to be made from animal skins, mountain-goat wool as well as cedar bark and other vegetable fibers before the Europeans introduced manufactured cloth to the North West Coast of British Columbia. The crest designs were decorated with shells that were sewn onto wool blankets acquired from maritime fur traders and later the Hudson's Bay Company. Squares of abalone shell were sewn to the eyes and joints of the crest figures to reflect bits of light as the wearer danced around a fire. When pearl buttons obtained from fur traders came into use, they proliferated onto the formlines. Today, buttons are sometimes used to either fill entire zones of the design elements or just the borders.
Button blankets have rich mathematical connections. The borders display a variety of patterns, as discussed earlier in the section on beadwork. Some of the shapes in the designs contain concepts such as measurement, transformations, tessellations, and symmetry. Some blankets might have vertical and horizontal symmetry, while others might be asymmetrical, with the top and bottom having different geometric shapes, representing the head and feet. Elders suggest that women mostly wear blankets that are red and have the black design for balance. Men usually have black blankets with a red design. In this way, the different dancers can easily be recognized. Today, artists are using different colors and designs that depict their personal creativity and preferences.

Irene Mills, a master button blanket maker, describes the process of blanket making:

When I wanted to do a new blanket I asked a young artist, Tyson Brown, if he would do a design for my blanket. I am an eagle so he said he would put together a design with my crest. I decided on the size of the blanket and marked out where the border would be so he could ensure that the design filled the blanket. He wanted to make sure that the design was mostly on the back so if you stand with your blanket most of it is on the back. I enlarged the design to three foot in length—the integrity of the
design would fill most of the blanket and made sure that it wasn’t too small on the back.

And then for centering—once you get the design laid out—you just measure how much room you have on either side and there needs to be twice as much room on the bottom as there is on the top.

I have cut out my design in ultra suede and then I will just put it all back together so that the really fine spaces that the artist has drawn—the integrity of the design is kept—once it’s put on the blanket to be sewn. So it’s a bit tedious.
As to the colors, I copied it and then I colored everything so that I could be sure that I actually had it right and then I showed him again and there's some fine lines that I actually need to sew on before I can do anything else. Once that is done the last thing I do is sew the buttons on the border.

I learned how to put buttons on a blanket from my mother. For example, she showed me how to start out in the corners and then measure how much room four buttons takes up and then divide that in the length to see how many spaces are needed so that you end with four buttons. Sometimes
your calculations are incorrect, and you need to make minor adjustments as you get closer to the bottom—maybe, a fraction of an inch, so that it will still look like you followed the pattern. And it’s changed so subtly that you won’t notice. (Irene Mills)

Recently, a tradition among the Haida has evolved for students who graduate from high school or a post secondary institution. The student’s aunt, maternal grandmother (nonnie/ nuni) or others in the family will make a button blanket and present it to the graduate at a special Haida graduation ceremony. The symbols or crests displayed on such blankets come from the mother’s side of the Haida clan. The making of a blanket may take a couple of weeks up to a month, depending on the blanket’s level of complexity. Today, a variety of colors and fabrics are used for the backgrounds and crests on the blankets. At a recent Haida graduation ceremony in Old Masset, some graduates proudly wore the blankets that had been presented to them.
In Appendix 9, three, “hands-on” activities are presented that show how students can explore certain mathematical concepts by using culturally relevant artifacts, for example, the button blankets. In the first activity, the students’ prior knowledge is activated and connections are made between mathematics and artistic endeavors involving Aboriginal artifacts, in particular, the Haida, Coast Salish, or Navajo blankets. Students are to use their imagination and write a story, song, or poem that is central to the artifact (blanket). Storytelling forms the foundation for much of the traditional Aboriginal learning and teaching. Through the process of telling stories, skills are nurtured in listening, thinking, and creativity. In the second activity, students identify different mathematical components that are a part of the blankets, such as shapes, patterns, rotation, translation, and glide-reflection symmetry. In the last activity, students are to
create a blanket design of their own. The design should include a variety of different mathematical components. If possible, students should have the opportunity to make their own button blanket, and upon completion, write a reflection about their creative process.

Canoes and Paddles

Nika Collison, in a personal interview, explained how the cedar canoe originally came into existence, and the process that was used to make a traditional Haida canoe.

Our history spans back to the beginning of time—we have our own histories from the Ice Age to the Great Flood. Around 6,000 years ago or so, the first cedar tree grew in the Northwest coast and on Haida Gwaii and that changed our culture and I guess all coastal cultures profoundly.

Cedar along with the technology of the canoe changed our lives completely and fully because we were separated from the mainland.

The canoe, which is made from a single cedar tree, and stands up to 90 feet long, that our ancestors would go into the bush and fell them usually by burning them, and then hollow the tree out there—but even before they’d fall it, they’d have to do test holes into the tree to make sure it was going to be a good tree to make a canoe because otherwise it was pointless.
to fall a tree. So, the tree would be hollowed out to a certain degree into a canoe shape and then they would float it down a river near by.

Once they got the dugout form back to their village, they would finish the shaping/carving of the canoe—get it ready for steaming. They had to wait for the right type of weather to start the steaming process because if you didn’t do it properly you could ruin your entire canoe. Rocks were heated in the fire and placed in the canoe full of water. Sometimes seaweed was also added to help with the softening of the wood and keeping the heat in. The hot rocks made the water really hot and steamy and then they would cover the canoe for awhile which allowed the cedar to become quite pliable. So this is where the weather comes in—you’ve got hot rocks and hot water in wood and if it starts to get too cold or windy outside, it would crack the canoe. Once the cedar is pliable enough, wedge spreaders are carefully placed inside and it opens the canoe into this beautiful shape and then the finishing touches are applied.

The canoe is the reason we were able to get out into the middle of the ocean and fish for deep sea fish; the reason we could get over to the mainland and have an economy long before European contact. There was a thriving trade economy up and down the Pacific coast and beyond. So we really owe our rich way of life to the cedar tree, to the salmon and then later on to the canoe. (Nika Collison)
Guujaaw, President of Haida Nation explains that a number of mathematical ideas are incorporated into the building and designing of a canoe. Taking accurate measurements from a model, or existing canoe, and transferring these to a scale, or making a larger canoe, required the builder to have diverse experiences with measurement. Builders relied on their formal and informal experiences with measuring attributes such as length, surface area, and volume, and needed to use care with the units of measure. Builders also became proficient at measuring angles, using ratio and proportion, and solving problems that involved scale, similarity, and derived measurement.

In recent times, the building of a canoe has required back engineering, where we need to accomplish our goal of building a canoe, without the aid of an experienced carver. We had to learn the different steps through studying canoes abandoned in various stages of completion, while the few existing canoes were meticulously measured and blueprinted. We also had to seek out invaluable bits of information from elders, who had been told of or even seen, the building of canoes.

These canoes were not crude dugouts, rather a refined and outstanding piece of marine technology. The Haida canoe was the first, and several hundred years ahead in the concave prow which is now seen as a superior prow, which only became the prow of choice during the Second World War when considerable effort was given to the development of superior ships. We know that the canoe has to let the water pass under it while maintaining stability, we also know that the canoe will also have to move about on some of the most challenging waters, where tides and winds can be to your advantage and in a moment to your peril. The vessel is built in one form with the intention of stretching and changing practically every line on the boat. The gunnel moves from a stiff straight line to a gracefully sweeping gunnel like a rocker. A slight bend in the keel line becomes the permanent shape allowing for maneuverability. The steaming also makes the canoe wider and more stable. It is said that the Haida were shown how to make the canoes by the supernaturals.

The canoe is actually a good example to compare the curriculum from the Aboriginal and Western worldviews curriculums. They say the dugout canoe is kind of a relic from the past—a primitive vessel—and yet the
lines on the canoe are as good as or better than many boats that have been built today. (Gujaajaw)

In the winter of 1985, a 56-foot traditional Haida canoe was built in Skidegate. The dimensions for the canoe were replicated from other canoes in museums. Hence, the builders knew exactly where to place the wedges, and what thicknesses should be used. The project took more than four months to complete, and the initial canoe was shaped with the use of power saws and adzes. Later it was carved, and then stretched by steaming the inside with boiling water. The people from the village helped to stretch the canoe, but had to take turns as the boat was hot from the steam. In total, 64 wedges were put in place, which were moved back and forth until the correct position was attained. Once the canoe was ready, the minimum and maximum number of paddlers was determined. Many thought more paddlers would be better, but this was not necessarily true, as, for example, 10 paddlers, instead of 12 might be preferred so that the bow would be slightly raised to make the canoe more efficient in the water.

Christian White explained how measurements were important when the paddles are carved:

You measured the length of the paddle to be the distance from the ground to the paddlers’ nose. The width of the paddlers’ fist was the hilt or the crutch part of the handle on the top of the paddle and the length of his arm, was the distance where he will hold the paddle, and his two fists together would determine the width of the blade of the paddle. Also there is a centerline down the center of the paddle which is actually somewhat visible and just before the blade. The blade comes up the handle which is like a backbone on each side of the blade and that helps to strengthen the length of the paddle. And it actually gives us a measuring point to follow to keep the paddle balanced so it’s not twisting. (Christian White)
Drums have a deep-rooted history and an inseparable connection with the Haida way of life. The vibrations of the drums are in tune with the earth’s natural frequency and their round form represents the circle of life as well as the universe. In all aspects, the drum connects the people to life. Drum heads are made in a variety of shapes, but most are circular and have a cedar base. The frequency at which the drumhead vibrates depends on its shape. The pitch may also vary, depending on the tension and the assemblage on the back. Some drum beats are determined by the way in which traditional songs are sung. Furthermore, the dances usually dramatize a specific family story or
recreate encounters with spirit beings. Dancing, drumming, and singing are integral to most of the ceremonies, especially the potlatch. Through drumbeats and songs, several of the Haida traditions are passed down from generation to generation. The drum is not only a deep, sacred part of the Haida, but it is the heartbeat that sets the rhythm of the dances and the tempo of the songs.

![Photo by author included with permission](image)

**Figure 44. The Sound of a Drum also Depends on the Tension and its Assemblage on the Back**

Mathematical ideas of fractions, measurement, and equivalency are fundamental in the playing of drums. Musical instruments, such as drums, vibrate in a series of fractions called the harmonic series, and musical rhythms are based on equivalent fractions of time. Drumming is rhythmically based on the subdivisions of time into fractions. Since the frequencies of a drumhead’s vibration depend on its shape, known mathematical formulas can be used to predict the frequencies if the shape is known.
As a traditional circular cedar or spruce drum is assembled, the builder must ensure that sufficient material is used for the overlapping, gluing, and handle attachment. The builder also needs to calculate the amount of shrinkage that will occur in the wood from its green state to its dry (cured) state. The rate of shrinkage differs for different woods and, for example, spruce will shrink laterally by 12% and in length by approximately 2%. Once the dimensions for a drum are chosen, accurate measurements must be made to actually produce the drum. The drumhead is usually made from deer or other animal hide, which is soaked overnight in water in preparation to be stretched to shape. The skin is then placed on the frame and joined with string or other material in various geometric patterns. The tension used in assembling the drum will determine the sound once the skin is dried. After drying, the drum maker may paint a design on it. Such designs, as mentioned earlier, can represent a story, a family crest, or some combination. After its completion, the drum is struck either by the player’s hands, or by using drum sticks (made of hardwood and wool) with the resulting sound being due to vibrations of the membrane.

Figure 45. Drumming a Traditional Beat at a Ceremonial Event
We did traditional music and the beat—we had an understanding of the beat and where the song begins and ends within the beat—it’s not formalized by being written down. There are different drum beats and some are trickier than others and you are trying to keep a drum beat with a song that is not the same tempo as the drum beat. When you are dancing, you are counting, you’re doing math. Traditional music like contemporary music has the beats, half beats, quarter beats, etc. (Nika Collison)
Making Masks

Haida art and artifacts are representative of a way of life. Jewelry, masks and other forms of art are ways of visualizing the oral culture. The Haida called the masks and puppets "gagiid", which were used during dances to represent the wild spirits of the woods. The masks were also worn in the potlatch ceremonies to represent the spirit beings encountered by their ancestors. Usually, the masks were carved from yellow cedar, but now they are also made of argillite and other materials. The carvers show a highly developed sense of three-dimensional form and space.

Figure 48. Christian White Carves a Scaled Model before Carving the Actual Piece of Art
Christian White, a master carver, explains the process of carving a mask:

A lot of the time when I am working on a piece, I will start with a model. Sometimes, I use paper to work out the design because once it’s carved into the wood then it’s done. I will shape a large piece of wood but I wouldn’t carve into it right away. I would scale it down to a smaller size and then carve the smaller piece of wood. Once I have refined the design on the smaller piece then I would enlarge it to fit on the larger piece of wood.

When I am carving with argillite I actually go by eye quite a bit of the time. Argillite is black, carbonaceous shale found in Haida Gwaii. I have
been carving it since I was about 12 years old. My father was carving argillite at that time, so I picked up his tools. We go to a remote area and get the stone ourselves and carry out maybe 100 pounds on our back for several miles. I cut it up into usable pieces and put aside the larger pieces for sculpture and the smaller pieces for jewelry. In my mask carvings, I draw my centerline first and then use a divider tool just to measure out from the center. I just have a couple of reference points then I measure from the center to each point. (Christian White)

Jewelry Making

The art of making jewelry uses mathematical concepts such as symmetry, congruency, and transformations. The bracelets are representative of a transitional time when the Haida were no longer allowed to tattoo themselves, as it was considered to be primitive by the church. One of the solutions the Haida found was to carve on bracelets instead of tattooing themselves. These bracelets, which became a symbol of survival and continuity, were easy to remove before the church minister came to visit.

Source: http://www.virtualmuseum.ca/Exhibitions/HaidaJava/francais/art/a+o_image_art80.html
included with permission

Figure 51. Haida Bracelet Carved by Charles Edenshaw

133
James Sawyer makes jewelry, especially gold and silver. He also makes paddles, drums, prints, boxes, logo designs, and designs for prints. He explains the process of making a bracelet:

I know myself I use math just for breaking up things and dividing up spaces on bracelets. I will take a common size 6 inch bracelet; put a centerline on it, measure on each side of it, maybe half an inch to an inch—depending on if I am going to do two designs in the middle—like a split design. I would then leave an inch on each side of the centerline and draw that in. You only have to draw it on one side because after you are done carving out your formline, you then transfer or trace it. You draw it on tracing paper, and then flip it over and then you’ve got the same carving on the other side. You can measure it out if you really want to but it’s on such a small space, I’ve gotten to the point now where I’m just doing the secondary lines just by eye. (James Sawyer)
Pricing is another part of making jewelry that uses mathematics. Bernard Kerrigan, a jewelry maker, explains that a successful jeweler needs to know the concepts of fair pricing, ratios, and proportions:

If you want to make sure you get a fair market value for yourself plus a market value for the customer you have to look at the current price of silver and gold. You also need to factor in how much time it will take you to make the piece. If you work 1,000 hours on something and you sell it for a $1,000, mathematics would say you made a dollar an hour. We do a lot of ratios and proportions in our head, we would visualize a piece and then decide what it is you want to make and how are you going to divide it up. We also use fractions—so you don’t have half the gold on one side and none on the six other figures on the other sides—so the piece has to be symmetrical and proportional. (Bernard Kerrigan)

**Making Tools**

Making tools for hunting, fishing, building, food-gathering, or wood-working was a skill that every Haida man possessed. Traditionally, tools were made from stones, bones, shells, or antlers attached to wooden handles. Today, most of the tools are adapted from what is available locally or from items available at the hardware stores.
The major disciplines in mathematics first arose from the need to perform calculations in commerce, to understand the relationships between numbers, to measure land, and to predict astronomical events. Each discipline used different kinds of tools. For calculations, the Chinese abacus, Egyptian clay tablets, Quipu knotted strings, and Napier bones were used. In the 17th century, as technology changed, mechanical calculators came into existence, which were followed by electronic calculators. The first units of length in almost every culture were based on body parts. Diane Brown explained that even today the Haida measure the length of roots and bark, used in medicine, based on the length from the elbow to the tip of the middle finger. This measurement is one of the earliest standard units of measurement, devised by the Egyptians and called the ‘cubit’. At one point, the Haida simply used their hand span and the cubit for small measurements, and used their paces for longer measurements. By the 1700's, the Haida had a well-developed decimal system for counting, measuring and calculating.
White explains how the Haida used measuring sticks, which were also based on the body measurement from one fingertip to the fingertip on the other hand.

I used to hear about stories about the different tools they’d use for measuring and my father, Morris White talked about it. Each carpenter or artisan having his own set of measuring sticks and then they would use string or strips of cedar bark for measuring. Those measuring sticks would have a measurement of basically one fathom, which is fingertip to fingertip. A fathom is a unit of length which is 6 feet or 1.82 meters. That would be one of their main measurements because you used to work on such a large scale that it would be the most practical way. Even though the size of the people would vary a bit, and there was really no standardized form of sizes; it seemed like all measurements came out quite close.(Christian White)

Over the centuries, many systems of measurement were developed and refined as people found the need for consistent measures in commerce. Today, the most common standard measuring system is the metric system which uses the meter as its standard unit of length. Some countries, however, still use the Imperial system, with the foot as the basic unit of length (based on the size of the foot). The foot (12 inches) was originally the length of a human foot, though it has evolved and now is longer than the length of an average person’s foot. Different units are used to measure physical features such as area, volume, weight, or time. Important aspects of measurement include the use of compatible units for the attributes being measured, estimating measurements, selecting appropriate units and scales that determine the accuracy of the measurements, and using measurements for solving problems.
Longhouses

Due to the wet climate of the northwest coast, the Haida once built their traditional longhouses out of cedar planks. The longhouses were constructed of cedar beams supported by four corner posts that were large trunks of trees set deeply into the ground. The roofs of the homes were made of planks and cedar bark and the walls were made of cedar planks. At times, the walls were tied together so that they could be taken down easily and moved to fishing camps.
The traditional cedar longhouses of the northwest coast had only one small opening, which was the entrance. Inside, each family had separate living quarters and cedar mats were woven to make partitions. Each partition opened to the center of the house, where a fire burned continually for both light and cooking. Smoke escaped through an opening in the roof. The pitch of the roof lines and the area of the wall would vary depending on the location. Many related families lived together under one roof, though each family lived separately and was responsible for its own clothing, baskets, and meals.

Figure 58. Front View of Christian White’s Tluu Xaada Naay Canoe Peoples’ House

Christian White explains how he uses scale and measurement in building a traditional longhouse:

I had to first of all scale down the longhouse so it would fit on my piece of paper and from there I am able to draw a design so the longhouse would have the shape relative to the actual size. Once I combined that then I was
able to use those measurements and scale them back up again. I would look at several longhouses and from that I was able to figure out the pitch of the roof. From this one angle I determined the pitch, then I used that angle on several occasions and that angle stayed true right from the scale down and then scaling back up. Most longhouses use similar types of angles. (Christian White)

Looking at the front of a traditional Haida longhouse, its appearance is visually appealing. Longhouses vary in their dimensions but, in some cases, the ratio of the longer side to the shorter side is the ‘golden ratio’. Mathematicians have studied the golden ratio because of its unique and interesting properties. Golden ratios are found in nature, and have been used in art and architecture for centuries. The ratio was also used by the Egyptians, Greeks, Romans, and other cultures around the world. It has also been called the extreme and mean ratio, sacred ratio, golden section, and divine proportions.
Dalton (1983) described the three steps for constructing a golden rectangle and for finding the numerical approximation for the value of the golden ratio.

1. Construct a unit square (red).
2. Draw a line from the midpoint of one side to an opposite corner.
3. Use that line as the radius to draw an arc that defines the long dimension of the rectangle.

The golden ratio with its numerical approximation is:

$$\phi = \frac{1 + \sqrt{5}}{2} \approx 1.618033989$$

Haida longhouses are usually constructed using a post and beam method, which uses large, widely-spaced posts to provide structural support for the beams. With the post and beam construction, the columns and beams support their vertical loads. Interestingly, the framing for longhouses, of many years ago, with the traditional form of post and beam, still meets today’s building codes. The Haida were able to figure out where to place the posts so that the beams were able to handle the loads. They also had the ability to calculate the slope of the roof to withstand rain and other forces of inclement weather.
Halpin (1981), Stewart (1993), Kramer (1995), and other authors have written about the different totem poles of BC and how they embody the carver’s art, culture, and history. Bill Reid, in Raven Travelling (2006), eloquently explained these distinctive poles.

The poles were many things. The house pole told of the lineage of the chief who presided within. The memorial pole commemorated some great events. The grave pole contained the body and displayed the crest of a leading noble. In many of the great houses, massive figures-illuminated by firelight-supported the roof beams. Each pole contained the essential spirit of the individual or family it commemorated, as well as the spirit of the artist who made it, and, by an extension, the living essence of the whole people. While the people lived, the poles lived, and long after their culture died, the pole continued to radiate a terrible vitality that only decay and destruction could end. All things must die, and great art must be a living thing, or it is not art at all. (p. 25-26)
Visitors to Haida Gwaii and other parts of BC are usually in awe of these great wood sculptures. Visitors are bewildered and intrigued by the complex designs, symmetry, and the timeless message of the art. In addition to the frontal, memorial, and mortuary poles that Bill Reid described, today, a commercial pole can be found that is usually commissioned by an outside agency such as a corporation, government, or special event. These totem poles are not displayed in their traditional context, but placed as artifacts for tourists at airports, art galleries, museums, schools, parks, etc.

Most totem poles, even today, are carved from the trunks of a single mature red or yellow cedar tree. Cedar has many qualities, especially its resistance to insect and fungi, and its fragrance and flexibility. Hence, the cedar has been used for thousands of years for shelter, clothing, and tools. The crests on a totem pole belong to a family and tell that family’s story, which may be a myth, legend, or a story from the life of a person being honored by the pole. These historical narratives or symbols are known in their entirety only to the pole’s owner and to the carver of the totem pole. The most common crests of the Pacific Northwest people include the eagle, raven, thunderbird, bear, beaver, wolf,
killer whale, and frog. Everything on the pole is usually symmetrical. From the initial square, a three-dimensional piece emerges, since most carvers begin with blocks and do their work from the blocks. After the blocks are outlined, the carvers ensure that the blocks are even, and then round them into geometric or ovoid forms.

Historically, carvers of a totem pole were once paid $5 a foot. Today, they sell their work for prices of $1,000 to $20,000 a foot, depending on the carver. These prices depend on a variety of factors such as: How many man-hours will be needed to carve the
pole? Whether the carver will hire one or more helpers? How much detail is to go into the pole? How much money is needed by the carvers to maintain their lifestyle? Two poles might look the same, but their prices will be based on the reputation (i.e., the name) of the carver. Currently, six commercial totem poles are being carved on the island by local artists, which are valued at more than two million dollars. These commissioned poles, once completed, will be moved to locations off the island.

Figure 64. This Pole has Three Watchmen at the very Top, who are Guardians, looking out for Danger from the Land, Water, and Supernatural World

Carving Totem Poles

Arthur Pearson, a master logger, has prepared a number of cedar planks that are used to carve totem poles. He explains what needs to be done before a carver can start working on a pole.

I make totem pole planks and the longest I have done now is 30 feet. A friend of mine had a contract for a totem pole and he had brought me a fairly big pole—actually a tree—which had a base diameter of 42 inches, so what I do is I take the back off so it’s flat to the thickness he wants. Then I take “the heart” out off the back which may be 6 inches by 8
inches. It is really important to take out the heart because it reduces the potential for cracking, since it is the hardest part of the wood. I then make angle cuts as we go around the log so it becomes a six sided log with the back being the sixth side. Usually the back is a straight cut and then all the other ones can angle—they can go 8 inches and taper down to maybe 4 inches at the top. (Arthur Pearson)

Guujaaw explains that certain mathematical concepts are used when putting together a totem pole:

Math is in the layout, proportioning the pole, generally figuring out who you’re putting on the pole, and what all of the characters are going to look—but there comes a point when the art form takes over. Like on every shape whether it’s an eye, a nose or a mouth or cheeks or eyebrows, there’s a rule of plains that is involved. It’s got to be proper, even when somebody who doesn’t have any idea of the rules views it, in their mind’s eye they can tell if the carving is right or not. So if you were to computerize a canoe it will be quite an amazing thing to see, especially when you start examining the different plains, their relation to the other plains, the negative reverse plains, and the flow of energy. (Guujaaw)
Ben Davidson is a young carver who first apprenticed for about four years with his father, Robert, and his uncle, Reg, and then worked with his father for four more years before starting carving on his own. He explains the process of carving a commercial pole as beginning with a cedar log, making a scale drawing, and then doing the actual carving with a variety of tools.

I am carving a 30-foot totem pole. We started off with chain saws and then used adzes after that when we got closer to the finish we moved to smaller tools—two-handed chisels and then there’s even smaller chisels after that.
for fine detail. We did the roughing out for about 3½ weeks and now we are just starting to do the matching up and the next step will be to finish. We have got three main figures which is the killer whale at the bottom he’s biting onto the tail of a grizzly bear in the middle, with a raven on the top.

I start with a drawing, which is on a scale of 18:1. The scale drawing is mainly done in metric but depending on who I am working with I sometimes also use inches. The main thing I am matching right now is to get the eyes looking in the right direction. This one is angled out compared to that one. So in matching you have to take it so far and then you max the other side to see if you have the right angles of things and then that’s when you start making your fine adjustments. If one side is a little bit lower I kind of see-saw back and forth and work on both sides. Once I like something, then that will become the final figure. (Ben Davidson)
Polya (1957), in his classic book, *How to Solve It*, gives the following four steps for problem-solving:

1. Understanding the problem. (*Recognizing what is asked for.*)
2. Devising a plan. (*Responding to what is asked for.*)
3. Carrying out the plan. (*Developing the result of the response.*)
4. Looking back. (*Checking. What does the result tell me?*)

Problem-solving is central to inquiry and application; it provides a context for learning and applying mathematical ideas. Van de Walle (2001) emphasizes the importance of mathematics being taught through problem-solving. A problem is a task or an activity for which students have no prescribed or memorized rules or methods, and a single, specific method does not serve to find all solutions. Kramer (1995) outlined the steps for carving a pole, which could be accomplished using Polya’s above four steps for problem-solving.

1. Understanding the problem. A planning meeting of the artist, carver, commissioning body, and elders takes place where each party understands their role. A design is made and revised as needed, and based on the size, decisions are made about which tree or plank will be used and the location where the pole will be carved. The problems associated with transportation and raising the pole also need to be discussed at this stage.

2. Devising a plan. Before the tree or plank is delivered to the carving shed, a small model of the pole may be carved to see how each figure would integrate into the total design. The tools are assembled, and blocks are placed where the pole is to be placed. Sometimes, elders are called for a blessing ceremony before the carving begins.

3. Carrying out the plan. The artist or master carver draws the outline of the approved design on the wood and the carving begins. Most carvers begin from the bottom of the pole, moving gradually to the top. Sometimes the design for the characters is revised from the original plan so that a natural flow evolves that is visually appealing. As the work progresses, the master carver guides and inspires the apprentices and teaches them the concepts in the context of
situated learning. Finally, the shapes are refined, finishing techniques are applied to each detail, and paint is applied, where necessary.

4. Looking back. Carvers work in teams and consistently review what has been done and what needs to be done. The duration of the project could be from a month to a year, depending on the length of the pole and the detail of the carving. Once the carving is complete, the pole is transported to where it will be raised. The raising ceremonies differ according to the elders who conduct them, the traditions of a particular nation, and the prestige and protocol of the owner of the pole. In all ceremonies, the carvers and their families are honored, as are the owners of the pole.

![Photo by author included with permission](image)

**Figure 68. Ben Davidson, Carving a Totem Pole at Skidegate with an Apprentice**

*Raising Totem Poles at Haida Heritage Centre at Qay'llnagaay*

In June 2001, 6 cedar totem poles, each at least 13 meters in height, were raised on the shores of Second Beach, between Skidegate Landing and the main part of the Village of Skidegate, in front of the new Haida Heritage Centre being built at Qay'llnagaay Bay. The new poles were the first to be raised here since 1978. They honor six major southern Haida villages: Skidegate, Chaatl, Cumshewa, Skedans, Skung Gwaii, and Tanu. Scheduled to open in 2007, the 50,000 square foot centre will house an international teaching centre, a new oral history and archives centre, a canoe house, a performing arts theatre, and headquarters for the world-renowned Gwaii Haanas National Park Reserve.
Nika Collison, the curator at the museum, describes the day some ancient burnt poles were moved out of an old storage house to a new space.

I was terrified watching these men from the village move these poles—I was like ‘Oh my god, they are going to break these poles, they are fragile poles, they are going to split in half?’—they knew exactly what they were doing—they knew how far they could push the wood even in its fragile
state—they moved them flawlessly, meticulously, without any damage.
(Nika Collison)

Nika Collison, the curator at the museum, describes the day her father’s memorial pole was raised in Old Massett.

They know exactly where the ropes need to be positioned on the pole—how to tie them—you are raising a 37 foot pole that hasn’t even been hollowed out—it is a very heavy pole—part of it has to go in the ground right into the hole and they know exactly how many ropes and where to tie them so that it can be pulled up vertically. (Nika Collison)

Nika Collison, the curator at the museum, describes the day the poles were raised in front of the Haida Gwaii Heritage Centre.

They raised six poles in six days in the traditional way, but some of the loggers who knew about rigging I think incorporated some pulley system to help them. One of the poles was put into place leaning against something just because it was so darn heavy—like leaning on a angle because it could only be pulled up so much—the placement of it didn’t allow for people to be out in front of it unless they were out on the beach—for the most part it was still all ropes and angles and that’s engineering—I’m really impressed with the knowledge in our village. (Nika Collison)
Haida Mortuary Poles at SGang Gwaay

In 1981, the magnificent display of standing Haida mortuary poles at SGang Gwaay was declared a World Heritage Site by UNESCO. Twenty longhouses were in place, along with many memorial, frontal, and mortuary poles. Nika Collison describes how her uncle Tucker, with very little formal education, had the innate mathematical ability about angles and ratios to assist with the restoration of many of the poles without compromising their integrity.
My Uncle Tucker, who has passed on, I think he had grade two education but he was brilliant. And when Gwaii Haanas was established and they had to straighten the poles from SGang Gwaay—they consulted with the hereditary leaders of the nation and asked them what to do with those poles that were being moved and some had fallen, the hereditary leaders said raise the ones that could be raised—they were still leaning but you have to do it in a way that doesn't compromise the integrity of the poles—you can't just cut them out of the ground and straighten them—you have to dig them out—you have to re-raise them. It was my Uncle Tucker who actually developed the engineering design for how to do that and then parts were sent to a consultant who then said it was brilliant and, you know, that was Uncle Tucker without any formal high school math so it is an innate thing.(Nika Collison)
Numbers and their Significance

The Haida number system, like many number systems of North and South America, is based on ten, or what we today call the decimal system. The formation of number words is based on groupings of ten. Root words are used for one, two, three, through ten, and then these words are used and reused in a cyclic pattern based on ten, until ten such cycles reach one hundred. After 100, the pattern repeats, and the only thing that is different is that a hundred is in front of the number. The words waagi, which means to add, and the word gaw, which means less, are combined with other words to represent or group the numbers. Tlaalaay means groups of ten, so that fifty is tlaalaay tlayhll, which means five groups of ten. The following list is of some numbers with their corresponding Haida word, as outlined in the Skidegate Haida Immersion Program (2005, Lesson 3, page 26, CD # 2).

1. sgwansing
2. sding
3. hlgunahl
4. sdansing
5. tlayhll
6. tlgunuhl
7. jiiguuga
8. sdaansing xaa
9. tlaahl waasda sgwansing gaw (10-1)
10. tlaahl (10)
11. tlaahl waagii sgwansing (10 +1)
12. tlaahl waagii sding (10 +2)
13. tlaahl waagii hlgunuhl (10 +3)
14. tlaahl waagii sdansing (10 +4)
15. tlaahl waagii tlayhll  (10 +5)
16. tlaahl waagii tlgunuhl  (10 +6)
17. tlaahl waagii jiiguuga  (10 +7)
18. tlaahl waagii sdaansing xaa  (10 +8)
19. tlaalaay sding wasda sgwansing gaw  (20-1)
20. tlaalaay sding  (2 groups of 10)
30. tlaalaay hlgunuhl  (3 groups of 10)
40. tlaalaay sdaansing  (4 groups of 10)
50. tlaalaay tlayhll  (5 groups of 10)
60. tlaalaay tlgunuhl  (6 groups of 10)
70. tlaalaay jiiguuga  (7 groups of 10)
80. tlaalaay sdaansing xaa  (8 groups of 10)
90. tlaalaay tlaahl wasda tlaahlgaw  (9 groups of 10)
100. tlaalaay tlaahl  (10 groups of 10)

Figure 72. Blanket of a Haida Graduate with the Number 10, a Significant Number in the Haida Culture
Numbers are an integral part of most cultures around the world. Today, numbers are part of our daily life in the division of time, the use of currency, weighing, and measuring.

Your whole life revolves around numbers. You get up at 6 in the morning, lunch is at 12 o’clock, supper is at 6 and you go to bed at 10 o’clock and so on like that. So all your life you are dealing with numbers to count, tell time, measure, earn money, etc. When you are measuring for your figures on a pole, most artists even today deal in inches and feet, so they have got to know the conversions and be able to divide into the length of the log that they are going to carve – it all comes down to numbers (Herb Jones).

Many cultures consider certain numbers not only for their quantities but also as a cultural representation. Some cultures consider certain numbers to be lucky while others to be unlucky, or some numbers are viewed as being more significant than others, due to their occurrence in the natural world. Vonnie Hutchingson explains the significance of the number four in the Haida culture:

Four is of significance to the Haida; it is just the way the world is organized. A house has four corners, and you put the medicine in the corners to drive away evil spirit. In the world, there are four directions, East, West, North, and South. Haida go beyond that, there is a spiritual connection with numbers. When you are doing the cleansing ceremony you do it over four nights, you boil the medicine and the water down four times, you put four pieces of a particular medicine into the whole. It is the only number that has connections with the real and the spiritual world. If you were going to go out and focus your mind, you would go out for four days and four nights into the bushes to think about a good outcome. So four is really important. (Vonnie Hutchingson)

Another example of a significant number is 40. Diane Brown explains:

Certain fish, say dog salmon, was smoked and dried when it was totally dried, and always tied in bundles of 40. And then they would keep the intimate detail of the blankets given away, by bundling sticks. The sticks
would be used for counting purposes and stored. So, in the event of a marriage breakup, the man was entitled to take two things—his crest that hung over the door and his sticks. (Diane Brown)

Figure 73. Fusion of Cultures. A Blanket of a Recent Haida Graduate (who was a Basketball Star), depicts Number 23 (Michael Jordan’s number)

Cycles: Seasons, Months, and Tides

The Haida, like many other First Nations people used to calculate the passage of time based on their daily life cycles and essential skills needed as fishermen, hunters, and gatherers. The need to have calendars and divide a day, season, or year into discrete units did not occur until post-contact. Seasons and months were kept track mainly by counting the cycle of the moon and the tides. Chronology of significant events was passed on as oral traditions. In the evenings, elders would gather the children in the longhouse and tell them the stories of their ancestors. Months were also named and identified with events that affected their livelihood. For example: When should food be gathered; When does the bear sleep; or When will the berries ripen? Cogo (1979) identifies the Haida months as follows:
January  Bear Hunting Month
February  Goose Month
March     Noisy Goose Month       Herring Egg Time
April     Migratory Geese Month
May       Food Gathering Month   Black Seaweed
June      Berries Ripen         Red Salmon
July      Ripe Berries
August    Salmon Month
September Cedar Bark for Hats and Baskets
October   Ice Month              Dog Salmon egg
November  Bears Hibernate
December  Snow Month

*Rhythm of the Tides*

As Haida Gwaii is a collection of islands, the livelihood of the people depended on being able to travel and fish in the water. The people had an instinctive ability to predict the weather by studying the speed and direction of the winds; looking at the size and direction of the waves; and observing phenomena like wind funnels. Connections and relations between tides and currents was made by listening, watching, and interpreting the whole. Elder Roy Jones explains how, as a fisherman, he had to know about tides and use mathematics.

To me, math is the most important thing in the life because I grew up as a fisherman. When you are traveling around in the waters, you’ve got to figure out the tides. You’ve got to subtract, and add time—that’s why I think the most important thing you teach is math. I haven’t had much schooling, but I learned this as I went along because I had to do it. I used to run boat and we had nobody to do our chattel winds. So I had to do it myself. I had to do it and learn as I go along. I had to make settlements for five men on a boat—settle them up, get the fuel, get the grub—settle that
all and then prepare men out. That’s where I think math is very important.
(Elder Roy Jones)

Parks Canada (2004) explains that Haida Gwaii, like other parts of the world has two high and two low tides in each 24-hour period, with approximately 6 hours between the high and low. Tidal range can be up to 8 meters, with the highest and lowest tides occurring around the time of a full or new moon. As the tides get larger their impact on the speed of the current also increases. Tides flood (rise) from south to north, and ebb (fall) from north to south. Nika Collison explains how to tell if the tide is coming in or going out.

You can tell the tide is going out simply because there are wet patches left as the tide goes out. I just learned from Captain Gold the other day that you can tell the tide is coming in because the water where it reaches the beach is foamier because it is pushing the air—like it’s covering the air pockets and pushing the air out of the little holes that might have formed.(Nika Collison)

Figure 74. Is the Tide Coming In or Going Out at North Beach?

Tide times and heights listed in a tide table are specific to a location, and are usually based on a theoretical calculation. The exact pattern at any particular spot depends strongly on the shape of the coastline and on the profile of the seafloor nearby.
One has to adjust and estimate the height and time for each different place. High and low tides take place approximately thirty minutes to an hour later from one day to the next. Below is a typical table of tides that shows the time and height of the water over seven days in Masset, BC.

### Table 7. Tide Tables for Masset, BC (54.0167° N, 132.1500° W) July 2006

<table>
<thead>
<tr>
<th>Day</th>
<th>Low</th>
<th>High</th>
<th>Low</th>
<th>High</th>
<th>Sunrise</th>
<th>Sunset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sat</td>
<td>12:08 AM PDT / 1.37 m</td>
<td>5:47 AM PDT / 2.85 m</td>
<td>12:32 PM PDT / 0.71 m</td>
<td>6:54 PM PDT / 2.85 m</td>
<td>5:20 AM PDT</td>
<td>10:23 PM PDT</td>
</tr>
<tr>
<td>Sun</td>
<td>12:55 AM PDT / 1.33 m</td>
<td>6:38 AM PDT / 2.64 m</td>
<td>1:04 PM PDT / 0.89 m</td>
<td>7:35 PM PDT / 2.86 m</td>
<td>5:21 AM PDT</td>
<td>10:23 PM PDT</td>
</tr>
<tr>
<td>Mon</td>
<td>1:51 AM PDT / 1.29 m</td>
<td>7:39 AM PDT / 2.44 m</td>
<td>1:39 PM PDT / 1.10 m</td>
<td>8:22 PM PDT / 2.89 m</td>
<td>5:22 AM PDT</td>
<td>10:22 PM PDT</td>
</tr>
<tr>
<td>Tue</td>
<td>2:57 AM PDT / 1.22 m</td>
<td>8:48 AM PDT / 2.30 m</td>
<td>2:22 PM PDT / 1.30 m</td>
<td>9:14 PM PDT / 2.96 m</td>
<td>5:23 AM PDT</td>
<td>10:22 PM PDT</td>
</tr>
<tr>
<td>Wed</td>
<td>4:10 AM PDT / 1.09 m</td>
<td>10:03 AM PDT / 2.24 m</td>
<td>3:16 PM PDT / 1.48 m</td>
<td>10:07 PM PDT / 3.08 m</td>
<td>5:24 AM PDT</td>
<td>10:21 PM PDT</td>
</tr>
<tr>
<td>Thu</td>
<td>5:18 AM PDT / 0.91 m</td>
<td>11:18 AM PDT / 2.27 m</td>
<td>4:22 PM PDT / 1.59 m</td>
<td>10:57 PM PDT / 3.22 m</td>
<td>5:25 AM PDT</td>
<td>10:20 PM PDT</td>
</tr>
<tr>
<td>Fri</td>
<td>6:14 AM PDT / 0.73 m</td>
<td>12:26 PM PDT / 2.37 m</td>
<td>5:30 PM PDT / 1.61 m</td>
<td>11:43 PM PDT / 3.38 m</td>
<td>5:26 AM PDT</td>
<td>10:20 PM PDT</td>
</tr>
</tbody>
</table>

Source: [http://www.mobilegeographics.com:81/calendar/year/3637.html](http://www.mobilegeographics.com:81/calendar/year/3637.html) included with permission

Tides are often cited as a mathematical example of periodic behavior which matches a sinusoidal function which, in turn, resembles a sine function in the sense that it can be produced by shifting, stretching, or compressing the sine function.

![Figure 75. Example of How the Tides Visually Match a Sine Function](image)
Figure 76. Rippled Ponds are Formed by the Receding Tides at
North Beach

Danny Robertson, a boat captain who admits to not being “good” at doing mathematics describes how he masters the skill of reading tide charts and other skills with “situated learning”.

I had to learn how to calculate a particular thing—like how to deduct from the tide tables exactly when slack water would be so we could transit this narrow area of currents—and I’d use the math that I’d need to do that and I could do it. I trained myself to do it for that particular reason. However, if I had to suddenly do the same calculation but for a different purpose—like if somebody gave me a math test for instance and said ‘use your same skills to figure out this number or that number,’ I’d be scratching my head.

It is really important to be able to read a tide book properly. Determining when high tide or low tide is going to be as it could have very serious effect if you are talking about ocean currents because that’s what affects the currents—you have got people in kayaks and you have got to be responsible for a group, you don’t want to transit an area at a dangerous time.

So, once I learned, I was able to do it repeatedly and then, you know—so in the beginning it was like really nerve-wrecking because I didn’t trust myself. So I’d double check with the other guides and, sure enough, it would be fine. After awhile I got the confidence and then I was able to do it effortlessly and flawlessly. But any time that a new math concept had to be applied in a new situation, I was always lacking in confidence and underestimating my ability and then I’d have to learn the process—once I
learned it and I was right a few time in a row and then with that confidence comes a better understanding of it all. (Danny Robertson)

Figure 77. Seaweed on the Banks and Rocks on the Bottom of a Channel Reveal Different Water Levels

Tides rushing through narrow inlets and channels increase in speed. The danger increases when the wind and tide are running in opposite directions causing steep standing waves. Judson Brown, an officer with Parks Canada, who spends a lot of time on the water traveling to Gwaii Haanas, explains how he needs to be able to “read the waves”.

One of the things when you are on the water you need to be able to do is “read the waves”. So you are in your boat and can see patterns and you can go along and see this wave coming and then two more waves and this next wave will show up and, you adjust your course and speed to make your traveling smoother. You don’t want to pound through the waves on a constant basis so sometimes you alter your course 10 degrees to the next—so you try and travel in the troughs of waves and roll instead of the pounding.

So I was watching the waves, and we go up four meters, go back down, and we saw this wave off in the distance and when you get to the top of a 4 meter wave and you just see this huge wave and Clint was starting to get a little panicky because he was driving us and I said, ‘No, no let’s go see how big it is’ and we were getting closer and we just kept going up and up and then we had to turn off the side because we couldn’t go straight up anymore, so we are going up the wave almost vertically and then we get to
the top and then on the way down we made it up to 10 meters! (Judson Brown)

Sunrise and Sunset

In Canada, since 1996, June 21 has been celebrated as the National Aboriginal Day from coast to coast to coast. This date was chosen because it corresponds to the summer solstice, the longest day of the year, and because for generations, many Aboriginal groups mark the day to celebrate their culture and heritage. Like the cycles of the tides, the passage of time with the recurring cycles of the sunset and sunrise are an important consideration for the Haida. Since most of the outdoor activities are done during the day, keeping track of the sunrise and sunset are important to the people. In many cultures, the day begins at sunrise, but in mathematical terms, the day begins at midnight. Although the natural rhythm gives us days and nights of varying length, we hold the mathematical idea that every day is of equal length (Harris, 1991). The amount of daylight, and the particular hues of red, orange, and yellow, varies in different locations at different times of the year, decreasing and increasing the further you are from the equator.
The earliest sunrise and the latest sunset (the longest day) occurs on the same day, the summer solstice. On that day, due to the earth's tilt on its axis, the daytime hours are at a maximum in the Northern hemisphere, and the length of night time is at a minimum. A number of factors influence the variations in sunrise and sunset, from one location to another. Latitude is one of the most important factors and is directly associated with the length of sunrise and sunset. Another factor is the altitude, which influences the appearance of the sunrise and sunset in two ways. First, if the observer is located in the high mountains, sunrise and sunset may appear earlier or later, depending on the direction faced. Second, if another geographical feature exists that disturbs the pattern of the
normal landscape, then the amount of color visible during sunrise and sunset can be affected.

![Image of sky during sunrise and sunset in June]

**Figure 79.** Changes in the Contrast and Color of the June Sunset at North Beach near Masset

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### The Art of Weaving

For thousands of years, people around the world have weaved baskets and other items such as hats, mats, panels, blankets, etc. Different cultures have carried out weaving using different materials—feathers, grass, pine needles, cloth, paper, roots, bark, etc. As with most handcrafted items, a culture’s traditional artifacts are woven with local materials. In Haida Gwaii, the predominant materials used for weaving are either cedar bark or spruce roots. The gathering of materials is a multi-step process. For example, spruce roots are gathered at only certain times of the year, which typically involves digging, cleaning, splitting, and drying.
In the past, Haida women made a range of baskets that were large, coarsely woven to allow clams to drain; or were tightly woven in the shape of drinking cups to hold water. Every woman had her own work baskets, which were usually hung from the walls or rafters of the house. Other baskets were made for storing clothes, as well as roots and vegetables. Cooking baskets, of red cedar bark, had an open weave for boiling berries before they were mashed and dried for the winter. Containers were also woven for many other specific functions such as burden baskets, bait baskets, basket quivers for arrows, and even stout baskets for anchor stones.
Most baskets or other artifacts are woven in symmetrical patterns. Symbolic patterns are created to represent the spirits of things, both tangible and intangible. With cedar bark, ‘weaving’ is done, and with spruce root, the process is called, ‘twining’. Spruce roots enable double, triple, or even quadruple twining with a variety of patterns.

Patterns can also be incorporated with dyed bark and different weave techniques. Plain weave uses two groups of strips that are woven perpendicular to each other. The strips can be of different colors and sizes. The vertical strips are called the ‘warp’ and the horizontal strips are called ‘weft’ (Bazin, 2002). The warp strips are first arranged in a vertical direction, and then the weaving is begun by putting the weft strip over and under the warp strip, one at a time. Each time a strip is completely woven into the mat (or basket), it is pushed up against the previous weft strip. The pattern is continued with each strip until all of the strips are used and the resulting mat is tight and firm. The basic pattern of plain weave is the same, even if the mat is turned by 90 degrees. This kind of
symmetry is called a 90 degree rotational symmetry. The decorative shapes might be squares, crosses, or zigzag patterns.

![A Small Basket, made with a Plain Weave using Cedar Bark](Photo by author included with permission)

**Figure 83.** A Small Basket, made with a Plain Weave using Cedar Bark

Another technique is called the ‘twill’, which is a little more complex in its structure. Twill creates a visual pattern of diagonal lines from the vertical and horizontal strips. The pattern might be over/two under or three over/two under to create different kinds of designs. Twill patterns only have a translational symmetry of a basic block, rather than overall symmetry.

![Weaving with Different Designs and Patterns](Photo by author included with permission)

**Figure 84.** Weaving with Different Designs and Patterns
Nika Collison explains that, like baskets, hats are woven by counting the line before and mathematically calculating what is needed. Once the first row has been done, more rows are simply added as needed. The work is all done by eye, to ensure that it is symmetrical.

A weaver might use graph paper at first, before applying a design to a hat. Various rotating wooden molds of various shapes and sizes can also be used to guide the weaver. The selling price of a cedar hat will depend on the weaver and the time for preparing the cedar bark and carrying out the weaving.

With weaving, if you turn the round hat upside down, you know, you can see it started with a certain number of warps and you add on as you go along but you need to add on in a systematic way so that you have the right number of warps so that once it is turned over and you have the design, you can do the design properly—because if you have one too many warps or one too little, the pattern wouldn’t work perfectly all the way around.

There are different styles of weaving. As you come down with your hat, the warps have to increase as you get to the flair. You have to keep your pattern going—like these are diamond patterns and they’re quite beautiful. If you look at a hat weaved with cedar bark, it looks like you’d get soaking wet if you wore it in the rain. Actually that doesn’t happen. As soon as it starts to rain the fibers swell and it becomes waterproof. (Nika Collison)
Today, weavers use different patterns and geometric shapes to make their hats. Isabel Rorick, a master weaver, describes the dragonfly design in *Raven Travelling* (2006).

The dragonfly pattern involved concentric diamonds, five or seven diamonds that circle around the hat. The dragonfly pattern is done with a three-string twining pattern using one third more roots on the crown, and is a lot finer. The dragonfly is on the brim, starting with a two-string twine representing how a dragonfly flies. The same number of stitches is continued from the first row to the last with a consistent pattern. A hat like this could take three months to complete (p.131-2).

Isabel considers weaving to represent an unbroken line of her family’s legacy. She weaves without a hat-form, and makes hats of different shapes using a stand with different sized discs corresponding to different sized hat crowns.

**Games of Chance**

Like many people from around the world, the Haida played games of chance (commonly known as gambling games). The two most common games were the Stick Game and the Dice Game. Both of these games of chance involved strategy, probability, and a little bit of luck. Each game had its own set of rules, strategies, and means for determining the winner. These traditional games of chance have lost their appeal over time since most of the young people today play electronic games, and some of the older folks prefer to play Bingo.

*The Stick Game*

This is played with two teams, one player from each team plays at a time. Since the game requires concentration, the teams try to distract the other team members with songs and dances. The stick game is played with a beautiful set of 40 to 60, 15 cm carved
sticks. All but one of the sticks has a pattern painted on them. Like a deck of cards, four groups of sticks have the same pattern painted on them. The blank stick is called the *djil*, or bait. The game is played as follows:

1. Player One grabs two handfuls of sticks and shuffles them under a cedar bark mat.
2. Player Two watches his opponent carefully and selects the hand he thinks the *djil* is in.
3. Player One dramatically throws the sticks on the mat to see if the blank stick is there. If the blank stick is there, Player Two gets the bundle of sticks.
4. If the blank stick is not selected, Player One wins nothing.
5. Each player gets a turn until one of the players loses all of his sticks. Sometimes gamblers will lose many of their personal possessions in the game.

This game is basically a guessing game where a player tries to confuse and successfully hide an object from his opponent.
The Dice Game

The Dice Game, or gu’ tgi q’la’ atagan (they throw it to each other) is another Haida game, mainly played by women. This game is usually played in the smokehouse according to the following steps:

1. Player One holds the die by the thin side and throws it onto a mat.
2. If it lands on the cross-hatched side, Player One gets no points and gives the die to Player Two.
3. If the die lands on the long side or concave side with the X-pattern, the player gets two points and takes another turn.
4. If the die falls on the bottom, the player gets four points and takes another turn.
5. The player with the most points is the winner.

Source: http://www.virtualmuseum.ca/Exhibitions/Inuit_Haida/haida/english/games/gallery1.html included with permission

Figure 87. A Die with a Cross-Hatched Side and an X-Pattern

In this case, the die basically has five different outcomes. The most likely outcome is the die landing on the flat cross-hatched side, giving the player no points. The next likely outcome is the die landing on the long side or concave side with the X-pattern. All three of these outcomes are given the same number of points. The least likely outcome is the die falling on the bottom, and the player then gets four points, and takes
another turn. Since this is not a “fair” die, its construction might influence the way it lands and the eventual outcome of the game.

### People are like Trees, and Groups of People are like Forests

People are like trees, and groups of people are like the forests. While the forests are composed of many different kinds of trees, these trees intertwine their roots so strongly that it is impossible for the strongest winds which blow on our islands to uproot the forest, for each tree strengthens its neighbor, and their roots are inextricably intertwined.

In the same way the people of our Islands, composed of members of nations and races from all over the world, are beginning to intertwine their roots so strongly that no troubles will affect them.

Just as one tree standing alone would soon be destroyed by the first strong wind which came along, so it is impossible for any person, any family, or any community to stand alone against the troubles of this world. (Chief Skidegate - Lewis Collinson; March 1966, Haida Gwaii; from Turner, 2005, p. 35)

![Old Growth Rainforest in Haida Gwaii](Photo by author)

**Figure 88. Old Growth Rainforest in Haida Gwaii**

The above quotation by Chief Skidegate, which begins with “People are like trees, and groups of people are like forests,” elucidates the intimate link between the people of Haida Gwaii and their trees and forests. Many plants and trees play an important part in the lives of the Haida, in culture, medicine, ceremony, or victual. The rainforest is a fixture of the islands’ contemporary life and economy, a source of Haida culture, and a
continuous thread that provides links with generations past. Protecting the trees and rainforests from being logged on Lyell Island drew international media coverage in 1985 when the whole community came together to protest the logging. Two years later, logging was stopped on the southern tip of Moresby Island. With a joint agreement between the Haida Nation and the Canadian government, a national park was created at the site, called Gwaii Haanas – “place so beautiful, it inspires awe.” Gwaii Haanas National Park Reserve and Haida Heritage Site consist of over 138 islands and are accessible only by boat or airplane. Its natural setting offers opportunities for viewing wildlife, marine discovery, solitude, and cultural and spiritual connection.

Even today, the Province of BC and the Council of the Haida Nation are engaged in discussions on land and resource matters on Haida Gwaii. Haida Gwaii has a total land area of one million hectares, each hectare being an area of 100 meters by 100 meters (an area of 10,000 square meters is approximately the size of a soccer field). The Ministry of Forests and Range (2006) has temporarily suspended harvesting within newly proposed protected areas on Haida Gwaii as part of the process to reach a lasting land use plan. The allowable annual cuts have also been temporarily reduced by a total of 424,500 cubic meters, to help ensure that harvest levels support sustainable forest management outside the designated areas. An additional 83,000 hectares has been off-limits to timber harvesting and forest development activities while the land-use planning is under way.

As issues of environmental sustainability and forestry became increasingly vital to the people of Haida Gwaii, the Council of the Haida Nation has sought to find ways to present accurate and objective information about the land. As a result, they decided to make maps from their perspective.
One thing that had to occur was that we develop a mapping capacity. These were all done in our offices, by our own kids and they developed the capacity to track everything that is going on and to be able to really clearly say what it is that we are trying to accomplish through maps. For instance once we drew the line on the west coast—it separated it from the rest and didn’t take long before they were showing up on provincial maps.

(Guujaaw)

Maps are sets of points, lines, and areas defined both by their position in reference to a coordinate system and by non-spatial attributes. The relationship between distances on a map and the corresponding distances on the earth’s surface are expressed as fractions or ratios. Numeric terms such as latitude and longitude are typically used to represent locations on the earth’s surface. The coordinate system of latitude and longitude uses angle measures that are expressed in degrees, minutes, and seconds. Another function of a map is to transform coordinates of points from a curved surface to coordinates of points on a plane. Maps also use symbols to represent certain geographic phenomena, and use names that can be either traditional or adapted.
When speaking about trees, a direct connection exists with the forestry industry. This section outlines some personal experiences and how mathematics is an important component in forestry. Arthur Pearson was once a professional tree-faller and he describes his experience:

I’ve been around trees all my life—I still do my own tree falling. When you fall a tree you can pretty much make the tree go almost anywhere and that’s just using force with wedges and cutting at different angles. I will usually take a pie out the direction I want to fall the tree and then the back cut is a straight cut. The reason you do this is because if the tree leans over and it’s a straight cut, it will pull all the wood inside and also create a ‘barter chair’ and the tree will split in half. If it’s falling and the tree splits in half, then it snaps and it will come up and you’ll be standing there and this whole thing can come down on you. A lot of tree fallers have been killed like that or injured and the ones that are usually injured don’t ever go back to falling after that as it’s a pretty scary ordeal. Human error can
and does happen. You have to be really careful and accurate with the saw... you’re trying to cut and you don’t realize you need to reach far enough or you miss something and it can create a chain reaction. (Arthur Pearson)

Herb Jones has had many jobs in forestry. He was a faller, high-rigger, and a ‘Head Bull Bucker’. He discussed his life experiences and how he used his mathematical abilities:

My first 20 years was just practical experience. I wanted to learn how to do everything. Two things that I wanted to do were be a high-rigger and a faller. As a high-rigger you are on top of the world on those big spruce trees—an average of 165 feet high—and you had to hang up there in belt and spurs. I was a faller for 20 years and really learned a lot, being a faller is considered a top-ranking job in the logging industry.

When I was in management, I had to do a lot of planning and estimating. I was continuously working with lots of numbers. Everything was decided with numbers because I had X number of fallers who were expected by management to produce 90 cubic meters of wood per man day in order to be successful. I used to manage 54 fallers all by myself, and other camps such as the McMillan Bloedel camps on the coast had an average of 10-15 fallers. So, I was rewarded by the company and moved into a higher position for a few years, what was called the “Head Bull Bucker”. ‘Head Bull Bucker’ is a name that was given to a faller supervisor.

Everything was centered on numbers. You were assigned a big area of cut block and you had to divide your fallers into that and figure out your mandate productivity—if you are running at 90-95% capacity, you had to
figure out how many days it was going to take to do that and also add time—two to two and half days a months for wind when the fallers didn’t work. You really had to know the numbers in order to be able to be close to your expectations from the fallers and what you had proposed to the management. You just couldn’t throw in an X amount of days or an X amount of cubic meter per man day—you had to be pretty close.

A lot of it was based on experience, knowing your crew, and what they could realistically produce each day. I also had to figure out who was the ‘home garden’—married men not living in the camp. Some of them took a day or a day and half sometimes up to two days off a month and I had to work that into my equations and formulas as to what I expected out of the crew. An example is one area where we worked had 1300 acres of wood to be felled and I was asked by upper management to give a rough estimation as to how long it would take. This was a lot of wood and they had to know within 15 minutes. So, I sat down and figured everything out according to a way that I felt was a realistic goal to reach. I was very happy that we managed to finish in exactly the number of days that I didn’t bank on when we had a fair amount of wind. I thought that was pretty good not really knowing how to figure out what your crew was going to be able to do.

I did everything by tens when I was a contract faller. I had to figure out everything—what I was making per day and I always did it by tens. I learned to do it so quickly that I can look at a number and I write down what the answer was to it and I instilled that into my boys, particularly, numbers like tens all the time and then when I went into management I had to sit down and planning for an entire year of production with ‘X’ amount of dollars and I was told by upper management I had to be within $10,000. Now that was very difficult because I learned to do it and I learned to reason with fellow workers too. I once reasoned with an individual—he was taking off 10 minutes a day longer than he was supposed to—and it was just no ‘big deal’ to him. So I said ‘let’s figure out…10 minutes a day for 200 days and we’ll figure out how much money we lose because you are taking 10 minutes over an entire year. Would you hire somebody like you if you were losing thousands of dollars a year?’—‘No.’—‘Should I keep you?’—‘Please’. So I said ‘no more 10 minutes a day then.’—‘Ok’. So we then had an individual using numbers to help them see the value of doing things the right way. That’s what I learned when I was in management because I was responsible for all the fallers in the division here. During the time I was in management, my duty helped the division make $39 million in 11 years net profit—not gross profit. So there was a tremendous amount of money made because of reasoning and getting people to work on time. Even one minute makes a big difference—but I learned to use number 10 all the time. (Herb Jones)
Rings of a Tree

By observing the rings of a tree, one can determine its age and the climate variations during its growth. Every season, a tree adds a new layer of wood to its trunk. Arthur Pearson explained that, over time, these yearly growth layers form a series of light and dark concentric circles, or tree rings, that are visible on cross-sections of felled trees. Tree-ring analysis requires observation and pattern recognition. Each year a tree's growth ring has two parts; one is wide and light colored, and the other is narrow and dark. The first part grows during the wet spring and early summer when the tree has a lot of sap. As the summer comes to a close, and a transition takes place to the cooler autumn, the tree's growth rate slows. By winter, when the sap finally stops flowing, a smooth dark ring marks the end of the tree's annual growth. By counting the dark ring segments, scientists and mathematicians can tell a tree's age if the cross-section of the trunk is complete. Because the width of each tree ring varies with the particular growing conditions, one can also learn about local climate during the tree's lifetime by examining and comparing the tree rings. A misconception exists that one tree ring corresponds to one year, but in actuality, four rings, one per season, could represent a single year. As an example, higher
rainfall and a longer growing season could produce wider rings, compared to the rings occurring in a season of low rainfall and prolonged cold.

The heart is the center of the log, and has a smaller growth ring. As the tree gets bigger, the rings get a little larger and the center becomes the hardest part of the wood. The center is the actual starting point of the tree, and with its growth, the rings proceed on the outside. If, for example, a 4x4 piece of lumber contained the heart, it could be split in two, and the weakest point in the wood would be revealed. When a totem pole is made, the heart is usually removed to minimize the chance of the wood splitting.

![Photo by author](image)

Figure 92. Side View of Logs, showing the Tree Rings

*Calculating the Amount of Wood*

Once the quality of a tree has been assessed, special measuring devices and methods are used to calculate its dimensions. Smith & Apsley (2006) outline how a tree measuring stick can be used as a tool for measuring trees and logs. Although less precise than other wood-working tools, it is inexpensive, easy to carry, and sufficiently accurate for most measurements. This stick incorporates several tools that are commonly used by foresters and is primarily used to measure the diameter of standing trees (in inches), their height (in 16 foot logs), and their volume (in board feet or cords). It can also be used to measure the diameters of logs for estimating their volume.
The lumber industry today still uses Imperial instead of metric units. Saw timber is measured and sold in terms of board feet, with a unit of lumber being measured as one inch thick, one foot wide, and one foot long, thus equal to 144 cubic inches. A common unit of measure for firewood is the cord, which is the amount of tightly stacked wood contained in a space 4' wide x 4' high x 8' long (equal to 128 cubic feet). Most 1/2-ton pickup trucks can hold 1/3 to 1/2 cord of wood, depending on how high and how tightly the wood is stacked.
When measuring the diameter of a tree, two factors should be considered: 1) the diameter of a tree should be measured at a point that is about four feet off the ground (Diameter at Breast Height or d.b.h.), and 2) trees are usually not perfectly round; therefore, two measurements should be made perpendicular to each other, and the average value used. Measurements are taken with a "Tree Scale Stick" with one side held about 25 inches from your eye, and the other side held against the tree. Figure 95 shows how to use the stick to measure the tree diameter.

![Figure 95. Using a Tree Scale Stick to Measure Tree Diameter](http://ohioline.osu.edu/for-fact/0062.html included with permission)

The height of a tree is commonly measured in 16 ft. logs or multiples thereof. The measurement is usually taken at a point on the tree where the diameter is 8 inches (inside bark). With older trees, however, excessive branching or a high number of forks may reduce the usable height. To measure the height of a tree with the measuring stick, one paces 66 feet from the base of the tree. Then, facing the tree to be measured, the stick is held vertically at a distance of 25 inches from the eye (Figure 96). The base of the stick is aligned with the top of the stump (about 1 foot above the ground). Looking past the right hand side of the stick, to the point on the tree, a reading is taken from the scale. This method uses the principle of similar triangles to determine the unknown height.
Dimensional Lumber and Logs

Arthur Pearson has been working on 88 pieces of dimensional lumber, of various sizes, for the Haida Heritage Centre project at Qay'Innagaay. Some of the pieces will be used for decorative purposes, while others will be used as part of the structure. The diameters of the pieces vary from 4 to 36 inches. The length of the biggest piece is 64 feet. To ensure that the pieces are able to withstand the weight loads of the spans, he therefore must add up all the loads acting on a header or beam, and translate this load into
the individual load for each lineal foot of header or beam. With this information, he can then determine the minimum size, span, or strength of the beams. For sawn-lumber, mathematical calculations are needed. Live and dead loads, listed in the building code for roofs and floors, are approximations of the distributed loads.

Before cutting a particular piece of log, Arthur starts with a drawing and considers the different factors that come into play as he cuts the piece.

It is more difficult than something that is stationary because you have got to take into account the different pressures on the wood, especially when you are cutting big pieces of wood. (Arthur Pearson)

He begins with accurately measured angles for the circular log, since the running lines must match with the four corners of a circle (Figure 99).
Construction

As mentioned in an earlier section on Haida longhouses, the framing done many years ago with the traditional form of post and beam, still meets today's building codes. The dimensions of a longhouse and the inclination of the slope depended on the location, availability of materials, and forces of inclement weather. Today, construction of houses and other buildings must follow local or regional building codes. The purpose of such codes is to ensure that the structures are safe and can withstand certain weather conditions. For example, when stairs are constructed in a house, they are made of treads (the part you step on), risers (the part your toe bumps), and stringers (the structure that supports the treads and risers). For safety, codes regulate tread depths and riser heights, and require steps to be uniform (uneven steps can cause people to trip).
Figure 100. The Height of Each Stair Must be Equal

Since all risers must be equal, the total height of the stairs must be evenly divided to determine the riser height. Most houses have a floor-to-floor height of about nine feet. The floor-to-floor height encompasses both the height of the ceiling, and the structure that the supports the floor above. In most cases, the height translates to 15 risers at about 7 to 8 inches for each riser. The steepness of the stairs, called slope, rake, or pitch, has an optimum value in the range between 30° to 35°.

Constructing a house is a multi-step process, with most steps involving some aspect of mathematics. The first step is financing; ensuring that enough money is available to complete the house. Then, plans are needed that will suit your lifestyle and budget. After that, a suitable location must be found to start the construction. The plans might need to be adjusted, as the cost estimates might make you realize it takes more money than originally thought. A building permit is also required for ensuring that you follow the building code. For the actual construction, several aspects are involved: site preparation, laying the foundation, framing, insulation, siding, roofing, plumbing, electrical, and finishing. Every step requires various mathematical measurements and calculations.
By the Sea

In an earlier section, canoes of the past were said to play a key role in getting food from the sea, and in developing a thriving trade economy up and down the Pacific coast, and beyond. Traditionally, Haida depended on fishing as a source of food and employment. Over the years, however, fish stocks in the region have become depleted and the Haida have stopped fishing for food, social, or ceremonial purposes, after catching the amount they need for the coming year. With information gathered over the
years, accurate predictions can be made about fishing conditions; time and locations to
catch different species such as salmon, halibut, squid, clams, mussels, crabs, and scallops.
With changing times, the people must also increase their understanding and awareness of
marine life and ecosystems, while promoting personal connections with the marine
environment, and using tools for action to foster healthy oceans and coastal communities.

The Haida fishermen in the past knew the coast and sea very well. Bernard
Kerrigan explains:

It was amazing to watch the Haida fisherman on their boats at sea—they
knew where every rock was on the coast. They knew the coast so well and
they knew where the fish would be at the time. I remember one fisherman
who told me how he could feel the current was running through the floor
boards of the boat.

Arthur Pearson gives details about the term, ‘chasing the Sockeye,’ instead of
fishing:

We would ‘chase the Sockeye’ by guessing the tides. I guess as the moon
moves, it pulls the water higher as it goes and so when fish are traveling,
they will move and as they move, the tides will flood in areas and so what
the fish are doing is they are following the flood so we try to figure out
where the fish are going to end up and sometimes it is not the case and you
get nothing. Herring is another thing we caught. We would look for the
ekelp and that’s where we looked for the nice big school of herring and
then we’d set our nets on them then we tow them to the ponds and put
them in the ponds. Mainly it’s just being at the right spot at the right time.
Judson Brown, an officer with Parks Canada is currently Operations Coordinator for the wind service at Gwaii Haanas and shared with me an example of how he uses mathematics as part of his job:

Our 23 foot boats have a certain capacity that they can carry so we estimate, the weight of the personnel on board, the weight of their gear and we have to determine if that particular vessel can hold that much and, if not, then we have to divvy up amongst two boats and then try to calculate how much fuel that we’ll use and try to determine if we should have one person in their own vessel and be more economical or just take two vessels, and put half of the weight in each. (Judson Brown)

Commercial Fishing

Knowledge of when to fish, how to fish, and where to fish can change the probability of how much fish is caught. Although concepts of probability are not explicitly used in the Haida culture, they are embedded in the cultural values and games of chance, where concepts of probability (i.e. fairness) are explored.
Four common methods are used in commercial fishing: gillnet, seine, troll, and trawl. The gillnet method is used to snare target fish that attempt to swim through the net, which has deliberately sized mesh openings, as the fish are caught and unable to swim forward. Once in this position, the fish cannot back out of the mesh because their gills are caught in the net. Seine fishing involves a large net that hangs vertically in the water with weights along its bottom edge and floats along its top. Trolling is another method of fishing, where some form of bait, such as a living fish, is on a line and drawn through the water. Finally, trawling involves a large net, conical in shape, that is towed along the sea bottom.
Christian White discusses the different patterns used for making nets:

The Haida used a variety of measurements, especially for making nets for fishing. As far as I know we invented fishing nets. Since each species of fish is a different size you would use different sized gauges for making the nets. For sockeye you had to have a certain width of net. So they would use a gauge for measuring each species at that time. Nowadays, of course, we use a lot of rulers for measuring but at the same time there is still a lot of estimation—just judged by eye. We would drop the seine nets many times during the season, and these nets had to be fixed four to six times a year depending on their use. (Christian White)

Like the steps in problem-solving or in carving a totem pole, fishing also involves a number of steps. The first step, finding the fish, requires the skipper to consult his log books of past seasons, consider which areas are open, and choose the best fishing spot. A common way to fish is to search for schools of fish, and catch them in several short sets. When looking for schools of fish, the skipper and crew search by steering slowly around the area, looking for jumping salmon or other signs of fish. Typically, the fish will form schools near the spawning streams. The next step is to set the seine net. The skipper plans when and where to set the net, and gives instructions to the crew. As the net is released off the stern of the boat, the crew is on high alert, watching for anything unexpected, such as a loop of rope that might snag on the towing cleat, etc. Eventually, when the net has finished spooling off the stern, the net forms a large circular loop around a section of
water that is hoped to contain a lot of salmon. The next moment is critical, as the seine net is quickly brought aboard using a power block, a large hydraulic pulley with a rubber surface. If a lot of fish are in the net, extra care must be taken to prevent the fish from clumping into the same area, which might cause the net to sink, and allow the fish to escape. The next step is to bring in the catch, where the skipper hooks up a large dipnet to scoop the fish out of the net and into the fish hold. Finally, the skipper calls in another boat, the tender, which would have been prearranged, to come and pick up the catch (this allows the seine boat to remain at the fishing grounds, instead of having to travel to the processing facility). The fish are usually sold by weight.

Counting Fish

A lot of controversy is concerned with the actual fish count per season. Different number estimates are given by the Fisheries and Oceans, the Haida Fisheries Program,
and the fishermen themselves. Christine Bentley, an officer with Fisheries and Oceans Canada explains the different counts:

They are about averages. Well, I think it has to do with different types of sampling when you get out there. Different people are out there at different times—fishermen are out there at different times—and the fisheries workers are seeing different things out on the water than we are seeing. It depends on where you are, and what time of year you are there, sometimes you will see something different that other people never see.

When asked as to why the fish stocks seem to be declining over the past few years, Christine Bentley had the following explanation:

There’s quite a number of different theories as to why there is less fish—climate change, difference in appearance around the islands, loss of habitat. Nobody really knows for sure, which one it is, but I think they all contribute to it in some degree. (Christine Bentley)

Counting fish is commonly done by statistical estimation. One method is to first catch a number of fish, tag them in some manner, and then toss them back. After the fish have had time to swim about, a sample of the fish is caught and the number of tagged fish in the sample is counted. If the sample is representative of the overall population of the pond or body of water, it seems reasonable to assume that the ratio of the total number of tagged fish to the total number of fish in the pond is approximately equal to the ratio of tagged fish to the number of fish in the sample. That is:

\[
\frac{\text{Total number of tagged fish in the pond}}{\text{Total number of fish in the pond}} = \frac{\text{number of tagged fish in the sample}}{\text{number of fish in the sample}}
\]

or, in symbols:
$\frac{p}{n} \approx \frac{x}{q}$

where

- $p$ = the total number of tagged fish in the pond
- $n$ = the total number of fish in the pond
- $x$ = the number of tagged fish in the sample
- $q$ = the number of fish in the sample

Hence, we can derive a general formula for approximating $n$, the total number of fish in the pond:

$$n \approx \frac{pq}{x}$$

**Photo by author included with permission**

Figure 108. Fisherman, Hoping to Catch the Big One! Finally Catching One near Masset

**Sport Fishing**

Freshwater Fishing Regulations and the BC Tidal Waters Sport Fishing Guide provide detailed information about quotas, size limits, equipment restrictions, closures, special measures, definitions, and laws. In BC, a number of truly great sports fishing opportunities can be found, in both salt and fresh water. Haida Gwaii has a reputation as a world class angling destination. For the coastal angler, chinook, sockeye, coho, pink, and
chum are five different types of salmon that offer a range of challenges to the angler. In freshwater, rainbow and brown trout are abundant in lakes and rivers throughout the region.

Danny Robertson, a captain of a boat, explains the importance of using maps and being able to convert figures between Imperial and metric systems:

As a captain, I use maps all the time. It’s not just a matter of understanding depths but it is being able to translate numerical values of wind speed and current speed into what to expect in the water. So when they are calling for 25 knots of wind, there are so many cross references you need to consider. When you are setting an anchor or you are sailing off the wind it involves the use of angles. There is also a lot of conversion between the imperial and metric system. However, so many things are still one foot on each side so you have to calculate back and forth constantly and a lot of nautical charts are still in the imperial system, depths are calculated in fathoms which are six foot increments. And then you have some charts that are metric. So you need to be able to convert between nautical miles, kilometers and statuary miles. (Danny Robertson)

Sam Davis Jr. is a charter boat captain who uses mathematics as a part of his work:

As the captain of a charter boat, you have to figure out how many hours you will be out and how much you are going to charge your clients and then you have to try and figure out how much it is going to cost you per day for fuel, plus your time, bait, and wear and tear. You have also got to be aware of the weather and figure out the tides, what time to go, and what’s the best time to fish. (Sam Davis Jr.)
Drying, smoking, and canning fish in the summer has been a tradition in many Aboriginal communities, to ensure a supply of food for the winter months. Years ago, when the families would spend summers at a fish camp, they would make their own fish racks to dry the fish. The racks were made by chopping a tree into workable lengths and then measuring subsequent pieces of wood for the building of the rectangular fish rack. The fish rack had to be proportional to the height of the users and had to be strong enough to hold the fish, without falling over with a gust of wind. Dick Bellis is a cultural interpreter and he spoke about why the Haida used to smoke and dry the fish:

In the old days, with no refrigeration, we had to smoke the fish for two to three days so you could stack it up like cord wood in your longhouse. But nowadays we smoke only to taste; it could take from about 8 hours to overnight.

In the old days, when we were traveling down the coast as far south as California, we would pack enough food in bentwood boxes to feed 40 men for 30 days. The bottom layer would be Gil-gee flattened smoked dried fish. The next layer would be dried berries, and the third layer would be Gow kelp or herring spawn on kelp. For lunchtime you’d get a two-inch square of Gil-gee, a two-inch square of Gow and for dessert a two-inch square of berries. If you were sick to your stomach, the dried food items would swell to at least three times its original thickness and your sickness
would go away. You would also get one drink of water and your meal was complete. If you’re still thirsty, every man had a rock and you put this in your mouth and chew it and your body would think that you are eating and it would produce saliva and you wouldn’t be thirsty anymore. As you can see we invented dried food, not necessarily freeze dried. (Dick Bellis)

Sam Davis Jr., after a day of fishing, cleans and guts the fish, and then fillets or slices them, as needed. For smoking, the fillets are cut into thin slices and hung on a rack inside the smokehouse. Different wood is burnt in the smoker to give the fish different flavors. For drying, the fish are evenly cut into strips and hung on the fish rack.

Figure 110. The Fish are Cleaned, Filleted, and Hung to Dry in Strips on a Fish Rack

Figure 111. Thin Slices are Placed on a Rack Inside the Smoke House
Instead of drying or smoking, Nika Collison explains how she cans some of the fish she catches:

We got seven sockeye when we were out with our net and I knew it would take me approximately four hours from start to finish to can the fish. Each process requires time and I am also figuring out how many jars I would need for seven fish and make sure I had enough jars washed. I wound up getting 16 two cup size jars ready for the seven sockeye—that was about right. I just estimated the number of jars I needed by eyeing the fish. I guess I had the intuitive sense as to how many jars I would need for the fish I had. I'm sure somebody could also calculate it mathematically ‘the fish are this big so I can get this many fish in this many jars’.

You have to keep an eye on the temperature when you are heating the lids to put on the jars. It can’t be too hot or too cold, it has to be just right. You also need to keep an eye on the pressure of the pressure cooker and understand why it needs to be a certain pressure. And also, because you can only fit so many jars into a canner—so you are also trying to figure out if I have to do more than one pot of canning then that means at least another three hours on top of the four hours that you have already planned for. (Nika Collison)

![Photo of Nika Collison and canned fish](Photo by Janice Kilgour included with permission)

**Figure 112. Canning Fish into Jars**

**Crab Fishing**

Dungeness crabs are an integral part of the ecosystem and have been and continue to be an important part of the diet of coastal Aboriginal peoples. Crab fishing remains an important economic activity for Aboriginals in Haida Gwaii where crabs are plentiful. Crabs generally live on sandy ocean bottoms up to depths of 50 feet. Recreational dip-netting...
crabbing on North Beach near Masset during a falling summer tide is a popular activity for the locals and for visitors. Crab fishing, like other activities in the sea, needs its participants to be aware of the ever-changing weather conditions and know about the tides, currents, red tide, and various regulations.

Sometimes, smaller traps are used, along with ring or hoop traps, and recreational fishers can catch crabs by leaving the traps in designated areas. The recreational daily possession limit per person is six male crabs. All recreational crab gear must be identified with the fisher’s name and telephone number. The primary management tools used for this fishery are a minimum size limit (165 millimeters), limited entry, and fishery closure regulations. The rationale for the size limit is to protect crabs until they become sexually mature and to give them an opportunity to spawn, at least once, prior to being harvested.

The process of crab fishing involves some embedded mathematics. Participants should have an understanding of the geometric design of traps and knowledge about where to put the bait. A rope is needed that should be long enough so that the trap can be dropped at various depths on the docks or from the side of a boat. Participants should also have an understanding of the length of time a trap should soak, and the mandatory length
of the crabs that can be kept. Once the crabs are caught in the trap, undersized and female crabs should be released. The cooking of the crabs also requires some degree of calculating and organization.

The sea around Haida Gwaii is a major contributor to the total BC commercial crab catch. In past years, Masset was home to a major crab industry that employed many people. Today, the size of this industry has diminished, with only a handful of license-holders operating in the area. Commercial crab fishers are restricted by the number of traps they are permitted to use. Trap limits vary by management area, and the limits range from 200 to 1,200 traps per vessel. All traps must be fitted with escape holes for undersized crabs and with biodegradable devices to prevent ghost fishing, in case a trap becomes lost at sea. Depending on the management area, traps are either individually buoyed or attached at intervals along a ground line, which is anchored and buoyed at each end. Crab fishers generally haul their traps once every 1 to 10 days, but are required to haul their gear once every 18 days to prevent ghost fishing. Bait such as clams, squid, and fish heads are used. Nowadays, commercial vessels have mandatory video surveillance
equipment for monitoring any suspected illegal harvests of undersized, female, or soft-shelled crabs.

![Image of stacked commercial crab traps]

*Figure 115. Stacked Commercial Crab Traps Ready for the Season*

Commercial crab fishing takes a toll on the body, as the hours are long and a lot of heavy lifting is involved. Sam Davis Jr. used to be a commercial crab fisherman and shares his experiences about how mathematics is an integral part of the job:

Well, the thing about crab fishing is you’ve got to get up quite early and it’s a lot of calculating to see how much bait you have to use per trip per day and how much weight your boat can pack. Each trap that you set is set by a certain amount of time apart for allowing the time that it takes to get a trap back on the boat and then you have to calculate where you have fished in the past and have done well. You also need to calculate the distance from your homeport to where you have to travel to set your gear and make sure you have enough fuel. Usually our boat would pack 30,000 - 40,000 pounds of crab, we also had to bring 3,000 - 4,000 pounds of bait per trip and all the grub for the cook. It used to take us nine days to get our gear out in the water, but nowadays I think it takes like three days. The skipper had to figure out what distance they need to cover, and at what speed should the boat travel so—there was usually a lot of math involved.

You have to work pretty long hours and it is just continuous movement with lots of heaving lifting. The average pot was 80 by 110 pounds with the lines—it means you’re trying to figure out the weight and loading at the same time. The bigger boats can hold 400 traps per boat so little boats hold maybe 50-60 pots.
You had to do a lot of calculations to figure out how much the crew would be paid. You keep track of the number of crabs caught per day and then, you know, average it out to 2½ lbs. per crab. Usually the crew got a percentage of the profits, which could be anywhere from 10% to 12%.

Sometimes you don’t make any money. Once we lost a whole load of gear—I guess a rogue wave rolled the boat and all the lines snapped—buckets snapped on the traps and then all the traps slid and then went overboard. (Sam Davis Jr.)

**Eco-tourism**

National Geographic Traveler magazine’s Web site lists Gwaii Haanas National Park Reserve and Haida Heritage Site as the number one National Park in North America. The expert panelists have commended the unique partnership between Parks Canada and the Haida Nation to give the region high cultural integrity and refer to it as “Beautiful and intact. A great model for other regions.” The park not only protects the legacy of Haida culture, but features some species of plants and animals that are not found anywhere else in the world. Hotspring Island Gandl K’in is the site of one of the most picturesque hot springs in the world. This island is in the Gwaii Haanas National Park Reserve and has three natural hot pools overlooking the ocean and the islands.

![Photo by author included with permission](image_url)

**Figure 116.** Hotspring Island, Gandl K’in, in Gwaii Haanas is one of the most Picturesque Hot Springs in the World
In recent years, the fishing and forestry industry has experienced a downfall, and eco-tourism has thus become a major part of Haida Gwaii’s economy. Salmon fishing, fly fishing, kayaking, crabbing, whale watching, beachcombing, wildlife viewing, bird watching, hiking, and biking are some of the activities offered as part of eco-tourism.

Eco-tourism is a nature-based or cultural travel experience that conserves the ecosystem and respects local culture and traditions. Eco-tourism promotes the outdoor recreational use of the natural environment, without disturbing wildlife or their habitat. It also respects the local communities and the Aboriginal people that co-exist on the land.

Figure 117. Eco-tourism promotes Haida Gwaii’s Natural and Cultural Environment

Figure 118. Brochures Advertising and Promoting Eco-tourism at Haida Gwaii
In 1981, the Skidegate Band Council and the Haida Nation responded to concerns about the potential for vandalism and other damage to old Haida village sites by initiating the "Haida Watchmen Program". From May to September, watchmen are posted at the five most frequently visited cultural sites in Gwaii Haanas: SGang Gwaay, Gandll K'ín Gwaayay, Hlk'yah Ilnagaay, T'aanuu Ilnagaay and K'uuna Ilnagaay. Usually, two to four Watchmen live at each site as guardians to protect the natural and cultural heritage of these sites (Parks Canada, 2004, p.46). These watchmen, in addition to being cultural interpreters, are also able to assist in case of emergencies. Hence, they are knowledgeable about their culture and the local environment, and have the ability to problem-solve or assist in case of emergencies.
Conclusions

This chapter has provided insights into how the people of Haida Gwaii use their knowledge in dealing with quantitative, relational, and spatial aspects of their lives. As such, it provides insights into both the social role of mathematics and the nature of mathematical thinking (D’Ambrosio, 2001). The examples presented illustrate how mathematical ideas and culture interplay in this context. Mathematical ideas exist in many different contexts (Ascher, 1991), and mathematical activities can be exhibited in a variety of ways that are directly related to formal, conventional school mathematics. The Haida people’s knowledge of problem-solving, spatial relationships, estimation,
measurement, and the interpretation of physical phenomena have enabled them to live for thousands of years in Haida Gwaii. Lipka & Adams (2006) emphasize the importance of observing mathematics in nature and society, such as in the tides, building of fish racks, or in building models for various cultural artefacts. In addition, documentation of the elders’ stories and related cultural practices should be used to assist in the teaching of mathematics, since familiar situations, used as examples, can help students attach meaning to the concepts they learn in school mathematics. The contextual familiarity and types of problems that students solve can increase their access to mathematics and increase their motivation to be engaged in school mathematics. Mathematics, when derived from students’ everyday life experiences, is typically more accessible and enjoyable to them, and can enhance their ability to make meaningful connections and deepen their understanding of mathematics (Zaslavsky, 1991). Devlin (2000) states “Mathematics is not about numbers, but about life. It is about the world in which we live. It is about ideas. And far from being dull and sterile, as it is so often portrayed, it is full of creativity” (p. 76). The challenge is to recognize and acknowledge the rich embedded numeracy practices of the community and apply such contexts to teach school mathematics. In today’s changing economy, Guujaaw explains that, regardless of one’s job, one still needs to make payments, manage finances, and be conscious of the environment. A wide range of professions are available to those who graduate, and each profession requires its members to have some kind of mathematical ability.
Figure 122. Thank You, Howa, Sign outside the Rainbow Gallery in Queen Charlotte City

Photo by author included with permission
CHAPTER SIX—Honoring the Voice of Educators-Change Agents

Introduction

In this chapter, data from the transcripts of interviews with educators are interpreted and analyzed with emerging themes on how numeracy practices and thinking can be drawn to engage students, particularly Aboriginal students, with the prescribed mathematics curriculum. What works, and what needs to be changed, based on the personal experiences of the educators who teach Aboriginal students in Haida Gwaii will be discussed. To maintain the anonymity of these educators, they are identified as Teacher A to H. The specific questions that were asked during the interviews are listed separately in Appendix 5.

Community Connections

Relationships with parents and extended families can have a positive and meaningful impact on a child’s educational success. Involving parents is sometimes difficult due to their negative experiences in school or lack of confidence and knowledge.

There is overwhelming evidence that parents can make a critical difference when they are involved in their children’s home and school learning. In fact, family support has been shown to be a greater factor in student success than family income or education levels.

Unfortunately, many First Nations parents have not had positive experiences in the education system, and they may therefore be reluctant to be active within the school setting. Also, some parents are not confident that they have the skills and knowledge necessary for involvement in home and school learning, or parents may believe that they should not interfere with teachers’ practices. (Kavanagh, 2006, p. 29)
Teacher G feels that many teachers think that parents are totally apathetic, but she believes that it is not entirely the case. She believes that every parent has some skills that they can bring to the family and to the education system – but they just do not know how to do it. Many parents, except for a few who are strong and confident, usually say ‘I can’t help my child read, do math, or their homework – I don’t know what I am supposed to do’.

Teacher H thinks that the biggest stumbling block for children learning math is their parents. She has heard it in interview after interview, ‘Well, I wasn’t very good in math’ or ‘I don’t like math,’ and these negative attitudes are then passed onto the children. She recalls that when she played math games in her classes, the children seemed to be having too much fun, and parents felt that math should not be fun, but should be traditional and difficult.

Teacher B, a long-time teacher in Haida Gwaii, believes that the situation varies from home to home. He has seen how the past impact of residential schools and how economic changes in the community have affected the education of students.

Many students tended to leave school at Grade 9 or 10 and I could talk to them about the negative impacts on their lives with no effect. They would go out and start working on a fishing boat or start working in the woods or working as a deckhand on a seiner or a troller, they were making as much money as I was as a school teacher. Those days are, unfortunately, gone but the impact is that a lot of parents who don’t necessarily understand exactly what the demands are of education.

There are generational aspects from the residential schools era that have created the inability to bridge that gap. I do feel though that a lot of people in Skidegate do value education, and when I go to the button blanket graduation ceremony, it’s representative of every family there over time and there’s a great deal of pride but how much constructive motivation, how much actual help the families are able to provide in some cases tends to be a problem for some kids. (Teacher B)
Another teacher mentions that some parents will say that they value school and education, but they do not how to be supportive, nurturing, caring, and above all, how to set boundaries for their children.

You have got parents that love their kids—they love them to death literally by providing them with all the toys: Nintendo, Play station, X-Box, satellite TV in their room. So these kids are coming to school really tired and they just fall asleep in class. You need to take the toys and the TV out of the room until the first report card comes around and they have a decent report card. Sometimes you have to be cruel to be kind. So you have got parents that are letting these kids do anything. The kids are not studying, sleeping, or even eating properly. (Teacher E)

Teacher A believes that the Haida have a close-knit community, and a lot of family support is available, though it does not always translate into good strategies. Many of the parents seem to struggle with how best to support their children. With extended families giving away to nuclear families, many families feel isolated and helpless in the situation. This teacher also tries a variety of strategies for relating with the students and for making connections with them.

I think I am fairly firm and insist on a basic conduct for the students in my classes. I have always tried to be sensitive to create a safe place for everyone. So if somebody is out of line, I deal with the issues as they come up and I avoid direct confrontation—it just works with the kids. I know the kids, sometimes they are a little bit more motivated, their energy levels are up and down—I kind of get a read—some days you can push some kids a little more than others.

Some kids need to be challenged at a particular time a little more than others and you need to back off. I can only relate it to my class but it’s always a constant, readjustment—just reading the kids—you always have a number of different things that—people have different stages and different levels—so it just seems to be my style and what works for me.

I believe modeling is very important. Some kids are reluctant to be put in the spotlight—I found that when I start a new unit—there’s that kind of inertia and then you’ve got to kind of build up the energy and participation
and then it kind of goes down and out and then you have to reset it.
(Teacher A)

Opening up channels of communication with the home sends a message to the children and parents that the mathematics they are learning in school is worthwhile and important. Better communication is needed with parents, who often do not understand why their children take certain courses and then fail to graduate.

What I see in terms of participation in senior math courses is that a lot of times the percentage of Haida students is down because the students take the easy way out and stay away from the more challenging courses. The parents don’t know which classes their children are signing up for—a lot of times parents don’t even understand the course selection process, so they don’t have any input as to what courses the kid takes. So what happens a lot of times is that the parents are not aware of what is going on when course selection happens, the kids’ just end up signing for the easiest course and then don’t have the required courses to even graduate. (Teacher E)

Bringing Role Models into the classroom or taking students to where a community member is working, allows students to experience first-hand how mathematics is used in certain careers. Such experiences not only motivate students but also enable them to connect with real people who are successful at what they do. “Finding Native content which is appropriate to a particular community and presenting it in an appealing way to students and parents is a difficult but necessary component of education” (Taylor, 1995, p.238). When home and school work together, students have more opportunities to gain numeracy skills that will be necessary for their success in school and beyond.

The trauma and distress associated with residential schools still affects many members of the Aboriginal community in BC, especially the parents. Residential schools have had a devastating long-term effect on Aboriginal people and their communities.
(Reed, 1999). Some parents choose not to visit a school because it brings back memories of the emotional trauma they experienced in the past.

One teacher took the initiative to have an outreach program in the community to help students with their homework. Teacher D started a Homework Club to help students with their mathematics once a week in the evening at a location in the village. He noticed that the students who attended the sessions were improving in their learning.

One thing I found in my Math 10 class is that every non-Haida student was doing better on their homework. The Haida kids seem to leave everything at school—they don’t take anything with them at home. So I started going to “Homework Club” sessions in the village. They were held in Skidegate at the church every Thursday evening for two hours. When I saw the students for math on Fridays I noticed an immediate turnaround in a few kids—the ones who come for help. About six to eight students would show up from grades 8-10. (Teacher D)

Parents want their children to be successful, but sometimes lack the knowledge about how to help. For example, when they read stories, parents can do interactive mathematics activities like counting, measuring, designing, estimating, locating, or even game-playing. By involving parents in a friendly environment, the students gain greater self-confidence, self-discipline, and teamwork, which are developed at both the home and school. Some teachers believe that the involvement must be reciprocal. Teachers need to make an effort to be part of the community, to learn more about the beliefs, values, and traditions of the Haida people. By attending functions and feasts, teachers can build stronger connections and a greater sense of trust with the community (Taylor, 1995).
Pedagogical Implications

The NCTM Position: Closing the Achievement Gap (2005) outlines that, to close the achievement gap, all students need the opportunity to learn challenging mathematics from a well-qualified teacher who will make connections to the background, needs, and cultures of all learners.

The quality of instruction is a function of how well teachers understand the mathematics they must teach (NCTM, 2000). For teachers to be well-qualified and effective, they must have a “profound understanding of fundamental mathematics” (Ma, 1999). Hence the “what” and “how” the students are being taught depend on the knowledge, skills, and attitudes of the teacher. Over the years, Teacher E has seen many non-math specialists teaching mathematics with regrettable results.

I have been teaching for 15 years now and a lot of the time mathematics is taught by non-math specialists in the lower grades. The people who really love math are few and far between. So people end up teaching math even though they might have a negative attitude towards math. The priority needs to be having teachers who know how to do math, apply math and make it interesting teach the subject. (Teacher E)

Vonnie Hutchingson believes that the curriculum or the learning outcomes should not be differentiated since students need to know the content to endure in the non-Haida world, but must also have the background to function in the Haida world. She emphasizes that other aboriginal communities are wrestling with similar issues which have deep-rooted social issues and that will require flexible and creative solutions.

What I see is the problems that we are experiencing here on Haida Gwaii is also a common experience of Aboriginal people throughout Canada and they are real problems to be wrestled with and aboriginal people are calling upon educational institutions to be flexible and to be creative about what it is that we need to do, and until we change the very structures of the education system we’re really not going to see a whole lot of success for our children. So you have to pay attention to all of the social problems that we’re facing—the social problems that are the impending problems of
colonization. I think the problems that occur here with our children aren’t any different than any people around the world who have been colonized.

Since our kids are eventually going to be stewards of the land, we need to figure out how we are going to give them the best academic background so that they can interface with the outside world and find the strength in who they are as Haida people. (Vonnie Hutchingson)

Change must occur within the classroom, which is the locus of change. Many voices have initiated the discussion for such change, but it occurs slowly. Students also need to be supported when dealing with the social issues. Teacher A points out that there is a need for awareness about “special needs, fetal alcohol syndrome, attention deficit disorder, substance abuse – which are quite common here.” Furthermore, Teacher G feels that in some cases poverty is an issue that is found across race, class, and culture. Teacher E suggests that learning should be more hands-on and relevant.

What we need to do is—not just for aboriginal learners, but for all learners, is to give them more hands-on, more relevance—not just the rote learning. Memorization doesn’t work in subjects like mathematics; you need to show them how to logically derive things and figure things out. I think there needs to be more focus on how to teach the kids to think, not just memorize. If you teach them how to think it through for themselves logically and work their way through things they will be able to do it for themselves. (Teacher E)

Teacher B thinks that he has been relatively successful teaching First Nations students in the BC interior, and now in Haida Gwaii. Over the years he has found that students entering Math 8 have weak skills in procedural fluency in mathematics. Some students lack basic number sense, for example, on a diagnostic test, many students were unable to identify the number 19 200 000 in words. Students entering grade 8 have a range of mathematics skills from grade 7 to grade 1. The situation is especially challenging for teachers, who must teach students with such a range of abilities while, at
the same time, dealing with student behavioral issues. Teacher B provides insight into some of these complex issues, which have become compounded with the over-crowded curriculum, difficult student attitudes, and societal problems.

It is essential to have a really structured environment in the school to teach mathematics. It is my understanding that the amount of time devoted to mathematics is not enough. You have so much content you have to get through that it is just not practical. There is also an innate fear of math—it's just a series of rules for these guys! They need more time and less content.

I think that the biggest thing that we have to deal with the kids is their tendency towards avoidance. They have learned, through the system, that if they avoid work they will pass anyway and, therefore, the incentive to work isn't there. It's an attitude thing because you have a kid with perfectly good intelligence who has no confidence or no work ethic around it.

When the students are having trouble in Math 10 a lot of the times the parents are saying 'Well I never got past Grade 8 math so you are doing really well or I don't blame you'—it's almost like the kids start to back away then.

I find a lot of times the kids that need the help, don't come. They are the ones that don't have the secure home life, they're not interested in doing well, and they are more worried about where their next meal is going to come or where they are going to spend the night versus whether they get fractions or not. (Teacher B)

Classrooms need to be places where students can feel safe, welcome, and motivated to learn. In effectively differentiated classrooms, teachers should have a clear understanding about the essential questions. If a teacher is knowledgeable and passionate about mathematics or about any subject they teach, they may be able to teach in a way that students can understand and find ways for relating the material to students, and motivating them at the same time. Putting a curriculum in place without a sound program of professional development or strategies for hiring mathematically competent teachers
might just exacerbate the problem. Having well-qualified math teachers who are mathematically competent and pedagogically proficient would be beneficial for all learners: Aboriginal and non-Aboriginal.

Cultural Relevance vs. Personal Relevance

Irvine and Armento (2001) identify the significance and urgency of implementing culturally responsive pedagogy. This term implies that teachers should be responsive to the students’ culture in their teaching. Teachers should have high expectations and be aware of the prior knowledge, language, and experiences of the students in their classes. Nichol and Robinson (2000) suggest that teachers in the methodology courses should be equipped with a range of teaching strategies reflecting the diverse learning needs and preferred ways of learning for Aboriginal students. The teacher’s underlying beliefs are also of fundamental importance in the effective teaching of mathematics. Another aspect to consider is the appropriate and respectful integration of culture in the classroom.

Each community has its own protocols for appropriately and respectfully using the language and culture, and there are specific rules regarding who can share the community’s traditional knowledge. For that reason, teachers should consult with colleagues, the school principal, and/or community representatives before using any aspects of the language and culture. Many First Nations also have recognized Language Authorities that have the authority to determine how their languages and cultures are to be used. (Kavanagh, 2006, p.27)

In the last few years, many teachers have seen their students drifting away from their traditional Haida cultural background. They fear that, in the absence of the traditional cultural influence, they are now being influenced by a “gangster culture.” Gangster rap, for example, has been strongly identified with basketball, and as basketball is a big part of the islands, those interested in basketball are identifying with the gangster
Many students are becoming a part of this new culture, glorifying it, and turning it into an accepted norm. Teacher E sees a connection between personal relevance and cultural relevance which is continuously evolving.

I think cultural relevance isn't as important as personal relevance because culturally a lot of these kids identify more with Black rappers than with their own heritage. So if you are talking about cultural relevance it might make a difference if you did math on rap songs. The biggest question and the most asked question by the students of their math teacher is 'What the heck is this good for? I am never going to use this again.' But if you can show them where, why and how they will use this math again then you will have some relevance.

If someone tells you to memorize a series of phone numbers—chances are almost zero you are going to remember those phone numbers. Now if it happens to be a really good-looking girl or really good-looking guy's phone number—you're going to remember those seven digits because that has relevance to you and if you can do math that has relevance—those kids are going to click in and their brains are going to be switched on and they will remember that for the rest of their life. If you think you could teach math through cultural relevance, how it deals with carving—it's a real stretch. You try to shoehorn something into a math like carving—the kids aren't going to buy it. But if you can make it relevant to their personal lives, then it could help.

For instance you're out on the beach with your ATV or 4X4 and you see a big truck that is stuck. Now you want to pull that big truck out with a smaller truck or an ATV, here's where you have to figure out exactly what kind of mechanical advantage or ratio you would need. So it's more like geographical relevance, another example would be relevance on fishing boats—and that's part of the daily living and culture. (Teacher E)

Finding culturally relevant materials to be taught in a mathematics classroom is a challenge. Many teachers do not have the knowledge or resources to teach culturally relevant materials, or feel that they do not have the time when the curriculum is so packed. Some teachers also try to incorporate examples from life on Haida Gwaii, but their efforts are limited. They know that if a student wants to enter a trade, such as that of
an electrician, mechanic, or ship’s captain, they will usually identify with some aspect that really makes sense to them, which is where the relevance comes in.

Conclusions

According to the Report Card on Aboriginal Education in British Columbia (2006), one of the secondary schools in Haida Gwaii has the lowest ranking in the province. The situation has been longstanding, and as one teacher puts it: there needs to be change, real change:

There is a lot of misinformation out there that is based on the history because of the parents and grandparents who went to this school. People have to start recognizing that those challenges belong to everybody, it is not just the students or the teachers or the parents that need fixing—we are all fine the way we are, except that we need to work together. It’s time to start a revolution—whether it’s going to work or not, who knows, but there’s got to be something different. (Teacher G)

The change process will be slow, but it must be ongoing, for any improvement to take place. Learning opportunities need to be provided both inside and outside the classroom, must respond to the diversity of learners in the classroom, and take advantage of the students’ connections with their communities. A rich mathematics community begins with the classroom community, but must also include the greater school community, the home and family community, and the outside community. All of these communities can help students to be comfortable with the processes of mathematical inquiry and provide opportunities for students to explore, reason, solve problems, and form connections. An inclusive classroom community with grade-specific ideas, routines, and activities will help students to see mathematics as being fun, exciting, engaging, and doable. Student understanding of mathematical concepts is deepened and enhanced when students can see connections between what they are learning and what they experience in
their communities. From the connections they see in the classroom, they can begin making real-life connections that have personal relevance.
CHAPTER SEVEN –
Honoring the Voice of Role Models 
and Community Members in Haida Gwaii

Introduction

In this chapter, data from the transcripts of interviews of members of the Haida Role Model Program and other community members in Haida Gwaii are examined and analyzed. As discussed in Chapter 4, members of the Haida Role Model Program are of Haida heritage, and consist of elders, professionals, and community members who go to schools and assist teachers in integrating Haida knowledge and perspectives with the school curriculum. Some of the community members whom I interviewed were non-Haida, hence were not part of the Haida Role Model Program but were related to the Haida nation through marriage.

Through the interview process a number of themes emerged concerning the impact of different ways of knowing on the success rates of Aboriginal students in school mathematics and math-related disciplines. Different people focused on different aspects of the issue and offered their point of view from their personal experiences in the community. Questions asked during the interviews are listed in Appendix 5. In Chapter 5 a wide range of cultural activities and professions were identified that entail some kind of mathematical ability in Haida Gwaii. Many connections were shown between the types of problems that people solve in their daily lives and the concepts taught in school mathematics. Many students find it difficult to make a connection between the mathematics concepts they learn in school and what they are using in their daily lives.

Mediating meaning for Aboriginal students by showing them how traditional and
contemporary cultural activities have many mathematical concepts embedded in them could also motivate them.

**Situated Learning**

When participants were asked to share a story about how they learned best, their answers invariably pointed to two factors. One, that learning was easier if it was situated and in context. Lave & Wenger (1991) identify social interaction to be a critical component of situated learning. Secondly, the need to interact with those who have more experience and knowledge, such as a mentor, teacher or a guide to mediate their learning (Vygotsky, 1986). Many Aboriginal students have difficulty relating to certain teachers because of cultural conflicts. They need a teacher who is a "culture broker" (Stairs, 1995). A culture-broker teacher could help students move back and forth between an Aboriginal culture and the culture of Western mathematics (conventional school mathematics), and will help students deal with cultural conflicts that might arise. For the vast majority of students whose home worldview differs from the worldview of school, cultural border crossing is not smooth (Aikenhead, 1997).

Danny Robertson, director of the Rediscovery Program in Skidegate, is not Haida but his wife Nika Collison is of Haida heritage. He points out that he was successful when the learning mattered to him and it was practical.

Math was one of the subjects I found most challenging throughout elementary school and high school. So, I managed to get my way through high school and actually graduate without any real solid comprehension of math. When I started working in the outdoor recreation business and started working as a sea kayak guide or rock climbing instructor—I really felt the pain of the lack of knowledge because simple calculations that are absolutely fundamental for safety were challenging for me. I got my unrestricted captain’s ticket and I got 95% on the exam. It is because it was really practical and something that I could wrap my head around. It
was daunting but I was fully capable. Again, because it was relevant, there were other guides to help me, and I was interested. (Danny Robertson)

Elder James Young started to learn mathematics when he was only three years old. His learning took place neither in a traditional way nor in a pre-school, but in a situation that involved reasoning, logic, patterns, and mental calculations while he played the game of checkers.

I started school when I was seven up here. When I was a little boy, maybe three or four years old, my uncle used to come, and everyday we would play checkers. We had the checker board, and lined all the checkers up—I had twelve on my side; he had four on his side. Even though he had four checkers, he used to beat me. I never gave up and everyday we played checkers. Finally I won a game. When I won a game he added another checker to his side and played with five pieces. As I grew up and got better at the game he had to add more checkers. Pretty soon we were playing twelve against twelve. Since the way my brain was developed, before I even started school, I was good at math. (Elder James Young)

Guujaaw, an experienced carver and president of the Haida Nation, explains that learning is life-long, and he learned how to carve not by going to school but from others.

I learned to carve from all the peers, the old people, the old collections—that is how most of us learn, eh. We didn’t go to school for that, it is on a one-to-one working as an apprentice and then learning on the job or actual doing it. It is continuous learning. I don’t necessarily think that if somebody goes to school they become smart—you just learn to organize and manage things in a different kind of way. Learn to be more analytical—it is kind of a design for economics more than anything. (Guujaaw)

Cecil Brown, a young entrepreneur, relates his experience of also having difficulty in learning mathematics, but was able to learn the concepts once they were mediated in smaller components, and made contextual.

I was never good at math but I always started thinking with dollars. How could I put this money in my pocket and take it away. Fractions was the
toughest thing for me but one of my teachers just explained with fishing and measurements of a pole and it eventually all clicked in. Basically you have to break it down, break it down, break down and then after a while you start finding all these shortcuts for yourself. I had to do an upgrade in math and this teacher really helped me because he broke it down for me. Breaking down all the concepts was—like basically just teaching you how to add again—everything made sense. (Cecil Brown)

Philip Gladstone, a charge hand mechanic, stresses the importance of asking questions and recalls that he learned the most on the job from others.

We learned on the job. We weren’t afraid to say ‘I don’t know anything about this and that’ and the master mechanic would say ‘go see so and so.’ Nowadays people are afraid to admit if they don’t know something—but sometimes the older timers, they would ask you and you felt good about it. Eventually I had to write a ticket so I asked the personnel supervisor ‘when do we go to school?’ and he said ‘you don’t have to go to school, you are doing it everyday’ and I said ‘no, we’re not—we’re doing things—lots of things but not what is going to be on the exam’ so they brought in an instructor and after work we had to go to the camp for a week every night for five hours and then at the end of the week the instructor said ‘I just gave you a six month course’. I took the exam which had lots of math and passed. (Philip Gladstone)

Sid Crosby, a carpenter in Skidegate, needed to upgrade his mathematics so that he could get his journeyman’s ticket.

I had been a carpenter for a number of years and I decided to go to school to try and get my journeyman’s papers and the first thing I bumped into was math on the first day of college. It was like being back in high school and I am trying to remember what did I learn then? But after using my carpentry skills, and comparing it to what they were trying to teach me, it all sort of clicked after a couple of days. I had to learn trigonometry again in college and I never remembered learning it in high school. I just needed to do some plain old studying. Everything is about numbers in carpentry. You start out square when you build a house and hopefully by the time you get to the top of the roof it is still square—once you are on the roof you start to use angles, right angles, triangles, and trigonometry. (Sid Crosby)
Tanu Gamble, a social science researcher who lives in Vancouver but grew up in Kitkatla and Prince Rupert, wonders how learning can be made meaningful when different people have different interests. Like Tanu, many people find that working with money is a brilliant way to learn about number and number operations.

I think people talk about that all the time with every subject—just make it relevant to the people’s lives and then it will be more meaningful—but I mean how do you do that when every person has different interests? I think as children, young children, you can make it relevant in a lot of different ways. I know for me and my nephews it’s money, when we’re talking about toys and we go to the store it’s like you have $20 to spend, that’s it. We would go through the aisles and find an item that costs $5.99 and then we had to figure out how much money we have left to spend on something else. My nephew was so good at subtracting the amount and figuring out how much the taxes were going to be because he knew that is also going to factor into his $20. He did it all in his head. (Tanu Gamble)

In Haida Gwaii many people used to work in fishing, forestry or other resource-based industries and those jobs are becoming few and far between. Since many of these people don’t have formal education they now need to upgrade their education in order to be qualified for jobs in other trades. Bobbi Parnell, who works at the Masset Learning Centre, assists clients to gain skills and education so that they become self-sufficient through employment or self-employment. She observes that many adults find it a challenge when the learning is not contextual.

I would say there’s been very little success in the Adult Basic Education that’s going on in the community. Actually working on computers doesn’t work for a large number of people—they just give up. I think connecting it to their lives is really important. I think a lot of people drop out of the programs because ‘What is the use of this?’ ‘What does this have to do with my life?’ and so I think if they could learn math within the context of their everyday life—they’re trying to train for careers they have never been in before so they can’t connect to it that way so at least if they could connect it to their lives.
I think if someone is just doing math without context, it isn’t going to work especially in the pre-trades programs where you are learning math but you don’t know how it is related specifically to a trade. For example, if I am going to go into carpentry and I am going to learn how to build a longhouse or something practical, then learning math is in context. I think practical projects are where they know it is a link to something—building is not cultural but practical. I have seen people who have succeeded in upgrading when they had a very specific goal. When I have people with really low levels of mathematics and English I haven’t seen them succeed until they really know what it’s for. (Bobbi Parnell)

There is a commonality among the various participants. Learning takes place in situations of co-participation mediated by others in that community. Learning is not seen as the acquisition of knowledge by individuals so much as a process of social participation. Situated Learning in a community of practice involves much more than the technical knowledge or skill associated with undertaking some task. Members are also involved in a set of relationships over time (Lave and Wenger, 1991). Eventually “learning as internalization, learning as increasing participation in communities of practice concerns the whole person acting in the world” (Lave and Wenger, 1991, p. 49).

Early Intervention and the Role of Parents

Palmantier (2005) reported that Euro-Western approaches often do not fit the needs, interests, or development and learning styles of Aboriginal students. Early intervention to address student learning difficulties in mathematics is more successful than responding to accumulated deficits at a later date (MOE, 1999). The CTM Position: Early Childhood Mathematics Education (2002) also affirms that “high-quality, challenging, and accessible mathematics education for 3 to 6-year-old children is a vital foundation for future mathematics learning.”
Young children are naturally inquisitive about mathematics, and teachers can build on this inquisitiveness to help students develop the positive attitudes that often occur when one understands and makes sense of a topic (Expert Panel on Early Math in Ontario, 2003).

The most important connection for early mathematics development is between the intuitive, informal mathematics that students have learned through their own experiences and the mathematics they are learning in school. All other connections—between one mathematical concept and another, between different mathematics topics, between mathematics and other fields of knowledge, and between mathematics and everyday life—are supported by the link between the students’ informal experiences and more formal mathematics. (NCTM, 2000, p. 132)

BCAMT K-12 Vision Survey (2004) showed that 97% of the respondents agreed that parental expectations strongly influence a child’s achievement. Beginning early, perhaps even before formal schooling starts, and certainly before they are conscious of it, children form attitudes about mathematics. In many cases, a parent’s frustration or discomfort with mathematics influences a child’s perspective. The parent’s attitude may well result from her or his own early mathematical experiences, forming a vicious cycle of negativity.

This cycle needs to be broken, where the power of parental expectations needs to be acknowledged and turned positive. Disrespecting some parents’ valid frustrations will exacerbate negative attitudes, not alleviate them. Diane Brown suggests that just talking about the issue is not good enough, action needs to be taken.

I think there is not enough direction given at home. There is not enough emphasis put on the value of education. Some families don’t even have enough food or are struggling, so the priorities are different. I think it has to be changed—we are not going to really win the parents easily. Parents need assistance like the Nest Program where they can teach the children at a young age. I think at nine you are pretty much set in your ways. So when they are this age, you can teach them cultural values. I was good from
what I had learned from my mother from the age 9 and up. I think the younger you get at them and teach some values the better it is. Like my daughter is a nurse and you need our young kids to see that even—she’s from here, she was educated here and she was able to make it. (Diane Brown)

Herb Jones realizes that everyone parents their children differently; his children have been successful in learning mathematics because he instilled the zeal for learning into their hearts and minds.

When I was raising my children I told them I endeavor to instill in their hearts and their minds to have the ability to figure things out as they go through life and I told them there isn’t anything that they do and like that is not going to be associated with numbers. In order for our children to be successful, that has to be sealed within the family circle itself. There has to be that zeal to instill into the hearts and minds of the children of how to figure things out, how to work together, and using numbers and if there is no zeal from the family circle and in the school, how much zeal does the teacher that is teaching math have? If she or he has a lack of zeal and really wants to instill into the children to learn these things and the parents are not that zealous on it well then there is going to be difficulty with the child because the child learns from example.

I suppose my own desire and attitude to be successful in working with numbers transferred to my children—I told every one of my children that they had to be successful and in order to be successful in life, they had to know numbers. They had to be able to figure out very quickly what you could achieve for the month, for the week, for the day. And I always told them to set realistic goals—not some outrageous goals that are not achievable—something that was within your ability of reaching so that is why the children were successful. (Herb Jones)

Arthur Pearson gets his children to use mental math and estimation in their daily lives to change their attitudes.

I think one of the things that I do with my kids is to get them counting cars and colors and playing games. Every once in a while I throw a mathematical challenge at them and usually it has to do with things from my work and I would say to my older ones ‘you know that I told you that a 6 by 10 feet by 1 inch is sixty board feet’. And I explained how to get
one board foot would be 12 inches by 12 inches by 1 inch and I’d say if you take the board and cut it in half then cut it in half again, how many board feet would I end up with? (Arthur Pearson)

Sam Davis Jr. realizes that many parents don’t know any better, but the bottom line is that you need to spend the time with your children.

There is very little time spent on reading or doing homework. I see that as a big problem, I think the parents aren’t strict enough and that has been a problem. Mind you some parents don’t know any better because they don’t have the skills themselves. I’m lucky that my wife actually would sit with my daughter and make her do her homework or read two hours so now. She has a 4.0 average in school and is going to go to university next year. (Sam Davis Jr.)

Marvin Alton expresses the sad reality of historical factors and how a parent’s negative experience and attitude can easily affect a child.

If you could get that emphasis on mathematics as a basic necessity and something of value, then a lot more students would value it if the parent’s valued it. Parents have to be made aware of what is happening and how it is going to affect their children later on in life. So, my parents made it through Grade 10, a lot of parents did not graduate. So emphasis on education plus the historical value of education is important. Unfortunately the experience of residential schooling really affected generations, and it is still affecting generations now. (Marvin Alton)

Bernard Kerrigan also talks about the historical perspective and the difficulties encountered in breaking the negative cycle. He believes that there are multiple issues and we need to have education not only for students but also their parents so that family attitudes and parenting skills may improve.

I think parents just don’t value education. People say that they really support education but they don’t really know what that means. The Band Council says they support education but they don’t want to hire educated people from here. Well it all goes back to residential school when the children are taken away and then didn’t see how families were run where
parents would help them with homework and other things. So when the children came back, they don’t know how to do the parenting. And so it goes on to the next generation, and the next generation. So, the people are wondering who they were supposed to trust. They trusted the clergy and the government and see what happened. I think one of the biggest things that need to change is to have education for adults as well as school going students. The students need more positive role models here. And a lot of the kids don’t have that—they can’t do homework—they barely have a good home life—a lot of them have bad home lives, so for them to be expected to do homework at home or some of them need fed in the morning or getting sleep at night—it’s hard for them. (Bernard Kerrigan)

Tanu Gamble feels that she was really fortunate to have a mother who was a teacher and how having a mathematical discourse with her parents helped her learn the subject.

I think I was fortunate to have a mom who was a teacher when I was a child I think she probably used me as a little bit of a guinea pig to try out her teaching techniques. I do remember sitting at the kitchen table and her pulling out all of the forks and knives — like if you are in school they have these little blocks and other manipulatives to do your times tables or fractions. I think she taught it more like it was a game so it was not a really big deal. I remember going for walks—we would go for walks in the evening and she would test me on my times tables—just randomly. For me my parents were so instrumental in learning math. It wasn’t necessarily something I learned in the school system but it was the participation of my parents in my education. (Tanu Gamble)

Elizabeth Moore, chief councilor for the Masset Village Council, believes in the importance of all children being numerate, and that there should be mentoring opportunities for the weaker students. The children need to be challenged with learning opportunities inside and outside the classroom.

I want our children to have the needed math skills. My daughter is in grade 4 and I challenge her. The other day I asked her what is 16 times 60. I knew she didn’t know the answer, but I just wanted to challenge her. She just said that the answer is big. I also get my daughter to do workbooks and practice her basics. There are not too many kids that have
an opportunity to do that. We also need the kids to have way more opportunities on the land rather than sitting in the classroom. The kids need to be out there picking berries, gathering spruce roots, looking at the tidal pools. (Elizabeth Moore)

Reg Davidson feels that if as a parent he did his job, then teachers would be able to do their jobs as teachers. He also believes that the way it is now has been for so long that people have become accustomed to it. Another problem he finds is that children nowadays have too many things to do. He said that “You need to work with yourself first and then you work with your family. So you start with yourself first instead of trying to fix the world. The world will change”. Willis Parnell also stresses that in order to make things better one has to set their priorities straight and model by assisting others in need.

I think the biggest challenge is the support system. How do you change that around? You have to apply yourself—sacrifice. I think that is a big thing and that is why I think parents need to sacrifice because they want—they should be the best for their kids. I try to do that for my kids because they are examples of me. If I don’t read to them, if I don’t help them out, what are they going to be? They are an example of my raising. If we insist that we do things with them so that they can be better off in the future we need to provide good guidance. I don’t want my kids to fail.

I’m a firm believer that people need to help people. For young people, I try to give back what people taught me whether it be just listening to them, or just giving them some feedback. I am not the greatest individual in mathematics and English but I will definitely try to help because that is what I think young people probably just need—help. I think their self-esteem would be higher, and their confidence would be better. ‘What you put in to it is what you can get out of it’. (Willis Parnell)

While teachers and educators are still the purveyors of formal knowledge and the curriculum of mathematics education, parents and other members of society play a key role in a child’s success. Attitude about mathematics start to form even in the early years of a child. Sometimes, difficulties experienced in school time stay with member of
society for the rest of their lives, not just through the formal years of learning. Parents need to be more involved in what is going on and understanding the importance of their children getting an education and making a life for themselves.

**Changing Personal and Community Attitudes towards Mathematics**

For Aboriginal students to succeed in numeracy, they and their families need to have a positive attitude towards mathematics, and they need to view it as valuable component of their education.

Education programs carefully designed and implemented with parental involvement, can prepare Aboriginal children to participate in two worlds with a choice of futures.

(Royal Commission on Aboriginal Peoples, Volume 3, p. 442)

Community attitudes towards mathematics can have a dramatic effect on the learning of mathematics by students. Unfortunately it seems acceptable in many social settings to say “Oh, I was never that good at mathematics” and yet there is almost universal agreement that mathematics is an important school subject (NCTM 2000). Jason Aslop also hears many of his friends talk about mathematics as a subject that is ‘boring, they don’t like it, they don’t need it, or their parents weren’t good at it’. He thinks in order to do well in mathematics you have to sit down, practice, and have a good environment for studying. Danny Robertson thinks that you either have the natural aptitude for mathematics or you don’t. Unfortunately he and many of the students he works with are on the negative side of the fence.

For my generation and plus all the kids that I work with I have to say that the attitude is that some just have a natural aptitude for math just get it and they can see where it applies to everywhere in life and it is great. For those who don’t grasp the concepts quickly—it is a laborious, dry, boring, no fun, hard to get motivated to do it. I guess it would depend on which
side of the fence you are on, my side of the fence had difficulty grasping and lots of the kids I work with are on the same side- it's got a bit of a stigma to it. Mathematics seems to be for nerds or for professors and everyone else is bound to struggle. (Danny Robertson)

It seems like one of the solutions to halting the downward spiral of negative attitudes is to improve experiences in mathematics classrooms. Parents care a great deal about how their children feel about their classroom experiences, and do not value a classroom that bores their children, or, makes their children feel incompetent and worthless. If student success can improve, and they start to enjoy learning mathematics, we can not only put an end to the downward spiral, but initiate a cycle of positive attitudes. Students will find greater success when they find greater motivation to learn mathematics. Motivation and change of attitude can improve when students get to do tasks that are personally relevant, explains Danny Robertson.

My feeling is that it takes a lot more effort to keep kids interested in something that has no cultural relevance—I don’t just mean cultural but area-specific like something to do with the Islands. It is also a lot easier if kids can identify personally with what they learn. —there is motivation to want to learn more about it. Like in my case, learning mathematics was brutal for me until I was a captain and it really mattered and I really found it interesting and then I learned what I had to do. My attitude changed. (Danny Robertson)

Even something as simple as playing a card game can help with the learning process and contribute to having a positive attitude.

My wife tells me of all the times when she would be over at Copper Bay doing the traditional food fishery or spending nights out on the boat with her chinne (maternal grandfather), and they would be playing crib and card games and she knew all these card games. And it is basically one of those things where she had to use her brain a lot in playing games which was fun. It was a fun environment to learn math and she didn’t even know she was learning it. Counting, estimating, guessing, and keeping the scores in your head. (Danny Robertson)
In Chapter 5 the role mathematics plays in various cultural activities and occupations was discussed. Students often mistakenly believe they do not need math because they are “only going to be” some occupation that is in fact quite dependent on mathematics. When mathematics becomes clearly important to students' futures and their daily living then they will learn better, and enjoy it more at the same time. In fact, success itself breeds enjoyment. Changing societal attitudes discussed above are in themselves a challenge, but implementing these changes would require sustained efforts from the various stakeholders.

**Culturally Inclusive Pedagogy**

A key concept shared by many Aboriginal people is that of *relationality*, which is the belief and understanding of the interconnectedness of our world and all within it. In addition, relationality encompasses other realities that we cannot see, but of which we are aware (Wilson, 2003). Aboriginal students participate in two cultures – the culture of the home and the culture of the school. Many of these students see little connection between these two cultures; and consequently many potentially rich situations from the native culture are nowhere to be found in the school (Davison, 2002). James Sawyer, a carver and jewelry maker, suggests that student should get a chance to watch artist in action to learn concepts in mathematics.

I think the kids would probably get a lot more interested if they were watching guys carving up poles or sculptures or even showing them the breakdown of bracelets or whatever on paintings because everything sort of starts in a square. From the square you go out to a three-dimensional piece—because most of the carvers will start with blocks and do everything in blocks and then after the blocks are done and they make sure the blocks are even, then they round them into their geometric forms or
ovoid forms. Everything on the poles is symmetrical—they've got a lot of mathematics and measuring they do. (James Sawyer)

Christian White reflects about his own learning in school and found it to be irrelevant. Most of his learning came from watching others, especially his grandfather and father.

During the time I was attending school the teacher did not provide any relevancy. So, I can see why that could be helpful if we can find other ways in teaching in a relevant manner to—because a lot of the things that I actually learned weren’t taught to me in school. Most of what I know was taught through my grandfather and my father. They were boat builders and fisherman. They could build houses. So they were quite handy at different types of measurement. I think we have to bring in some of the more relevant work—teaching the culture but even to the geographical location—because I don’t think a lot of our people even understand what the size of these islands are really. (Christian White)

Davison (2002) asserts that the use of cultural situations can improve the learning of mathematics by Aboriginal students in several ways. When the teaching of mathematics uses ideas from the culture, students value their cultural heritage more. The integration of the students' experiential mathematics with their school mathematics can help them make new connections. Guujaaw suggest that we should not just focus on the curriculum but also find way to integrate the learning with the land.

I think that the problem with our schools here is that the real-life opportunities apparent and in the lands and culture around us are ignored. A student might learn about things all around the world, but there is little attention to seabirds, or any of the many aspects of biology or about care of the oceans, and management about the resources which people can build careers around. The flexibility has got to be built into the curriculum to allow our kids to learn about those things that are relevant to the life in the place that we live. (Gujujaaw)
Christine Carty, an accountant by profession who is also a weaver suggests that mathematics should be taught by integrating cultural activities. She also offers advice on what to do when you can't solve a problem.

In order to get by in this world you need math. Even in the trades there is a strong emphasis on math. You could make the curriculum more fun, incorporate activities such as weaving, which I find is relaxing. You would then be learning math and a bit of your culture. You need to create an interest for the students. You have to be creative. You need to build on a student's self-esteem.

I found that if I had any problems with math, I always asked. If I get stuck at something, I never let it go away, I would either figure it out myself or ask others or seek answers from other resources. I do the same for my children. I encourage my children to seek the answers. (Christine Carty)

Aikenhead (2002), Davison (2002), Hankes and Fast (2002), Irvine and Armento (2001), Jeffrey (1999), and Nichol and Robinson (2000) suggest that when culturally inclusive curricula and pedagogy are delivered in a way that accounts for learner diversity, then Aboriginal students' achievement improves significantly. Bishop (1988) indicates that the cultural background of students is rich in terms of the resources from which mathematics concepts can be developed. It is easy to talk about having culturally inclusive pedagogy. But the reality is if a teacher is just going to be using a handout or a worksheet to make it culturally relevant, then it defeats the purpose. The teaching needs to be done in imaginative, creative ways where the students are motivated to learn in ways that are Hands-On and Minds-On (Fettes, 2005; Courage and Fettes, 2005).

**Using Role Models**

As mentioned in Chapter 4 members of the Haida Role Model Program consist of elders, professionals, and community members who go to schools and assist teachers in
integrating Haida knowledge and perspective with the school curriculum. This vital connection between the school district and the Haida community fosters better relationships and enhances the outreach for Aboriginal students. Guujaaw believes that students need to have pride in who they are and to hear their own stories.

The kids have to hear their own stories, they have to start glorifying their own heroes not just of the Greeks or Americans. They have to know that they come from a place where people count, and from there, the relevance of other world cultures becomes even more interesting. (Gujjaaw)

Role models and other members in the community can also share the different ways that they use mathematics, how it applies to the job they do.

**Learning on the Land**

As mentioned earlier, contextualizing and making connections are powerful processes in the development of mathematical understanding. "When mathematical ideas are connected to each other or to real-world phenomena, students can begin to view mathematics as useful, relevant, and integrated" (WNCP, 2006, p.7). About thirty years ago, the Rediscovery Program started as a single camp near Masset in the north, and then it grew from its successes in that location to an international organization. The purpose of this program was to reintroduce the youth of a particular culture or nation to their culture on the lands they own. Every summer Swan Bay Rediscovery Program is run in the south part of the island, for the purposes of giving the youth life skills, job skills, and cultural knowledge through such activities as hunting and food gathering, cedar bark weaving, and learning about historical and archeological sites. The students learn how to read tide books, charts and mapping, compass work, chart work. They also have to do the meal
plans—where they need to calculate how much food they need to bring, and take the responsibility of finding resources in the wilderness. Danny Robertson, director of the Swan Bay Rediscovery Program mentions that they “teach concepts that can be tied to their culture—anything from just simple food gathering to safe hunting protocol to reading the tides. All the activities require a lot of problem solving and focus on mathematical skills”.

Judson Brown, an officer with Parks Canada, feels that things today are different from his childhood days, when they used to spend a lot of time outdoors—working with the tides, for example, learning how it comes in and out every six hours. On the weekend kids could go fishing with their chinin, or berry picking with their mom, aunt or nonnie. Then they would be learning the curriculum and culture through activities on the land.

Marvin Alton gives an example how students could learn mathematics through problem solving by having hands-on experience on the land.

If you could teach the math concepts by applying it to their environment, you would probably get a better response from the students. You need to do examples which show how math in everyday life can help you acquire jobs, for example, you are going octopus hunting, and you think ‘Well how much money can I make off octopus hunting?’ But when you go out, you have to look at the tides, winds, supplies, etc. You have got to relate to the land.

Solving problems like one train is traveling from Boston and the other is traveling from New York...I mean this problem has no bearing on their daily lives. A related problem could be ‘Well, you have got a patrol boat traveling from Rose Harbor and you’ve got the other one trading shifts, what time will they meet up?’ You have got to relate it to their environment and they have got to be able to visualize what they are doing. So, I mean, if you are in a boating community like we are, you can associate with boats, you can associate it with logging. You have got to help students associate it with their environment around them so they can actually visualize what they are doing. (Marvin Alton)
Schools and Classrooms

Many First Nations communities are still in the process of healing. It is critical to understand the current realities of Aboriginal communities: The problems and challenges they face are complex (Kavanagh, 2006). Schools need to build the confidence and trust of the community by reaching out to them, and being respectful of their cultural traditions. Kim Davidson, a carpenter in Masset, wonders how the cycle of oppression can be broken.

In aboriginal community across the country there is a system of institutionalized racism at work. What I see is that Aboriginal people that have gone through the school system have not had a very good experience. So they return to their communities with their bad experiences, their kids continue to struggle through it and they probably have bad experiences. Now, you have a whole population of people who don't understand what is going on in the world. Especially with the oppression that is happening within the Aboriginal communities. (Kim Davidson)

An outreach program like “Homework Helper,” could be developed to help parents or grandparents to understand what their children are supposed to do, so that they may be able to help them. Like reading stories, the parents could do interactive math activities such as counting, measuring, designing, estimating, locating, or even game-playing (Bishop, 1988). There needs to be a viable support system in place which could offer more one-on-one help for students in the form of tutorial sessions, these could be held at a venue other than the school. Danny Robertson thinks that students should be taught with relevance even in the early years. He also believes that standards should be maintained regardless of which curriculum is taught.

I definitely think that’s what needs to change is how we teach math and how we create relevance and a curriculum that can be transplanted from say like Haida Gwaii and the Island community that we have here and how we teach it to the kids here, it will probably be a lot of ‘on the land’ stuff to an inner city. I think at the elementary school level there is a lot of time spent on learning the multiplication tables and basic principles like
how you do long division and go through other steps. I wonder if this could be taught with a new way of approaching those same skills by creating relevance at that age. So developing a curriculum that the kids will process with an understanding—applying the ‘why’ to these skills is important and why it matters to them. But we also need to make sure that the provincial standards are maintained and the curriculum is taught.

(Danny Robertson)

Bernard Kerrigan, who formally studied education and law at university and now resides in Old Masset as a carver and jewelry maker, thinks that smaller classes would help. This way the teacher would be able to monitor each student and make sure that they know the skills. Another factor that he thinks impedes learning is that some students miss a number of classes due to a variety of reasons. In such a case the parents or guardians need to be contacted right away, with the assistance of a liaison worker or the support of a home-school coordinator. This should also be part of the outreach program. He also thinks that math anxiety and a teacher’s disposition towards mathematics is also a factor in students’ learning.

I think a lot of it is the fear of mathematics. I had one instructor in college who loved figuring stuff out and he just had a joy of mathematics and sees the fun—like the way he looks at it I couldn’t imagine someone not enjoying mathematics being taught by him because he is just so enthusiastic of it. I see a lot of teachers that expect the children that have trouble with mathematics to live up to whatever expectations you have, you live up to that—so if you expect them to enjoy math and have fun with it and you teach that to them that it is fun and not something to be afraid of, that it does have an answer at the end. And if you go through the right steps, you’ll end up with the right answer. I mean you can check or get assistance. (Bernard Kerrigan)

Jason Alsop, a recent graduate, talks about the realities of a mathematics classroom. How can a teacher support all learners, provide differentiated instructions, and give individual attention?
What I realized in my time is that you need the support—like in some colleges they have activity centers where you can go get extra help at a time when you have questions. But in a high school class it seems like—there is one teacher for the whole class and there are about four different levels for that one class. So teachers get impatient with the lower level students at times. They don't have time to re-explain things so they say 'I've already explained this, I don't have time to deal with you' and 'I have got someone over here that is doing really well and I would rather help them do really well than help you get to the mid-level.' It seems like they prioritize a little bit. They only have an hour to do their thing and teach all the students. (Jason Alsop)

Nika Coillison believes in experiential learning as opposed to classroom learning. She thinks there is a need for classroom learning, but that students also need to learn from real-life experiences. The school system could change a little bit and incorporate cultural activities like weaving, where the patterns could be incorporated in a mathematics lesson. Guujaaw reminds us not to forget our relationship to that place or region or other areas on the land. He also thinks that, even with the best of intentions, if a school administration does not run a school properly then students might not succeed.

**Straddling the Worldviews**

Knowledge among Aboriginal people is acquired in multiple ways, but the coming-to-know process is nevertheless extremely systematic in both epistemologies as discussed in Chapter 3. Vonnie Hutchingson, Director of Haida Education with School District No. 50 stresses that it is really important to know that in the traditional Aboriginal worldview everything came as a whole and there weren't separate and discreet parts. Everything you know connected to different aspects of our lives. "So, if you looked at mathematics specifically and you asked elders how it is that we use mathematics in our daily lives, they would have a really hard time trying to articulate
that because it was in everything that we did and it wasn’t segmented out”. Aikenhead (2000) provides a gentle warning to proceed cautiously as it is easy to misunderstand culturally embedded meanings when we do not fully share the other person’s culture. Show respect for Aboriginal knowledge. Learn from the Aboriginal people and remember that gaining Aboriginal knowledge is a process of coming to know.

Christian White, an experienced carver in Old Masset, points out that students need to know about different worldviews; both worldviews are an expression of the creative process which connects all things. Cajete (1999) explains that Indigenous peoples have historically applied the thought process of creative science within cultural contexts, which are holistic. Every Indigenous culture has an orientation to learning that is metaphorically represented in its art forms, its way of community, its language, and its way of understanding itself in relationship to its natural environment.

Students have to deal with the outside world but, they also need to know their traditional ways. I think a lot of the houses of learning now are becoming more understanding of the different cultural values. Different people have different values and they might not excel in mathematics or in other academics but they all need to have some sort of creative process. (Christian White)

Language is said to be the root of many cultures. Words in a language, the ideas and feelings they represent, and the ways they are spoken allow people to fully express their traditional beliefs (Reed, 1999). It is no exception with the Haida culture. Diane Brown, a Haida language teacher expresses the difficulty students’ face in learning their heritage language.

It is hard for the kids to be good in both cultures. I think right now they are more in the white world than our world. I think there is an inner need and an inner will to be that and some of them will come here and think they could learn the language just like that and the reality is it’s difficult so they don’t come very often. (Diane Brown)
Shared Learning (1998) states that Canada's Aboriginal peoples value a legacy of oral tradition that provides an account of each group's origins, history, and spirituality. Stories bind a community with its past and future, and oral traditions reach across generations, from elder to child, and bear witness to how women and men were created and populated the land. Marvin Alton expresses the frustration of trying to learn orally when learning mathematics today requires multiple ways of representation.

Aboriginals traditionally were taught orally through stories. So you have got to take our nation into consideration like a lot of the times the elders taught by speaking to you and then you would envision it but for students nowadays trying to get into the education system, they cannot picture in their head what exactly comes out of mathematics for them.

They don’t understand how it is going to benefit them—they don’t think in the future because mathematics is a complicated system and it is all these theories and theorems, and it is hard to visualize when you learn orally what to do and you are a resource-based community, you are more tied to the land and you are not as worried about science. (Marvin Alton)

Tanu Gamble, a social science researcher, also expresses concern about how people perceive Aboriginal students to be dominantly oral learners. She considers that to be historically true, but learners today need to have a foot in both worlds.

I have heard it over and over people say that Aboriginal people are more an 'oral people'—it seems like this was true historically. I was born and raised in Prince Rupert which is not a reserve community but has probably a 50% population of Aboriginal people and I have lived in Vancouver for the past eight years—I think I definitely have a foot in both worlds. I am Aboriginal and have a strong culture but at the same time have learned to maneuver within the dominant system. (Tanu Gamble)
Willis Parnell, Recreation Director in Masset who also coaches basketball for Haida youth, discusses the importance of having pride in oneself, whether Haida or non-Haida, in order to succeed.

The Haida world is pretty strong just because of Haida people being resilient, being fighters. I know that through the conflict on Lyell Island in the eighties—where we just stood up and you can’t be just drowning any more. The issues are still ongoing. Regards to basketball, it is the same thing. It is a pride thing. Basketball is very huge here because obviously the fall and the winter aren’t that favorable for being outside so people are indoors. So of course you do the best you can to be elite, on an individual basis. The Haida world should be seen in the non-Haida world. First and foremost I think you have to have respect for yourself, and then you have to have respect for others.

The non-Haida world is very knowledgeable—you can obtain a lot of knowledge from it. In order to be a doctor or an engineer—you have to get schooling in the non-Haida world. Are you going to get that in the Haida world? Only to a certain degree. Remember who you are and you should do it for yourself first. I see young people playing basketball and they play for other people and not themselves. They will say ‘I’m playing for my mother or for my girlfriend or for my dad’ Well, what happens if you don’t feel like playing—so now you are going to let down not just your teammates but yourself and your dad—and it will be all mixed up—so you do something for yourself first. (Willis Parnell)

There is a need to recognize the existence of multiple worldviews and knowledge systems, and find ways to understand and relate to the world in its multiple dimensions and varied perspectives.

**Strategies for Change**

Implementing changes is not easy. It is easier to talk about these ideas and themes than implement them because of a variety of factors, such as changing attitudes, personal relevance, lack of resources, etc. Progress will be slow, but first steps need to be taken with the intention of ongoing, continual improvement. The community of Haida
Gwaii is changing, and so are its resources. Christian White points out that the community needs to reassess the options that will be available.

Well I think that we really have to reach out further into the community, and have more speakers coming from the community that can speak to the students on the possibility of different careers. Once, we have control of our resources then we can start to utilize a lot more of our people for developing new things here on the islands—becoming more self-sufficient—being able to bring things to the market—new products—of course we are going to need people who have those managerial skills, calculation skills, math skills, and business skills. (Christian White)

Conclusions

A number of themes have emerged as to what can be useful in integrating students' experiential mathematics with their school mathematics, for the purpose of helping them make new connections and improve achievement. Learning needs to be situated and in context. Students need to interact with those who have more experience and knowledge, such as a mentor, teacher, elder or a guide to mediate their learning. Students need the ability to be able to straddle between different worldviews in imaginative and creative ways. Early intervention with increased parental involvement can make a difference to students who have difficulties in learning mathematics; this is far more effective than responding to accumulated deficits at a later date. Changing societal attitudes towards mathematics can be challenging, but they can have a dramatic effect on the learning of mathematics by students. Where possible, culturally inclusive pedagogy should be utilized that accounts for learner diversity. Schools need to change the structure inside and outside the classrooms so that there are more outreach programs that utilize the resources of the land and the expertise of role models.
The older generation is determined to improve the educational success of their children. The definition of success is complex and unique to each individual and community. Should success be based on the scores of a large scale assessment like the FSA (Foundation Skills Assessment) or should it “involve children being self-confident, understanding their own culture and traditional values, and have a positive self-identity” (Kavanagh, 2006, p.20)? According to the British Columbia, Ministry of Education (2002, 2005 and 2006), in the annual report titled *How are we doing? Demographics and performance of Aboriginal students in BC public schools*, data have consistently shown that many of the province’s Aboriginal students perform lower than non-Aboriginal students in their achievement in mathematics. This has become a cause for concern as success is solely measured on the basis of data from provincial assessment. Such results do not reveal the whole picture of the community. Many members of the community are adamant that their children should learn mathematics which is “authentic”. They also want to see that their culture is acknowledged and represented in the curriculum but do not want a “watered down” curriculum for their children. Success is a difficult concept which should not be solely based on academics or economics but should look at life in balance.

The complexities that come into play when two fundamentally different worldviews converge present a great challenge. Many participants suggest that Aboriginal students should seek knowledge from both worldviews and recognize their interconnectedness. The dialogue needs to be a two-way street, rather than a view that the problem is to get Aboriginal people to buy into the Modern system. Aboriginal people may need to understand mainstream mathematics, but not at the expense of what they
already know. Non-Aboriginal people, too, must recognize the existence of multiple worldviews and knowledge systems, and find ways to understand and relate to the world in its multiple dimensions and varied perspectives. Interconnected ways of knowing can motivate students in learning mathematics, and also increase all students' levels of numeracy. A framework that compares and contrasts Indigenous and Modern epistemologies in the Learning of Mathematics is discussed in the next chapter.
CHAPTER EIGHT –
Conclusions and Contributions:
Connecting Community, Pedagogy, and Epistemology

The results and analyses presented in each chapter have their own conclusions, which are connected and serve to influence the analysis in the whole study, and to provide answers to the research questions presented in Chapter 4. Since the three research questions are linked, the answers are presented in this chapter according to the order given in the title of the study: connecting community, pedagogy, and epistemology.

The questions in this study were explored through different voices, but within the same community. Each Aboriginal community is unique to its people, land, and context. As I mentioned earlier, my results are based on a particular community and may not always be generalized to Aboriginal students in other regions and communities; or to all students in general. In a personal communication, Vonnie Hutchingson, Director of Haida Education articulates the locus of change.

I do want to honor the work of those strong voices from outside of our Nation and within our Nation that have facilitated the discussion for change. Much hasn’t changed. It’s a worry because what the politicians out there say impacts our children at the locus of change—where is that locus? That locus is within the classroom with that teacher and if we haven’t facilitated and supported that child with all the social issues that they may have or facilitate and support the teacher to give them the tools to be able to teach in diverse cultures within the classroom—I think that that conversation has only just begun. (Vonnie Hutchingson)

Connecting Community
One of the major conclusions of this study is that the community of Haida Gwaii practices numeracy with its unique culture and environment in a way that makes sense to the people living there. The problems they solve are contextual and situated within that community, and provide insights into how the Haida use their knowledge in dealing with
quantitative, relational, and spatial aspects of their lives. As such, this study provides insights into both the social role of mathematics and the nature of mathematical thinking. The examples presented illustrate how mathematical ideas and culture interplay in this community.

Interviews and photographs of the people of Haida Gwaii practicing numeracy in their daily lives showed that some of the mathematical concepts that people practiced in their daily lives were not congruent to the mathematics taught in school. People were able to function in their daily lives without having to use some of the mathematics curriculum taught in schools. For example, the artist who draws different geometric shapes such as Ovoids and U-shapes has the intuitive knowledge as to what the final piece of art will look like. Somehow the artist has a sense as to what shape will be most appealing to the eye of an observer. The art may integrate mathematical concepts such as symmetry, congruency, and transformations without the artist implicitly or intentionally knowing that they are doing it. Mathematical thinking seems to be inherent with the artist. It is false to say that school mathematics is necessary to make cultural artifacts such as bentwood boxes, button blankets, basket weaving or carvings but it is true to say that having a mathematical lens could lead to greater appreciation of such artifacts, or perhaps to new modifications and applications of traditional techniques.

Lipka and Adams (2006) emphasize the importance of observing mathematics in nature and society, such as in the tides, the building of fish racks, or in the building of models for various cultural artefacts can assist in generating new teaching resources. In addition, documented stories from different members of the community show how related cultural practices can help students attach meaning to the concepts they learn in school.
mathematics. The contextual familiarity and types of problems solved by students can increase their access to mathematics and their motivation to be engaged in school mathematics. Mathematics, when derived from the students' everyday life experiences, is typically more accessible and enjoyable to them, and can enhance their ability to make meaningful connections and deepen their understanding of mathematics (Zaslavsky, 1991). The challenge to educators is to acknowledge the cultural activities and recognize the embedded numeracy practices of the community and apply the pedagogy to teach school mathematics.

No classroom environment is isolated within its four walls. It is part of a wider community (of school and beyond) which has cultural practices and social norms. Consequently, acts, actions, or activities happen because they are part of this socio-cultural setting. These acts may include mathematical, educational, and social acts, or combinations of these. Lave and Wenger (1991) speak about a community of practice to encompass the customs (social and cultural) of a particular community and its ways of operating. We can envisage a mathematical community of practice that has its established acts, from which the classroom environment draws and modifies for its own use and practices. One of the major contributions of this study has been to humanize the view of mathematics and to expand the idea of what is mathematical by exploring numeracy practices in the community of Haida Gwaii.

**Pedagogical Implications**

Through a discrete presentation of different definitions of numeracy, a succinct definition was composed that synthesizes numeracy to be a socially constructed process, requiring an ability to integrate mathematics, with a willingness to solve situated and
contextual problems. “Numeracy is the set of mathematical skills needed for one’s daily functioning in the home, the workplace, and the community. It is the willingness and capacity to solve a variety of situated and contextual problems that could be functional, social, and cultural” (Neel, 2007).

*Principles and Standards for School Mathematics* (NCTM, 2000) calls for a common foundation of mathematics to be learnt by all students. It also advocates for the need to learn and teach mathematics as a part of cultural heritage and for life. Achieving this goal requires a paradigm shift in the way mathematics is taught with an introduction of culturally inclusive curricula.

Teachers need to select culturally-oriented learning activities that can be used in studying appropriate topics in mathematics. Examples of such activities are given in Appendixes 8 and 9. Many members of the community were adamant that their children should learn mathematics that is “authentic”. They also want to see that their culture is acknowledged and represented in the curriculum, but not that it is a “watered down” curriculum for their children. The Haida people’s knowledge of problem-solving, spatial relationships, estimation, and measurement, and their interpretation of physical phenomena have enabled them to live for thousands of years in Haida Gwaii, and should be directly related to their formal, conventional school mathematics.

Some of the findings based on the interviews with the role models, community members and teachers is that learning needs to be situated and in context. Aikenhead (2002), Cajete (1986, 1999), Kawagley (1995), and Lave and Wenger (1991) support such findings in their literature. Students need to interact with those who have more experience and knowledge, such as mentors, teachers, elders, or guides, to mediate their
learning. Early intervention with increased parental involvement can make a difference to students who have difficulties in learning mathematics rather than responding to accumulated deficits at a later date. While changing community attitudes towards mathematics is challenging, it can have dramatic effects on the learning of mathematics by students.

Learning opportunities need to be provided both inside and outside the classroom, and should address the diversity of learners in the classroom, while taking advantage of the students’ connections with their communities. A rich mathematics community begins with the classroom community, but must also include the greater school community, the home and family community, and the outside community. All of these communities can help students to be comfortable with the processes of mathematical inquiry, and provide opportunities for students to explore, reason, and solve problems, and form connections. Students who build strong relationships with their teachers, families, and communities have a higher rate of success. This success is not only achievement in mathematics, but other subjects and having a positive attitude. A teacher who conducted an evening Homework Club at the village had a greater bond with his students who in turn performed better in school.

Teaching mathematics well is a complex endeavor, and no easy recipes exist for helping all students to learn or for helping all teachers to become effective (NCTM, 2000, p.17). When possible, culturally inclusive pedagogy should be utilized that accounts for the diversity of students. Schools need to change the structure inside and outside the classroom so that more outreach programs can utilize the resources of the land and the expertise of the role models.
Given the daily challenges of the classroom, and the pressure to prepare students for large-scale assessments, many teachers are resistant to change. Teachers face a tension in teaching with culturally inclusive curricula and a pedagogy that meets the needs of their diverse students. To adjust for the pressures, a paradigm shift is needed in how mathematics is taught. Teachers need to rethink their practices, and their teaching should be creative, and imaginative. Student understanding of mathematical concepts is deepened and enhanced when students can see connections between what they are learning and what they are experiencing in their communities. From the connections they see in the classroom, students can begin making real-life connections that have personal relevance.

Classrooms need to be places where students can feel safe, welcome, and motivated to learn. In effectively differentiated classrooms, teachers should have a clear understanding about the community. If a teacher is knowledgeable and passionate about mathematics or about any subject they teach, they may be able to teach in a way that students can understand and find ways for relating the material to students, and motivating them at the same time. Having well-qualified math teachers who are mathematically competent and pedagogically proficient would be beneficial for all learners: Aboriginal and non-Aboriginal.

Stigler and Hiebert (1999, p.85-101) view teaching to be a cultural activity, like participating in a family dinner. They believe that it is learned through informal participation over long periods of time rather than studying it formally. They identify two reasons why cultural activities are difficult to change.
First, cultural activities are systems, and systems—especially complex ones, such as teaching—can be very difficult to change. The second reason is that cultural activities are embedded in a wider culture, often in ways not readily apparent to members of the culture. If we want to improve teaching, both its systemic and its cultural aspects must be recognized and addressed.

(Stigler and Hiebert, 1999, p. 97)

Stigler and Hiebert (1999) in The Teaching Gap argue that most efforts to improve education fail because they don’t have any impact on the quality of teaching inside the classroom. They also claim that there is no system in place to make things better, and it is teaching, not teachers, that must be changed.

Learning activities should build upon a student’s prior knowledge and present mathematics in an exciting and inclusive way. Egan (2006) uses the term ‘cognitive tools’, which he describes as features of our minds that shape the ways we make sense of the world around us. The challenge is to stimulate, use, and develop these tools so that the students are engaged in learning which inspires their imagination and creativity. The use of a story, metaphor, images, or binary opposites are some of the ways of capturing a student’s imagination. Context combined with content could direct teaching in the ongoing cultural quest for knowledge.

Epistemological Considerations

A finding that surprised me was that many of the role models and elders talked about the importance of the children learning and growing up in the two worldviews, Indigenous and Western; they wished their young people to seek knowledge from both worldviews, recognizing their interconnectedness. I expected that the interviewees would favor one worldview over the other. Many interviewees understood that they live in a
world which is constantly changing, where the children need to be grounded in the environment they live in and understand their traditional cultural activities, but at the same time have the knowledge and skills to able to function in an economically sustainable society.

There is a tension between maintaining culture and letting culture evolve. There is also tension about how school mathematics should connect with daily numeracy practices. Many Aboriginal communities feel that student performance in schools is usually measured with a different cultural lens. These artificial polarizations, however, should not distract us from what the elders and role models are calling for: to situate the learning in student’s own culture to help them learn, but also to help them measure up to school mathematics standards in order to succeed in the modern world.

Many Aboriginal students find themselves participating in two cultures – the culture of the home/community and the culture of the school. Students see little connection between the two cultures; hence many rich learning tasks from the community are lost in the school. This is particularly true in mathematics, where Aboriginal students feel alienated from the de-contextualized mathematics curriculum. Therefore, teaching mathematics with the use of authentically engaging situations and examples can help students attach meaning to the concepts that they learn in school mathematics.

In order for students to learn in dual epistemologies it would be helpful if the students could learn from the land with integration of cultural activities. For example, the concept of patterns could first be learned through button blankets or the collections of shells, and then with the use of pattern blocks or algebraic functions. The elders and role models talk about ‘what is’ on the basis of their lived experiences. On the other hand
many of the teachers talk about 'what should be' in part because many of them have been in the community for only a short period of time and have limited knowledge of the Aboriginal worldview.

As I started this study I was thinking of finding a merged or common epistemology, but now I conclude that there needs to be dual epistemologies. This does not mean, however, that these epistemologies cannot be brought into a productive relationship with each other. Figure 123 presents a framework that shows the connected features of each epistemology. I have chosen to use the metaphor of a Haida canoe\textsuperscript{6} as a means of visualizing the connectedness of the two worldviews in the learning of mathematics. In many Indigenous communities the canoe represents the whole community, where many people work together to build it and then use it. If you paddle the canoe only on one side it turns to the opposite side, but if you paddle on both sides then the canoe moves forward in the direction you want it to go. Paddling on both sides enables one to stay on course. Figure 123 below is a visual representation of the Haida canoe metaphor showing the interconnectedness between Indigenous and Modern epistemologies in the Learning of Mathematics.

\textsuperscript{6} In June 2007, CBC.CA conducted a media contest to choose Seven Wonders of Canada. A list of twenty five thousand nominees was shortened to fifty two and then the final seven were chosen. As the judges deliberated their choices to make their final list, it was intriguing to see that the seventh and final spot was a toss up between Haida Gwaii and The Canoe. Haida Gwaii is the place where the research for this study took place; the islands that are unparalleled in their wild beauty but also provide testimonials to the highly developed and ancient civilization of the Haida people. The Canoe was considered as an important historical link between the Aboriginal traditions, establishment of European culture and industry in Canada. It was also considered to be the most versatile and reliable mode of transportation in Canada. The judges chose The Canoe as their final choice which I have chosen as a visual to link the worldviews.
Figure 123. Visual Comparison of Indigenous and Modern epistemologies in the Learning of Mathematics with the metaphor of a Haida Canoe.
Since 2001, 31 of the 60 school districts in BC have signed Enhancement Agreements with their local Aboriginal community, with the intention to continually improve the quality of education achieved by all Aboriginal students. The Enhancement Agreements establishes a collaborative partnership between Aboriginal communities and school districts that involves shared decision-making and specific goal setting to meet the educational needs of Aboriginal students. Enhancement Agreements highlight the importance of academic performance and more importantly, stress the integral nature of Aboriginal traditional culture and languages to Aboriginal student development and success. Many Enhancement Agreements have a goal to improve the numeracy achievement at all levels of Aboriginal students. Some improvement has occurred, though it has been minimal. Almost without exception, the Enhancement Agreements are premised on incremental progress: that is, districts will continue doing what they already do, but try to do it better. What is really needed is a commitment to do things quite differently: to rethink what schools are trying to achieve, and how. This thesis is a contribution to that rethinking process. To consistently close the achievement and participation gap for Aboriginal students in mathematics in BC, the above mentioned recommendations need to be implemented. To do so, the beliefs, attitudes, and policy must be changed, through the effective use of resources, and with a sustained effort, over time.
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262


265
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268


270


Appendix 1: Ethical Approval

SIMON FRASER UNIVERSITY

OFFICE OF RESEARCH ETHICS

February 1, 2005

Kanwal Neel
Graduate Student
Faculty of Education
Simon Fraser University

Dear Kanwal:

Re: Learning and teaching numeracy among Aboriginal students in British Columbia with culturally inclusive curricula and pedagogy – Ref. #36678

I am pleased to inform you that the above referenced Request for Ethical Approval of Research has been approved on behalf of the Research Ethics Board. This approval is in effect until the end date of February 1, 2008.

Any changes in the procedures affecting interaction with human subjects should be reported to the Research Ethics Board. Significant changes will require the submission of a revised Request for Ethical Approval of Research. This approval is in effect only while you are a registered SFU student.

Your application has been categorized as 'minimal risk' and approved by the Director, Office of Research Ethics, on behalf of the Research Ethics Board in accordance with University policy R20.01, http://www.sfu.ca/policies/research/r20-01.htm. The Board reviews and may amend decisions or subsequent amendments made independently by the Director, Chair or Deputy Chair at its regular monthly meetings.

"Minimal risk" occurs when potential subjects can reasonably be expected to regard the probability and magnitude of possible harms incurred by participating in the research to be no greater than those encountered by the subject in those aspects of his or her everyday life that relate to the research.

Please note that it is the responsibility of the researcher, or the responsibility of the Student Supervisor if the researcher is a graduate student or undergraduate student, to maintain written or other forms of documented consent for a period of 1 year after the research has been completed.

Best wishes for success in this research.

Sincerely,

Dr. Hal Weinberg, Director
Office of Research Ethics

c: Dr. Peter Liljedahl, Supervisor

/\my
Appendix 2: Consent Form

Numeracy in Haida Gwaii: Community, Curriculum, and Pedagogy

Purpose of Research:
- Identify and document various forms of numeracy practices and mathematical thinking involved in community life in Haida Gwaii, particularly by participants of the Haida Role Model Program;
- Work with Haida Gwaii teachers to find ways of using this work to make mathematics school curriculum and pedagogy more meaningful for Aboriginal students;
- Explore the implications of this work for other attempts to increase the participation rate and achievement of Aboriginal students in high school mathematics.

Uses of Research:
The research will be conducted in collaboration with the Haida Education Division of School District # 50 (Haida Gwaii/Queen Charlotte), and the Haida Nation in accordance with the following principles:
- Interview transcripts will be revised in accordance with the wishes of the participants;
- All materials for publication will be reviewed through a process involving the Haida Education Division of School District # 50 (Haida Gwaii/Queen Charlotte), and the Haida Nation;
- Products from the research will include a doctoral thesis, and a book and/or a CD-ROM designed for use in the schools and communities of Haida Gwaii;
- Publications from the research will be made available in the public domain for the benefit of all learners.

Confidentiality:
All information will be kept strictly confidential. No one will be included in the study without his or her informed consent. All recordings and transcripts of interviews will be kept secure by the researcher and available only to the participants of that specific interview. Once reviewed and approved by the interviewee, portions of the transcript may be quoted in the body of the research paper. All field notes and photographs generated through observations will also be kept secure by the researcher and available only to the parties involved in the specific observation.
CONSENT FORM

Consent:
I understand that my participation in this study is strictly voluntary and that I may refuse to participate or may withdraw at any time up to publication of thesis, and where the results can be found.

I CONSENT to participate in the study as outlined on this form. I give permission to have my photograph appear in print or electronic media produced or published by the researcher.

I acknowledge that I have received a copy of this consent form for my own records.

Name of participant: (please print)

Address

Phone Number:

Email:

Signature of participant: ___________________________ Date: ___________________________

Witness: ___________________________
Appendix 3: Survey of IPTEM Students

SECTION 1: GENERAL INFORMATION

1. Name: (Include your traditional name if you wish.)

2. Preferred Pseudonym:

3. If Aboriginal, what is your ancestry?

4. Are you Female or Male?

5. What is your educational background?

6. What was the last Mathematics course you took in high school?

7. What was the last Mathematics course you took after high school?

8. Email address:

9. Phone:

SECTION 2: BELIEFS ABOUT LEARNING/TEACHING MATHEMATICS

Please put an (X) in the appropriate column based on your beliefs about learning and teaching mathematics.

<table>
<thead>
<tr>
<th>SA: Strongly Agree</th>
<th>A: Agree</th>
<th>N: Neither Agree or Disagree</th>
<th>D: Disagree</th>
<th>SD:</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

10. Society in general values the importance of mathematics to be learned in school.

11. The present content of the high school
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>12.</td>
<td>High school mathematics curriculum is meaningful for Aboriginal students.</td>
</tr>
<tr>
<td>13.</td>
<td>Mathematics curriculum can be connected to the Aboriginal culture of BC.</td>
</tr>
<tr>
<td>14.</td>
<td>Giving grade 10 students a choice of three pathways in mathematics (Principles, Applications, and Essentials) is a good idea.</td>
</tr>
<tr>
<td>15.</td>
<td>Aboriginal communities have a positive attitude towards mathematics.</td>
</tr>
<tr>
<td>16.</td>
<td>I learn best when my teacher lectures.</td>
</tr>
<tr>
<td>17.</td>
<td>I learn best when I like the teacher.</td>
</tr>
<tr>
<td>18.</td>
<td>I learn well when I get a chance to ask questions and discuss my thinking.</td>
</tr>
<tr>
<td>19.</td>
<td>I learn well when I get a chance to use hands-on materials such as manipulatives.</td>
</tr>
<tr>
<td>20.</td>
<td>I learn well when I am given lots of time to practice.</td>
</tr>
<tr>
<td>21.</td>
<td>I learn best when my teacher gives me step by step notes.</td>
</tr>
<tr>
<td>23.</td>
<td>Aboriginal students succeed in higher level mathematics.</td>
</tr>
<tr>
<td>24.</td>
<td>Universities and colleges offer transition mathematics courses to help Aboriginal students.</td>
</tr>
<tr>
<td>25.</td>
<td>Elementary teacher education</td>
</tr>
</tbody>
</table>
programs offer adequate courses in mathematics.

Thank you for taking the time to complete the Survey.
Appendix 4: Results of Survey of IPTEM Students

SECTION 2: BELIEFS ABOUT LEARNING/TEACHING MATHEMATICS
Survey given to IPTEM Students, SFU on February 11, 2005.
Sample Size: 14. Results rounded to the nearest percent

SA: Strongly Agree  A: Agree  N: Neither Agree or Disagree  D: Disagree  SD: Strongly Disagree

<table>
<thead>
<tr>
<th></th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
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<tbody>
<tr>
<td>10.</td>
<td>Society in general values the importance of mathematics to be learned in school.</td>
<td>57</td>
<td>29</td>
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<td>14</td>
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<tr>
<td>11.</td>
<td>The present content of the high school mathematics curriculum is appropriate.</td>
<td>7</td>
<td>29</td>
<td>36</td>
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<tr>
<td>12.</td>
<td>High school mathematics curriculum is meaningful for Aboriginal students.</td>
<td>0</td>
<td>14</td>
<td>57</td>
<td>22</td>
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<tr>
<td>13.</td>
<td>Mathematics curriculum can be connected to the Aboriginal culture of BC.</td>
<td>57</td>
<td>36</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>14.</td>
<td>Giving grade 10 students a choice of three pathways in mathematics (Principles, Applications, and Essentials) is a good idea.</td>
<td>14</td>
<td>29</td>
<td>36</td>
<td>7</td>
</tr>
<tr>
<td>15.</td>
<td>Aboriginal communities have a positive attitude towards mathematics.</td>
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<td>0</td>
<td>36</td>
<td>43</td>
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<tr>
<td>16.</td>
<td>I learn best when my teacher lectures.</td>
<td>7</td>
<td>7</td>
<td>50</td>
<td>7</td>
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<tr>
<td>17.</td>
<td>I learn best when I like the teacher.</td>
<td>64</td>
<td>36</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>18.</td>
<td>I learn well when I get a chance to ask questions and discuss my thinking.</td>
<td>71</td>
<td>22</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>19.</td>
<td>I learn well when I get a chance to use hands-on materials such as manipulatives.</td>
<td>71</td>
<td>22</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20.</td>
<td>I learn well when I am given lots of time to practice.</td>
<td>65</td>
<td>14</td>
<td>14</td>
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</tr>
<tr>
<td>21.</td>
<td>I learn best when my teacher gives me step by step notes.</td>
<td>64</td>
<td>22</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>22.</td>
<td>Parent's expectations influence a student's success in mathematics.</td>
<td>29</td>
<td>29</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>23.</td>
<td>Aboriginal students succeed in higher level mathematics.</td>
<td>7</td>
<td>7</td>
<td>64</td>
<td>22</td>
</tr>
<tr>
<td>24.</td>
<td>Universities and colleges offer transition mathematics courses to help Aboriginal students.</td>
<td>0</td>
<td>22</td>
<td>57</td>
<td>7</td>
</tr>
<tr>
<td>25.</td>
<td>Elementary teacher education programs offer adequate courses in mathematics.</td>
<td>0</td>
<td>36</td>
<td>43</td>
<td>14</td>
</tr>
</tbody>
</table>
Appendix 5: Interview Questions used in Haida Gwaii

Elders, Role models and Community members:

1. You have become very successful in what you do. Is there a central experience (or set of experiences), a motivating person (or persons), a specific disposition or world view that you would consider as instrumental in guiding or motivating your success?
2. How do community members develop their mathematical abilities/skills, and how would they advocate teaching them to others?
3. What type of education about Aboriginal communities should teachers of mathematics receive?
4. How is mathematics viewed within the Aboriginal community?
5. How do you think school can make mathematics more meaningful for Aboriginal students?
6. How can societal attitudes towards math be changed?
7. As you know there are many challenges facing Aboriginal students to succeed in higher level mathematics today. In your opinion, what are the top three issues facing Aboriginal students?
8. Can you tell me a story from your life that exemplifies what you say in your answer to the above questions?
9. Is an understanding of any of the following important to your life in Haida Gwaii? If so, please explain how. Number or quantity; Patterns, Shape and space; Probability and frequency, or Logical reasoning

Teachers:

1. What strategies/ideas/methods do you think work in the learning/teaching of mathematics to Aboriginal students?
2. How can school mathematics curriculum be made more meaningful for Aboriginal students?
3. What math ideas/concepts do you think should be taught that value and honour the Aboriginal world view?
4. As you know there are many challenges facing Aboriginal students to succeed in higher level mathematics today. In your opinion, what are the top three issues facing Aboriginal students?
5. Is it possible to separate the challenges of learning and teaching mathematics in the Aboriginal community from those encountered for other disciplines?
6. Do you have any other insights that you would like to share with me that would allow me to move closer to an understanding of the best way to increase participation and performance of Aboriginal students in mathematics?
7. How can example of mathematics embedded in community life be used to teach school mathematics curriculum?
8. What type of education about Aboriginal communities should teachers of mathematics receive?
Appendix 6: Survey emailed to aboriginal role models across Canada

Dear,

I am a doctoral student working on my dissertation in mathematics education at Simon Fraser University, BC and I am asking for your help. I got your contact info by searching the internet for role models who are of Canadian aboriginal ancestry and have been successful in mathematics. A central question in my research is: How can the participation rate and achievement of Aboriginal students increase in high school mathematics? One group that I am asking this question is to role models like you. I am hoping that the details that lie within the story of your success can help me to answer my research question. As such, I am deeply interested in the stories that make up the fiber of your successful mathematical life. In particular, I am interested in:

1. What are your thoughts about your own success?
2. How did YOU become successful in mathematics? Is there a central experience (or set of experiences), a motivating person (or persons), a specific disposition or world view that you would consider as instrumental in guiding or motivating your success?
3. Can you tell me a story from your life that exemplifies what you say in your answer to the above questions?

Aside from my interest in your mathematical success, I am also interested in your views about what it takes for Aboriginal students to be successful. In particular, I am interested in:

1. What strategies/ideas/methods do you think work in the learning/teaching of mathematics to Aboriginal students?
2. How do you think school can make mathematics more meaningful for Aboriginal students?
3. What math ideas/concepts do you think should be taught that value and honour the Aboriginal world view?
4. As you know there are many challenges facing Aboriginal students to succeed in higher level mathematics today. In your opinion, what are the top three issues facing Aboriginal students?
5. Do you have any other insights that you would like to share with me that would allow me to move closer to an understanding of the best way to increase participation and performance of Aboriginal students in mathematics?
6. Finally, do you have a story about yourself, or about a former classmate, that you can share with me that exemplifies your responses to any of the above questions?

I would greatly value your thoughts on these nine questions, but responses to any of the nine would be greatly appreciated.

I would also appreciate if you can suggest the names of other engineers, scientists, and professionals of Aboriginal ancestry that I should contact who have been successful in mathematics.
Appendix 7: Field Notes

A Day in Queen Charlotte/ Skidegate

The day started at 8:30 am at the School Board office with a review meeting of the interviews scheduled for the day with Vonnie Hutchingson, Director of Haida education, and her assistant, Lisa Shoop. My first appointment was at 10:00 am at the board office with Anissa Davis, a recent graduate of Queen Charlotte city who was now working as a nurse at the Health centre in Skidegate. As we were ending our meeting, close to 8:45, Danny Robertson, the coordinator of the Rediscover program at Swan Bay came in with his baby daughter. He and his wife Nika could not arrange for daycare that morning due to a variety of circumstances. As Danny started to make some phone calls I volunteered to take care of his daughter for a few minutes while he completed his tasks. I had met Danny, Nika and their daughter a few days earlier when I visited their house to do an interview with Nika, hence the daughter readily came to me. We went out for about half an hour looking at the birds, touching the flowers, climbing the stairs, and of course counting the cars on the road. Just a little before ten, Danny had completed making the phone calls and he came to get his daughter from me. I now just had a few minutes to get ready for the interview.

Anissa arrived at ten with her 4 year old daughter. The interview lasted for about twenty minutes, during which time her daughter kept herself busy drawing and reading. In the interview I asked a range of questions to Anissa which she answered thoughtfully and passionately. Her responses reflected her multiple roles as a nurse and a parent. Parts of the transcript of her interview are included in a later chapter.
I decided to leave a little early for my noon appointment at Sk’aadgaa Naay Elementary school and return the photographs at the Haida Heritage Centre at Qay’Ílnagaay, which I had borrowed earlier. Since I didn’t have a car I borrowed Vonnie’s minivan, which I had borrowed on many other occasions to do my interviews in Skidegate and Queen Charlotte village. I returned the photographs to Natalie Macfarlane, Director of the museum and headed up the hill to the school near Skidegate. On the way I saw Sid’s truck parked in front of a house being constructed. Sid Crosby had graduated from the local high school and I was told that he would be an interesting person to interview as he was a carpenter and used math in his work. I had been trying to catch up with him to conduct an interview for a few days, but our timing was always off. So, I thought I better use this opportunity to do my interview on the spot. It was a short but informative interview, he and his apprentice Morgan Brookes talked about how they both learned the math a lot quicker once they needed it for their job. They were both motivated to do well for their journeyman’s ticket which was different from when they were learning math in school. After the short interview Sid suggested that I see a friend of his who is carving a thirty foot totem pole. Finding a specific house is a challenge as many houses don’t have numbers and one has to rely on accurate description. Sid said that Ben is carving in a big house on the left side of the main highway to Tlell and there will be a blue truck parked outside. I thanked him for the tip and wondered if it would be worth my time to see this fellow Ben, and see if I can make some mathematical links to him carving a pole.

I headed up the hill to Sk’aadgaa Naay Elementary school. The Haida name for the school translates to “House of Learning.” Lunch had just started, so I waited for a
few minutes before Vicki Ives was free to sit down with me. I admired the architecture of the school, integrating the modern cement posts and traditional use of wood post and beam structure like a longhouse. Vicki and I found a quite corner for the interview. Though she was a member of the LUCID project she was challenged in finding culturally relevant materials for her math classes. I agreed to email her some articles and a list of references. She had been on the island for a few years teaching at the elementary school but wasn't sure what could be done for the students who were having difficulty in grade 8 or 9 math. I now had a couple of hours before my next scheduled interview so I decided to go search for “Ben”.

To my surprise, I had only gone about a kilometer down the highway when I spotted a blue truck parked outside a big house. I took my back pack containing business cards, consent forms, audio recorder and digital camera and walked into the house. I introduced myself and told Ben how I found him and if he would be willing to do a short interview. I was delighted when Ben agreed to the impromptu interview and was pleasantly surprised to learn that Ben was the son of world renowned Haida artist and carver Robert Davidson. Ben kept carving as I asked him questions and snapped pictures with my digital camera. He was very articulate in explaining the mathematical concepts of: proportions, symmetry, and estimation he used in his carving. Some of the transcript and pictures from the interview are included in a later chapter. The pole had been commissioned by a businessman for a resort in Puerto Vallarta, Mexico, and was anticipated to be completed by the first of September. As I thanked Ben he suggested that I should drop by the carving shed in Skidegate and check out the traditional canoes. I
felt very fortunate to have been at the right place at the right time and to have met people who believed in what I was doing and were willing to be interviewed.

As I drove to the carving shed I kept wondering if these interviews and the people I met were not coincidences, but were meant to be. As I walked into the carving shed I was in total awe of the traditionally carved Haida canoe. Shane Collision was the guide on duty and he explained how the canoes and the paddles were made in the old days and how the art is still carried out today. Accurate measurements up to one sixteenth of an inch could be seen at different parts of the canoe. The proportionality of the paddle to the paddlers’ body was also explained. This is explained in detail in a later chapter.

My last scheduled appointment for the day was with Diane Brown, Program Director of SHIP (Skidegate Haida Immersion Program). In our brief interview she explained how the program was keeping the Haida language alive by recording elders in the daytime and teaching children and young adults in the evening. She briefly explained the significance of certain Haida numbers and how their numbering system was base ten.

After the conclusion of my last interview I headed to the school board office to return Vonnie her minivan and debrief my day. We talked about how I had managed to do six interviews, three scheduled and three unscheduled. How I was able to access some of the interviewees through word of mouth. We brainstormed ideas on how some of the young artists could be encouraged to be part of the School District’s Role Model program and how there also needs to be some alternate program for students who were not academically inclined but needed the basic numeracy skills to pursue a trade or a career. Such a program could teach the curriculum from the cultural context of where the students live.
This was an extraordinary day in terms of the number of people I met and the caliber of the interviews. Not all days were like this, there were some days when the interviews were canceled at the last minute or the interviewee had very little to say. This day ended like most other research days. After dinner I downloaded the digital audio files and the digital images onto my laptop computer. Then the audio files were uploaded and emailed to be transcribed and the digital images were sorted into folders for easy accessibility at a later time.

**A Day in Masset**

Though the day I have chosen to write about for this part is the 16th of June, I will talk about a couple of days prior to this day to provide some context. As I was returning to Haida Gwaii on the 12th for my next set of my interviews in the Northern part of the islands in Masset, I met Ben Davidson at the Vancouver airport. He was the carver I had interviewed during my previous trip in Skidegate. Ben told me that his uncle, Reg Davidson had carved a forty foot pole in Old Masset and it would be moved on the 14th. I thought this would be a great photo opportunity and also see if I could interview Reg to get his insights on how he used math in carving a pole and what would be the mathematical principles involved in moving a twenty ton piece of art.

I changed my travel plans and headed up to Masset on the 13th in anticipation of the pole being moved the next day. On the morning of the 14th during breakfast at Nonnie's Bed and Breakfast, where I was staying, I mentioned about the pole being moved to Sam Davis Jr., my host. Since Haida Gwaii is a small community, most of the Haida people are related in one way or another, Sam told me that he was related to Reg
and would make a phone call to see what time the pole was going to be moved. He phoned Reg, but there was no answer. Sam gave me Reg’s address and thought it might be a good idea for me to drop by the house just in case Reg was not picking up the phone. I went to the house and knocked on the door but there was no answer.

So, for the next few days as I went on doing my interviews I would always drive by Reg’s house to see if anyone was there. Finally, on the morning of the 16th as I was heading for my morning interview I saw a number of cars in front of the house. I knocked on the door and someone shouted “Come on in”. I went in and there were a number of people sitting around the dining table sipping coffee while a gentleman was near the kitchen sink slicing salmon. I instantly recognized the gentleman to be Reg, from the many pictures I had seen of him. I quickly introduced myself, and said that I was doing research to see how aboriginal students can do better in math, and if he would have some time to do an interview. A young man at the table jokingly said “that’s easy, you just talk about money. Like, it will cost you $100 an hour for the interview...since you are on band property we won’t even charge you tax”. Everyone burst out laughing and I had a feeling that I might be able to set up a meeting time with Reg. Reg had been out fishing for the past couple of days and he had just returned late the previous night and was busily slicing salmon to be dried and smoked. I was starting to understand the rhythm of the “island time” a little better. Time was not run by the clock, but the environment dictated it. When the salmon run starts, they all leave their “land” jobs or chores to catch the fish. Reg asked me to call him after lunch and said he may be able to do an interview in the afternoon.
I drove off to see my first appointment, Wilson Brown who was a carver and boat builder. Wilson didn’t live far from Reg’s house so I was there in a couple of minutes. I rang the door bell and Wilson answered. He said that today was not a good day but come back next Tuesday in the afternoon. I wasn’t sure if Wilson didn’t want to be interviewed, but I had to respect his decision. Having a little bit of time on hand I headed to see the district track meet at Tahagen elementary school. Students from all the elementary schools on the island competed in various events on a grass track. After that I went to the George M. Dawson Secondary School where I checked my email as there was no internet connection at the Bed and Breakfast I was staying at. After lunchtime, around 1:00 pm I called Reg and managed to get an interview time with him for 2:45 pm. In the meantime, Kim Madore, the math teacher had arranged for me to interview a couple of students from her Principles of Math 12 class. I met the students after lunch and they were quite articulate and self-motivated. They talked about their personal experiences and some of the pressing issues their peers were facing.

At 2:42 pm I arrived at Reg’s house, he was on the phone and he signaled me to open the sliding door and sit on the couch. As soon as he got off the phone he said “I am impressed you are on time.” I guess I hadn’t totally adapted to “island time”. I thanked him for his time and we started the interview. The interview lasted about twenty minutes, where I asked him a variety of questions, and some of his responses are included in a later chapter on results. I also asked him when the totem pole was going to be moved. He explained that the pole had to be moved on to a flat bed truck, and then the same truck has to be shipped to England, which was the pole’s final destination. He also explained
that the moving company was having a difficult time finding a truck, hence, the move of
the pole might be delayed for a few weeks.

In the evening, Haida Graduation ceremony took place. This was a community
event where all the graduates of Haida ancestry (grade 7, grade 12, and post secondary)
are recognized. The evening started at 5:00 pm at the Old Masset Community Hall,
where graduates and their family and friends started to arrive. Sixteen teachers were in
attendance, and I sat at a table with them. Each family group, including the group of
teachers, brought their own food and had a pot luck dinner at their own tables. Some
families really went all out, with table cloths, cloth napkins, fine china, and fancy cutlery.
There were about thirty long tables in total and the room was decorated with black and
red balloons and streamers.

The formal part of the evening started with graduates being introduced to the
audience. Each student walked across the platform escorted either by their Nonnie
(maternal grandmother), uncle, aunt, or other relative. Each Grade 7 student was
presented with a crested vest which was made by members of their family. Each of the
grade 12 graduates was presented with a button blanket, made by members of the family.
Each blanket was unique, depicting various colors and designs incorporating the crest of
the clan. As the graduate walked on the platform, they were presented and draped with
the blanket by their parents or uncle or aunt. In most cases the graduates were also given
a Haida name which was read and explained by their Nonnie. The evening was a very
significant event for the high school graduates, this is similar to the coming of age
celebrated in many other cultures. A couple of university graduates were also presented
with a button blanket acknowledging their accomplishments.
After all the students had received their blankets, some of the parents sang and played their drums to the beat of the celebration song. With the beat of the drums and the singing in the background all the male students did a celebration dance which was followed by the females doing a dance. The evening ended with all the graduates dancing together with many people taking photographs. You could see the pride in the eyes of the parents, grandparents and other family members as they hugged and congratulated the graduates.

As I left the ceremony that evening, I sensed the strong feeling of pride by the parents and the extended families. I could see the joy in the smiles and eyes of the graduates. As some of the teachers from the school were acknowledged and recognized in the ceremony, their feelings were visible with their tears of joy. As I reflected on the evening, I wondered how many of the high school graduates had been successful in mathematics and would be able to follow their dream of pursuing post secondary education.
Appendix 8: Bentwood Box Activity

**TITLE:** Largest Bentwood Box

**SENSE:** Spatial and Number

**PROCESSES:** Reasoning, Connecting, Estimating, Visualizing, and Technology

**EQUIPMENT:** A Bentwood Box, Scissors, Glue, Calculator, colored pens

**GRADE LEVEL:** Middle School / High School

**DESCRIPTION:**

**Part 1**
- show the students a Bentwood box and give them the background information
- give a sheet of grid paper 20 cm by 16 cm to each group of 4 students
- assign each group to make a unique box with different dimensions
- each unique box has four sides, a bottom and a top
- compare the boxes and discuss which box has the largest volume
- discuss the advantages and disadvantages of each box

**Part 2**
- in the second part allow students to cut and paste the sheet to make their largest box (volume) by guess and check
- the sides of each box should be made from a single sheet of paper
- make sure the students do their calculations before cutting the grid paper
- the only restriction for the box is that it is a rectangular prism with length, width and height, and you can only use the sheet of grid paper 20 cm. by 16 cm.
- the dimensions of the box do not have to be integers

**Part 3**
- in the third part students draw a unique design on each side of the box (preferably an aboriginal design)
- color the design

**COMMENTS:**
- this problem can be extended to include other shapes.
- another extension is to give the students a sheet of 8.5 by 11 paper and ask them to wrap as many unifix cubes as they can in the sheet.

**LINKS:**
- investigate bentwood boxes from the Northwest and look at their similarities and differences
- simulates a real-world environmental problem, where a company has to use numeracy skills to figure out the optimal box, which will give the maximum volume with a certain surface area.
- informed consumer choices, labeling regulations, airline carry-on baggage dimension restrictions, spatial awareness, optimization for packaging
Appendix 9: Activities

Activity 1: Imaginative Story

TITLE: Imaginative story

GRADE LEVEL: 6-9

LEARNING OUTCOMES: It is expected that students will activate prior knowledge and make connection between mathematics and artistic endeavors of Indigenous artifacts, particularly Haida, Coast Salish or Navajo blankets.

PROCESSES: Communication, Connections, Reasoning, Representation, and Visualization

MATERIALS NEEDED: A Haida, Coast Salish or Navajo blanket, if it is not available provide a photograph, paper and pencil.

ESTIMATED TIME: 20-30 minutes

DESCRIPTION: Students are to use their imagination and write a story, song or poem that is central to the artifact (blanket). Folk tales and legends make great stories, but almost any story that a student likes or finds meaningful can be told. The writing should leave a lasting emotional or affective impression on the reader, and also make the reader interested in the artifact. Storytelling forms the foundation for much traditional Indigenous learning and teaching. Through the process of telling stories, skills in listening, thinking and imagining are creatively nurtured.

COMMENTS: If students have difficulty in writing an imaginative story then ask them do one of the following: 1) Describe the blanket using mathematical terms such as: symmetry, pattern, triangle, square, rectangle, quadrilateral, rhombus, line, reflect, rotate, and measure. Or 2) complete the questionnaire about the blanket.

ATTACHMENTS: Black Line master of images of blankets and activity.

EXTENSION: Invite an elder, a weaver or a community member to the class and ask them to bring along their Coast Salish blanket. They can show the blanket and tell their story about it. Students could also have an opportunity to ask questions.

QUESTIONNAIRE: Describe the blanket. What is special about it? What is the function of such a blanket? How was the blanket made? Where else in the world would you find blankets similar to this one? What is the mathematics behind the blanket? What questions do you have about the blanket?
ACTIVITY: Imaginative story

Haida Button blankets

Salish Flying Geese Blanket by Krista Point  Navajo Blanket
Activity 2: Identifying Shapes

TITLE: Identifying shapes, symmetry and pattern analysis.

GRADE LEVEL: 7-8

LEARNING OUTCOMES: It is expected that students will identify the different shapes, patterns, lines of symmetry and recognize reflection (flips) in the blanket.

PROCESSES: Communication, Connections, Reasoning, Representation, Problem Solving, and Visualization

MATERIALS NEEDED: A picture of a Button blanket, ruler, paper and pencil.

ESTIMATED TIME: 10 minutes

DESCRIPTION: Ask the students to look at unique patterns within the blanket and identify the different shapes and colors. The ask them to identify bilateral symmetry, or mirror-symmetry. A reflection flips all the points in the plane over a line, which is called the mirror. A reflection changes the sense of figures in the plane. A figure with bilateral symmetry or reflection looks the same on both sides of a line except that the two sides of the figure are mirror images of each other. Identify: a) pattern with a vertical line of symmetry, b) pattern with a horizontal line of symmetry, c) pattern with more than one line of symmetry.

COMMENTS: Lines of symmetry can also be demonstrated using paper folding, Mira (see through mirror), or grid paper.

EXTENSION: Ask the students to bring artifacts other than blankets that represent reflection, symmetry, and patterns.

SOURCE: http://www.bced.gov.bc.ca/irp/mathk7/_7sastr.htm
Activity 3: Creating a blanket design

TITLE: Creating a blanket design

GRADE LEVEL: 7-9

LEARNING OUTCOMES: It is expected that students will create their own blanket design that would include a variety of Frieze patterns and transformations.

PROCESSES: Communication, Connections, Reasoning, Representation, and Visualization

MATERIALS NEEDED: A grid paper, ruler and colored pencils.

ESTIMATED TIME: 30-40 minutes

DESCRIPTION: Show the students a variety of Haida Button, Coast Salish and Navajo blankets and ask them to create a blanket design of their own. The design should include each of the following: reflection, rotation, translation, and glide-reflection symmetry. Upon completing, ask them to complete the reflection questions.

COMMENTS: Ask students to make a draft copy before coloring the final design.

ATTACHMENTS: Black Line master of sample blankets and activity sheet.

EXTENSION: Invite an elder, a weaver or a community member to the class who can actually show the students how to weave blanket. If possible, get the students to actually weave a small patterned blanket.

REFLECTION: What colors did you use in your design and why?
How do the colors repeat?
What are the major shapes you used?
What Frieze patterns did you use?
Which transformations did you use in your blanket?
What is the visual effect of your balanced and symmetrical pattern?
In what ways is this pattern reflective of yourself and your place in the world?
What do you like best about your blanket pattern or design?
How is creating a blanket similar to problem solving?

What might you do differently next time?
ACTIVITY: Creating blanket design
Name: _______________________

Create a colored blanket design that includes each of the following: reflection, rotation, translation, and glide-reflection symmetry.