

Math in Tlingit Art:

A Culture-Based Technology and Mathematics Project for K-12 Classrooms in Southeast Alaska

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Abstract

Math in Tlingit Art project merges Tlingit basketry with Mathematics and Technology. The study of baskets incorporates Tlingit language for designs, weaving techniques, and materials. LOGO is user-friendly computer programming language designed for classrooms. Basket designs are used as LOGO projects. The students are using Mathematics to navigate the turtle about the computer screen. Repeated patterns are created in LOGO procedures to be used in super procedures to generate the total pattern on the monitor screen. Students explore issue of shapes, patterns, angle turns, distance, and symmetry.

The Third International Mathematics and Science Study (2000) has created a new wave in mathematics education to upgrade the mathematics skills of K-12 students throughout the US. Alaska has joined this effort and instituted Benchmark Exams for grades 3, 6, & 8 and High School Qualifying Exam for 10th grade students. These exams are used to measure the effectiveness of curriculum and instruction and provide individual school ratings. (Perfection Learning Corp., 2002) After comparing the Benchmark Exam scores of 2000 and 2001, the Commissioner of the Department of Education and Early Development (DEED), Shirley Holloway, was encouraged by the slight increase in test scores and felt Alaska education is moving in the right direction, but express concerns over the scores of Alaskan Native students. Holloway said: “While the percentage of Native students performing at the proficient and advanced levels has grown, the learning gap is still there. To eliminate the learning gap will require a deep commitment from all of us – parents, teachers, school board members, policy makers, businesses, everybody.” (Holloway, 2002, Pg. 2)

Reviewing the data from the 2001 Benchmark Exams reveals 30% – 35% achievement gap for Alaskan Natives below White students in the scores for grades 3, 6, and 8. However, both White and Alaskan Native students are declining in mathematics achievement as they progress from grades 3 to 8. (Holloway, 2002)

Grade	Ethnicity	Advance/ Proficient	Below/Not Proficient	Ethnicity	Advance/ Proficient	Below/Not Proficient
3	AK Native	49.7%	50.3%	White	81.1%	18.8%
6	AK Native	39.4%	60.6%	White	75.9%	24.1%
8	AK Native	20.0%	80.0%	White	50.4%	49.6%

Does this decline continue though high school? Looking at these declining percentages what percent of Alaskan Native students will pass the High School Graduation Exam and receive

high school diplomas? It time for some serious interventions in mathematics education for Alaskan students.

In 1994 Herb Clemens of University of Utah Mathematics Department and Claudette Bradley (currently Claudette Engblom-Bradley) designed the “Ndahoo’ aah program at Monument Valley High School in Utah for Navajo students. The program employed 4 Navajo elders, who were rug weavers, loom beadwork makers and coil basket makers. Navajo students learn to weave the crafts under the careful mentoring of the elders. The elders spoke Navajo to the students while explaining the details of weaving, telling Navajo folk tales of weavers and their personal stories of learning to weave. (Rickenbrode, 1995 – 2000) The students learned the designs in the crafts and reproduced them on paper to bring them into the LOGO Lab and program the designs on the computer. LOGO is a user friendly, computing language designed to be compatible with human learning. In the LOGO lab the students learned to navigate the turtle about the monitor screen typing procedures and creating new procedures for the turtle to learn. (Bradley, 1993; LOGO Foundation, 2000) As students use mathematics to plan their designs and navigate the turtle on the monitor screen, they are discovering new mathematical ideas and reinforcing the ideas they already have. The ‘Ndahoo’ aah program operated for 3 1/2 weeks every summer for 6 consecutive summers. It engaged community members of all ages in school events, increased the number of computer labs, and inspired a growth in the school’s bilingual programs offered to Monument Valley High School students. (Rickenbrode II, 1995-2000; Engblom-Bradley & Reyes, 2004)

Andy Hope was the Southeast Alaska Coordinator for Alaska Rural Systemic Initiative. He and Claudette Engblom-Bradley decided to develop a similar program in Juneau, Alaska with the hope to impact both interest and skills in mathematics for Native students. Andy knew

Tlingit weavers and linguists and negotiated with the Chatham School District and Juneau School District to send and financially supports teachers to a summer workshop. That would provide the weaving and LOGO computing instruction for the teachers. In exchange the teachers would develop mathematics curriculum for their students that would involve weaving and LOGO programming of Tlingit basket designs. Teri Rofkar provided the weaving instruction and Claudette Engblom-Bradley provided the LOGO instruction. We started with four teachers from Chatham School District and four from Juneau School District, who enrolled in a graduate level course, designed for the project, which was entitled, Math in Tlingit Art. (Fry, 2003; Hope, 2003)

Tlingit people live in Southeast Alaska from Ketchikan to Yakutat Bay. Their baskets are made of split spruce root with false embroidery designs (Cory, 1995). The designs are generally geometric patterns that repeat around the side of their cylinder shapes. The designs have red, black, grey and vanilla colors against the natural tan fibers of the spruce root. They are woven with dyed wefts over horizontal bands. The right angle shapes are ideal for beginning LOGO projects. Students readily experience less confusion in creating right angle shapes for the exterior angle and interior angles are both 90 degrees.

This program was blend of Native culture regarding basketry with Mathematics and technology for the k-9 classroom. The teacher had the option of inviting a weaver to teach the children weaving and share the stories and cultural knowledge surrounding baskets, or the students could explore the cultural aspects of basketry through resources, like the Internet, or school Library. The Alaska Native Knowledge Network has compiled many resources for this project to provide easy access for teachers. (ANKN, 2004; Hope, 2003)

Teri Rofkar is a recognized weaver, who has sold her work since 1986. As a museum

employee of Sitka Museum, Sitka, Alaska, she studies and weaves Tlingit baskets, Chilkat Blankets and Raven's Tail. She is from the Raven Clan in the Snail House. Her Tlingit name is Chas' Koowu Tla'a from the T'ak dein taan Clan. Her lineage goes back a thousand years along the Northwest Pacific coast of Alaska. She visits the trees, which have are also thousands of years old and have known her ancestors. Spirits of the trees share their wisdom and provide Teri with comfort and strength to continue her weaving. "My weavings are a reflection of an ancient relationship rekindled." (Rofkar, 2000)

Chilkat Blankets are woven with the patterns of the Tlingit totem poles. They are woven in secret and presented as an entity with a spirit of its own. The blanket dances and needs the sounds of the singers and the surroundings of the mountains and ocean waters to nourish its spirit. (Chilkat, 2004)

Raven's Tail is a woven blanket or skirt. The weave is similar to the spruce root baskets. The yarn hangs down and the weave controls the tension. The weaver generally takes one hour to weave one row, making the task of weaving a Raven's tail blanket 600 to 2000 hours to weave the entire blanket. The geometrical patterns woven into the blanket tells a story, just like a totem. (Rofkar, 2004)

Teri Rofkar introduced the splitting of spruce roots with packages of string cheese. Students could practice splitting spruce roots by splitting string cheese along with Teri. The 8 students were teachers from the Juneau and Chatham School Districts in Southeast, Alaska. Two linguists, Dr. Richard Dauenhauer and Nora Dauenhauer and one faculty member of UAA, Dr. Claudette Engblom-Bradley participated as students to learn to weave. Teri brought materials that were easier to gather and appropriate for K-9 students to learn weaving skills. The participants received Yogurt cups and yarn. Under Teri's direction the cylinder side of yogurt

cups were cut vertically towards the bottom circular edge. To insure the spacing between the vertical cuts was uniform. The cylinder side was cut into equal halves. The halves were cut into equal halves yielding four sections. Each fourth was cut in half yielding eight sections. Each section was cut in half yielding 16 equal sections. The sections were wefts for the yogurt-yarn basket. The yogurt could lie flat on the table with 16 spider legs surrounding the circular base.

Teri carefully began the weaving with the 36 “ yarn string. The participants followed Teri’s instructions; wrapping the yarn around a weft at the circular base of their yogurt cup and started the weaving two strains of yarn. The strain in front is wrapped over the strain from behind the weft and behind the next weft. This weave is repeated and the yarn strains spiral up the sides of the wefts to complete a basket. At some point the weaver switches colors of yarn to insert a pattern in the basket.

When the teachers completed a yarn-yogurt-cup basket, they began a yarn-pipe-cleaner basket. Pipe cleaners allowed them to begin a basket with the interlocking weave used by Tlingit basket makers. The basket bottom began with 8 pipe cleaners placing 4 vertical and 4 horizontal. One vertical pipe cleaner was woven over-under-over-under the 4 horizontal pipe cleaners; the next was woven under-over-under-over and the third and fourth pipe cleaners repeated this weave. The 16 pipe cleaner ends formed a weft for the basket. The yarn was wrapped around one weft and woven around the 16 wefts forming a circular base for the basket. The basket maker had to be careful to adjust the tension to keep the base flat and to tighten the tension when the basket was to curve upward and become the side of the basket.

The yarn-pipe-cleaner baskets were harder to control the tension. Some baskets curved inward giving the basket a hyperbolic shape. The wefts would bend and twist like spider legs.

The teachers would wonder how this unruly object would ever become a basket. The baskets were completed and everyone was satisfied with their works of art.

Lori Hoover of Riverbend Elementary in Juneau, Alaska, teaches 2nd/3rd grade students. “We have been doing some pre- learning of skills before going to the software. We have spent time on symmetry and reinforcing vocabulary needed.” (Hoover, 2003, p. 1) Using colorful construction paper her students traced and cut multiple copies of the letters in their first name. For horizontal line symmetry they glued the letters on black construction paper, then glued a second copy of each letter below the matching letter and upside down to form a lake view mirror image of their name. For vertical line symmetry they glued the second copy of each letter in reverse order continuing from left to right. For rotational symmetry they glued four copies of their name clockwise at 90-degree angles of the previous copy.

Using The National Library of Virtual Manipulatives via Internet the Lori’s created colorful Pattern Blocks symmetric patterns. The students copied their virtual patterns with pattern block stickers on construction paper. They found this activity to be satisfying and reinforced their notions of symmetry. (Hoover, 2003)

The student explored symmetry in Tlingit designs along with their cultural meaning. The Backbone resembled the backbone of a salmon. The spinal center was the horizontal line of symmetry with slanted parallel rib bones reflecting on both sides of the spinal center. Butterfly in Flight pattern is a glide-reflection, side-view image. The wings are up, then flip down, then up, then down, and so on. The on-looker must image the butterfly flying. The Eye is a rhombus with a vertical and horizontal line of symmetry, which is also the diagonal of the rhombus. (Hoover, 2003)

The original robotic turtle was a 15-inch diameter clear plastic hemisphere with two 4-inch wheels on opposite sides. The electronic mechanism inside the hemisphere was visible with a wire connection to a mainframe computer. A felt-tip pen was inserted in the bottom center of the turtle to draw on the butcher paper beneath it. The user operated the turtle with a button box. Pressing Forward 30 moved the turtle forward 30 turtle steps. Pressing Right Turn 90 turned the turtle 90 degrees in the clockwise direction. Repeating these two procedures 4 times would cause the turtle to draw a square on the butcher paper beneath it. The user could press four additional buttons: Pen Up, Pen Down, Left Turn #, and Back #. With the 6 basic procedures the user navigated the turtle about the butcher paper causing the turtle to draw geometric shapes and lines if the pen was down or causing the turtle to move about the screen if the pen was up. Users could organize games or mazes by placing wooden obstacles on the butcher paper and planning to navigate the turtle to avoid knocking down the obstacles. (LOGO, 2003)

In 1975 the turtle was placed on a monitor screen. Its Home position is the center of the screen. The user types:

- FD 50 for Forward 50,
- BK 40 for Back 40,
- RT 60 for Right Turn 60 degrees clockwise,
- LT 60 for Left Turn 60 degrees counterclockwise,
- PU for Pen Up,
- PD for Pen Down, and
- Home to return the turtle to the Home position in the center of the screen.

These procedures allow the user to navigate the turtle about the monitor screen. (LOGO, 2003)

Lori's students needed to relate to the turtle. They simulated turtle behavior by playing Blind-Fold Turtle and Dinosaur Turtle. Safe obstacles are placed on the classroom floor. A student is blind folded; another student tells the blindfolded student how to move with LOGO procedures to the opposite side of the room without bumping into the obstacles. New versions of

Blind-Fold Turtle evolved. Two or more students are blind folded and take turns receiving procedures how to move across the room without bumping into obstacles nor each other.

Dinosaur Turtle required two players with Square Inch grid paper. Each player has a dinosaur figure to move about the grid. Students read LOGO procedures on a card and move their dinosaur accordingly. The first to reach the other side of the board is the winner. (Hoover, 2003)

Students are ready for LOGO programming. Their first project is to teach the turtle to make a square. They are ready to tell the turtle to move Forward 50 Right turn 90 and repeat these two procedures three more times. The turtle makes a closed figure, known as a Square. To write the 8 procedures each time the user wants the turtle to make a Square is labor intensive. They learn to make Square a procedure. In the procedure page the students introduce a new procedure with the word TO, followed by the procedure's name SQUARE. In the next line the students type the 8 procedures needed to make a square followed by END. They return to the workspace and each time they want a turtle to make a square they simply type SQUARE. The turtle has learned a new word.

The user can use square to make designs. A flag is a line plus a square. The user types FD 50 SQUARE, presses <return> and the turtle draws a vertical line and square. Three horizontal squares are constructed by rotating the turtle 90 degrees, drawing a square, moving the turtle forward 50, drawing a square, moving the turtle forward 50 and drawing a square. Four diamonds inside a diamond is constructed by rotating the turtle 45 degrees, drawing a square, and repeating three times the rotation of the turtle 90 degrees followed by drawing a square. A five square X pattern is created by rotating four flags counterclockwise: move the turtle forward 50, draw a square, repeat three times turning the turtle left 90 degrees, move it forward 50 and

draw a square. These simple designs give students practice using a procedure (SQUARE) to make designs.

Ryan Dorsey is the 9th grade teacher in Angoon, Alaska. He introduced LOGO to his students, who had few problems mastering computing skills needed for LOGO programming. “I have been using LOGO for two weeks now with my students. Some are doing very well.”

(Dorsey, 2003, p. 1) His wife is the kindergarten teacher in Angoon. Her students loved weaving the yarn-yogurt cups, but were not ready for LOGO programming.

Traditional Tlingit Baskets were made of spruce roots, which were split into very thin strips for a fine weave. The spruce roots were dyed bright colors. The designs were woven on the out surface, such that the weave was not visible on the inner surface of the baskets. Natalie Linn, a basket expert, describes a very beautiful and large Tlingit basket with a repeating rhombus shapes around the middle and two large repeating “T” shape patterns above and below the rhombus shapes. The “T” patterns are connected and when held upside down result in the same pattern. The “T” pattern is a glide reflection. (Mimbres, 2002)

(Figure 1 – Spruce Root Basket)

The “T” shape pattern woven on the Tlingit basket is an interesting LOGO project. Prior to programming the student makes the “T” shape pattern on dot matrix paper. This way they view the details of the pattern realizing the repeating unit. Now they are ready to make the repeating unit on the geoboard, placing the elastic bands about the pegs teaching them the feel and directions needed to navigate the turtle. For the “T” unit pattern the turtle is navigated up the “T” stem, around the rectangular “T” top, down the “T” stem and turned left to make a long horizontal line. The programmer/student creates the repeating “T” unit as a LOGO procedure (TEE) with the turtle turned left 90 at the end to head the turtle upward and get ready to start

another “T” shape. The unit pattern is repeated with a REPEAT statement in LOGO language.

The student makes a super procedure (BORDER), which tells the turtle to repeat TEE eight times on the monitor screen to make the “T” shape pattern of the Tlingit Basket. (Bradley, 1993)

(Figure 2. – Border pattern)

In Lori Hoover’s class the students created LOGO projects from Tlingit Basket Designs. A 3rd grade student constructed the “T” pattern. Her “T” unit was defined as “t”. The super procedure was “three t pattern”, which repeated “t” three times. Another child made a cross pattern with three “U” shapes. His “u” procedure made a three-sided open-square shape with the turtle turned left ninety at the end. His super procedure, “cross” repeated “u” four times. The Grid and Cockleshell pattern was a popular Tlingit pattern chosen by the students to weave in their yarn-yogurt cup baskets. The design alternated two colors. The student created two procedures: “vert” and “hors”. “vert” made the turtle draw 14 vertical lines and “hors” made the turtle 8 draw horizontal lines. His super procedure, “grid” told the turtle to draw the vertical lines then turn right ninety and draw the horizontal lines. Then the student filled in the red color in 7 columns alternating with 6 white columns. This completed the Cockleshell pattern, which many children had woven into their yarn- yogurt-cup baskets. (Hoover, 2003)

(Figure 3, 4, 5 – Student Pattern)

The Hohka pattern is popular in Navajo Blankets and appears in Tlingit baskets. (Bradley, 1993) The rhombus pattern has four sides, which are stair steps. Many times the steps are elongated either in the horizontal or vertical direction. The students create the pattern with the rise and run of the steps equal in length. However, with the introduction of variables for the lengths of the rise and run the Hohka pattern can be elongated in either direction to match the design on a particular basket.

(Figure 6 – Hohka Pattern)

After programming designs students prepared to weave baskets using colorful yarn and yogurt cups. They planned their design on graph paper, determined the number of warps in the design. Their warps were the vertical plastic strips, the students needed to cut into the yogurt cup. They estimated the number of rows woven with yarn their pattern would need.

Wanting her 2nd and 3rd grade students to be successful Lori Hoover's had all students weave the Cockle Shell pattern for their first yarn-yogurt basket. This pattern requires dark and light colored yarn on alternate warps. The students could quickly see the pattern. Weaving became "contagious". Lori's students wove over 100 baskets with various designs. They searched their family's refrigerators to find plastic containers of all sizes, margarine tubs, humus-spread containers, and Kentucky Fry buckets. (Hoover, 2003)

Tlingit Designs have many geometric shapes, including squares, rectangles, parallelograms, and triangles. The designs illustrate geometric transformations: translation, reflection, rotation, and glide reflection. Planning the design on graph paper presents issues of rectangular coordinates, which include vertical and horizontal positions of the design parts, which are related to wefts and rows in the baskets. Students must transfer designs into LOGO projects. They engage in spatial visualization and navigation problem solving. The turtle is navigated about the monitor screen using angles turns and proportional distances. They must determine the degrees and direction (left or right) of each angle turn for the turtle. They must cut vertical wefts of uniform width in the cylindrical surface of the plastic yogurt cups. They make a first cut and the second cut starts halfway around the rim. The two half sections are cut in half, creating four equal sections. The fourths are cut in half creating eight equal sections. They students may stop at eight sections or continue to make 16 or 32 equal sections. The number of

sections is determine by the student and depends on the desired amount of fineness. Beginning weavers are encouraged to start with 8 wefts for a yarn-yogurt cup basket.

Topaz Shryock teaches for Juneau School District. “My 8th graders are doing a great job, but my 7th graders are struggling a little bit because some of the math introduced is so new to them”. (Topaz, 2003, p. 1) At all levels of this project students are engage in Mathematical problem solving: the symmetric patterns of Tlingit designs, the coordinates of the graph paper and the basket, the navigation of the turtle, and the fineness of the weft. Students are discovering mathematics and reinforcing the mathematics they have already know because they are using mathematics in each step of the process. For Native students making the connection of mathematics to a familiar cultural artifact means their ancestors engaged in mathematical thinking and therefore mathematics is not just artifact of western thought, but also embedded in the cultural ways of Native people.

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Figure 1. Tlingit Spruce Root Basket
Source: "Baskets of the Northwest People"
<http://www.mimbresfever.com/north.html>



Figure 4: U and Cross Pattern
Source: (Hoover, 2003)

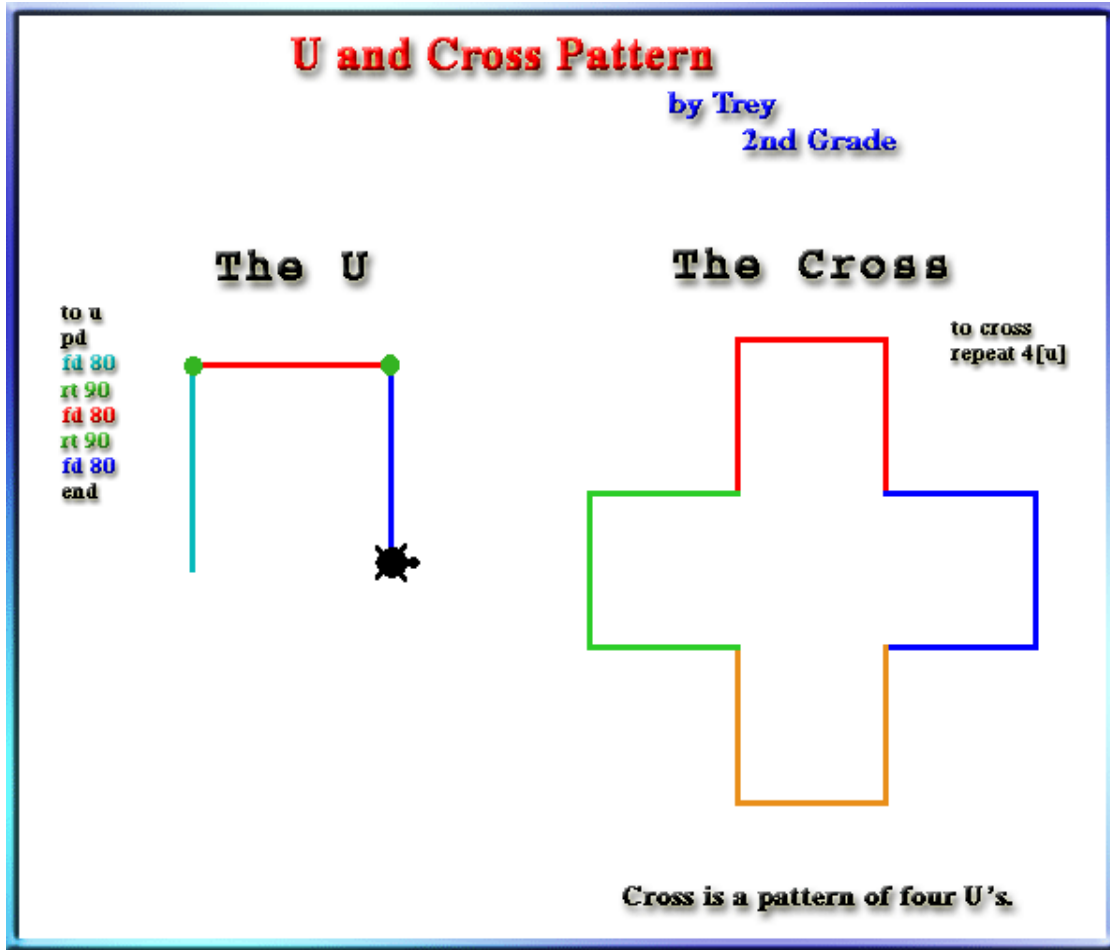
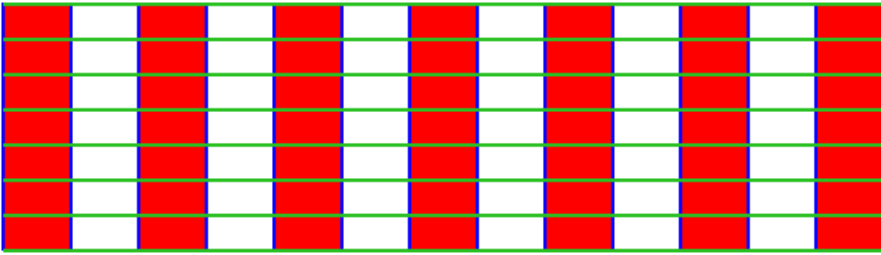


Figure 5: Grid and Cockleshell Pattern
Source: (Hoover, 2003)

Grid and Cockleshell Pattern

by Kevin
3rd Grade



A grid is
vertical lines...

```
to vert
pd
fd 260
pu
rt 90
fd 40
r90
pd
fd 260
pu
rt 90
fd 40
lt 90
pd
end
```

and
horizontal lines...

```
to horz
pd
fd 560
pu
rt 90
fd 20
rt 90
pd
fd 560
pu
lt 90
fd 20
lt 90
pd
end
```

drawn together.

```
to grid
repeat 7[vert]
rt 90
repeat 4[horz]
end
```

Figure 6: Stair and Hoka Patterns
Source: (Hoover, 2003)

