Ethnomathematics:Tipis
Ciarra S. Greene

Grade Level: High School

Duration of Curriculum: x4 50-minute classes

Content Focus: Native American tipis appear to be simple structures, although analysis of the structures provide varying levels of culture and mathematics. History and culture of tipis provide the explanation of why tipis are constructed in specific processes, which directs the structure shape. The mathematical practices used to analyze the tipis include developing a process, designing a model, constructing a model, developing equations, and calculating surface area and volume. The process of construction determines surface area and volume, students will explore this concept through their own experience and sharing their model tipi calculations and conclusions with each other.

Curriculum Design

Class 1: Introduction to Tipi Structures

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Materials</th>
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</thead>
<tbody>
<tr>
<td>5 min</td>
<td><strong>Observe</strong> photographs of tipis (both historic and current) and <strong>write</strong> a summary of what you know about these structures.</td>
<td>Tipi photos (historic and current); worksheet</td>
</tr>
<tr>
<td>15 min</td>
<td><strong>Sketch</strong> a 3D representation of one of the pictured structures and <strong>record</strong> any additional observations (materials used, estimated dimensions, structural details).</td>
<td>Worksheet</td>
</tr>
<tr>
<td>15 min</td>
<td><strong>Write</strong> a prediction of the process of constructing a tipi. Reminder: tipis were put up by people and therefore must be explained in that manner (i.e. how would they reach the top of the tipi if needed?)</td>
<td>Worksheet</td>
</tr>
<tr>
<td>15 min</td>
<td><strong>Learn</strong> about the different processes of constructing a tipi (Sioux and Blackfeet)</td>
<td>Niitoy-yiss: The Blackfoot Tipi: “How We Put Up Our Tipis” resource; “Pitching the Tipi” resource; “Erecting the Sioux Tipi” diagram</td>
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<tr>
<td>Hmwk 20 min</td>
<td>*Read the “Cree (Nehiyawak) Tipi Teaching to learn the cultural significance of the tipi (20m)</td>
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Class 2: Constructing a Tipi

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Materials</th>
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<tbody>
<tr>
<td>15 min</td>
<td><strong>Design</strong> a model tipi given the materials list: wooden dowels (20 per group), twine, poster board, toothpicks, and clear tape (used as “ties”. Reference the 3D sketch of a tipi. Give each group one dowel, one toothpick, and poster board. They can use these for making measurements and the draw the outline for the cover with appropriate dimensions.</td>
<td>Worksheet</td>
</tr>
<tr>
<td>30 min</td>
<td><strong>Construct</strong> a model tipi. Give groups the remainder of their materials</td>
<td>Wooden dowels (20 per group), twine or yarn, poster board, toothpicks, masking tape</td>
</tr>
<tr>
<td>5 min</td>
<td><strong>Describe</strong> the mathematical concepts used in constructing a tipi.</td>
<td>Worksheet</td>
</tr>
</tbody>
</table>
### Class 3: Measuring a Tipi

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Materials</th>
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</thead>
<tbody>
<tr>
<td>30 min</td>
<td><strong>Develop</strong> equations to describe the true surface area of the cover, and the volume of a tipi. Is the tipi a perfect cone shape? No. What about the smoke flaps? Rectangular in shape. What equations will provide information on certain parts of the cover? How do you combine these equations? Come to class consensus, on unit of measure (hopefully they decide cm, because it is easy to use because of base ten, and also size of measurements being made). Label the equations to describe what each part of the final equation represents. The ultimate goal is to have one complete labeled equation for the surface area and one complete equation for the volume.</td>
<td>Surface area and volume equations</td>
</tr>
<tr>
<td>5 min</td>
<td><strong>Measure</strong> the dimensions of the model tipi. What might the string be used for? Measuring nonlinear distances.</td>
<td>Ruler, string, worksheet</td>
</tr>
<tr>
<td>15 min</td>
<td><strong>Calculate</strong> the surface area and volume of the model tipi measurements using developed equations.</td>
<td>Calculator, datasheet</td>
</tr>
</tbody>
</table>

### Class 4: Constructing a Tipi

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Materials</th>
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</thead>
<tbody>
<tr>
<td>25 min</td>
<td><strong>Share</strong> and <strong>discuss</strong> calculations of the model tipis as a class. Each group will share the height of their tipi, labeled equations, and calculated values for surface area and volume. <strong>Record</strong> responses in a class datasheet with the information and <strong>identify</strong> patterns. <strong>Compare</strong> the class patterns to a commercial producer of tipi covers. As a class, <strong>develop</strong> mathematical statements about tipi dimensions, surface area, and volume.</td>
<td>Model tipi, masking tape, worksheet</td>
</tr>
<tr>
<td>25 min</td>
<td>*Complete critical thinking discussion questions: 1. Label each of the poles of your tipi according to the “Cree (Nehiyawak) Tipi Teaching”. Is it easier to label the base or the top of the poles? Think about the process and explain why one is easier than the other. 2. The tipi is not a perfect cone, give two or more reasons why this is the case. 3. Conical structures are highly stable and use minimal materials for construction. Why don’t we have many conical structures in society today?</td>
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*Extra Credit: Watch “[Elder Marie Lee – Rolcot (Tipi Teachings)](link)” and write a reflection.

*Denotes enrichment sections of the curriculum.
Introduction to Tipi Structures

1. **Write** a summary of what you know about these structures.

2. **Sketch** a 3D representation of one of the pictured structures and **record** any additional observations (materials used, estimated dimensions, structural details).

3. **Write** a prediction of the process of constructing a tipi.
Constructing a Tipi

1. **Design** a model tipi given the materials list: wooden dowels (20 per group), twine, poster board, toothpicks, and clear tape (used as “ties”. Reference your 3D sketch and given materials for dimensions. Write down any calculations you use for proportions and scaling.

2. **Describe** the mathematical concepts used in constructing a tipi.
Ethnomathematics: Tipis Worksheet

3. Develop equations to describe the true surface area of the cover, and the volume of a tipi. Label the equations to describe what each part of the final equation represents. The ultimate goal is to have one complete labeled equation for the surface area and one complete equation for the volume.

Tipi Surface Area Equation:

Tipi Volume Equation:
Ethnomathematics: Tipis Worksheet

1. **Measure** the dimensions of the model tipi and record.

2. **Calculate** the surface area and volume of the model tipi measurements using developed equations. (Show work)

| Tipi Height: | Tipi Surface Area: | Tipi Volume: |
1. **Class datasheet**

<table>
<thead>
<tr>
<th>Group</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tipi Height (cm)</td>
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</tr>
<tr>
<td>Tipi Surface Area</td>
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<tr>
<td>Tipi Volume</td>
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<tr>
<td>Tipi SA Eq.</td>
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<tr>
<td>Tipi Volume Eq.</td>
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</tr>
</tbody>
</table>

| Height (m) | 2.7 | 3.1 | 3.7 | 4.7 | 6.3 |
| Surface area of cover (m²) | 232 | 325 | 441 | 674 | 1,045 |
| Diameter (door to back) (m) | 3.6 | 4.2 | 4.8 | 6.1 | 7.9 |
| Diameter (side to side) (m) | 3.3 | 3.8 | 4.2 | 5.6 | 7.3 |

2. **Critical thinking discussion questions:**

4. Label each of the poles of your model tipi according to the “Cree (Nehiyawak) Tipi Teaching”. Is it easier to label the base or the top of the poles? Think about the process and explain why one is easier than the other.

5. The tipi is not a perfect cone, describe two or more reasons why this is the case.

6. Conical structures are highly stable and use minimal materials for construction. Why don’t we have many conical structures in society today?
A tipi of the Nez Perce tribe, circa 1900.

*Photo courtesy of New World Encyclopedia*

On June 16, 2005 a 150-year-old buffalo hide tipi in the park's collection was photographed. The tipi was probably made in the 1850s and consists of sixteen to twenty buffalo hides, stitched together with sinew. The tipi was originally much wider, but many years ago, the bottom was trimmed after it had gotten wet.

*Photo courtesy of the Nez Perce National Historical Park, National Park Service*

Bison were central to Lakota culture, but the Lakota also loved and honored their horses. Decorative painting on tipis and hides often depicted Lakota men on horseback.

*Photo courtesy of the North Dakota State Government.*

Blackfeet Tipis

*Photo courtesy of the National Park Service, Doug McMains*
Figure 1. Our tipis have a special number of poles. We alternate from each side as poles continue to be added. The tipi poles are carried by cart or truck to the site. In the past, poles would be dragged by horse and travois. Glenbow Archives NA-1481-9

Figure 2. Four poles are tied together with a rope and raised to form a stable foundation. The rope is firmly secured at the center of the tipi. Glenbow Archives NA-1481-9

Figure 3. The top of the canvas tipi is tied to one pole which is raised into position at the back of the tipi frame. The poles are then pushed out from the interior to tighten the canvas cover. Each side as poles continue to be added. Glenbow Archives NA-1481-11

Figure 4. The canvas tipi is loosely pulled around the poles. The wooden pins or "buttons" are used to fasten the front of the tipi. The bottom edge is staked using black birch pegs. Glenbow Archives NA-1481-10

Figure 5 (left). The canvas tipi is loosely pulled around the poles. The wooden pins or "buttons" are used to fasten the front of the tipi. Glenbow Archives NA-1481-10

How We Put Up Our Tipis

Niitoy-‘Yiss: The Blackfoot Tipi

http://www.glenbow.org/exhibitions/online/
“Pitching the Tipi”

1. Select three heaviest poles for the tripod. Set aside another heavy pole for lifting the cover with. Lay the tripod poles on top of the outspread cover and measure the tripod poles for tying (Figure 6a).
2. Most tipis face east, because winds blow from the west. Direct the bases of two poles in the south direction and the other pole to the right of where the door will be (east). Figure 6c indicates how the poles should be laid (dotted line).
3. Using a rope, tie the poles together securely. Be sure to have enough rope remaining to wrap around the poles several more times and also reach the ground.
4. To erect the tripod, 2-3 people are needed. One person will pull the rope to help lift the tripod. Starting at the top ends of the poles, another person will begin to lift the tripod off the ground, following the paired N and S poles. When the tripod is almost erect, the pole person will swing out the outer pole to the N position.
5. Adjust tripod poles as close to their starting location as possible. The N and S poles should be equidistant from center, while the door pole is a little further. Figure 6c shows the location of the apex labeled “p”.
6. Beginning on the N side, place one pole at a time starting to the side of the door. The first pole you place will be the other side of the door. Place each pole accordingly in sequence towards the N pole (typically 4 poles are placed). It is important that each pole is placed slightly within the projected final placement. This ensures that the poles and cover are flexible once placed.
7. Next do the same on the S side, placing 4 more poles and starting next to the door pole. These poles overlap the last four poles.
8. Place 3 more poles in the back. Two will be placed north and one will be south of the central point of the tipi.
9. Secure all the poles by wrap the rope around the poles four times tightly.
10. To secure the cover, lay the cover over the lifting pole and use ties. Fold up the cover from the outsides towards the pole on each side and overlap in the center. This makes it easier to unfold and place on the structure.
11. Two people place the lifting pole at the “backbone” of the tipi. Grab each of the outer fold of the cover on each side and walk towards the door. The cover will (in principle) unfold with little resistance or conflict.
12. The front of the cover has holes for wooden pins to secure it above the doors. Usually kids were tasked this or crossbars were secured on the door poles.
13. From inside, push the poles out gently to the cover. Keep symmetry of the structure, and leave slack for one more final adjustment of the poles.
14. Pin down the base of the tipi starting at the door and the back, then on each side.
15. From inside, adjust the poles again by pushing them out tightly against the cover.
16. Lastly secure a door by tying the door cover to pins above. A crossbar can be secured at the top and/or bottom of the door cover for stability.

Figure 6. Erecting the Sioux Tipi

A: altar
B: bed
C: cooking area
D: door pole
E: door cover
F: fire
G: guest
H: host
M: middle pole
N: north tipi pole
P: anchor peg
Q: wood
S: south tipi pole
T: front crotch
W: west tipi pole
X: wood crotch
CREE (NEHIYAWAK) TIPI TEACHING
ELDER: MARY LEE

INTRODUCTION
This way of being in the world was taught to me by my mother through the teachings of making a tipi. The tipi teachings, as I call them today, relate to nurturing the four aspects of the self, the spiritual, physical, emotional and mental, which are rooted in the four directions. The tipi is also a symbol of the women, so in honour of my mother and great grandmother and Cree women everywhere, I will share some of these tipi teachings with you.

LANGUAGE
The tipi teachings are passed on. When I talk about the teachings, it’s not to alter or change them; I can only share how it was told to me. There are many, many teachings that belong here with the tipi. I won’t be able to share all of them with you. But in sharing a little bit of the meaning it is hoped that you will continue on your journey to seek the teachings that you require. You’re never done learning.

For us, the word tipi doesn’t mean anything. There is a Cree word we use today; we say migawap. But traditionally, when my mother was teaching me about the tipi, she would say Kitche Migawap.

In the beginning, it didn’t come in the shape of a tipi. It came in the shape of a dome, which we still use today. It’s known as a Sweat Lodge. When that lodge came to us, you couldn’t make a fire in there. The people would gather the rocks outside, heat them up, and then bring them into a pit in the middle. This would keep them warm during the night. But they couldn’t make a fire in there to cook. They had to do all their cooking outside.

So when the lodge became bigger through the structure of the tipi, they could make a fire inside. My mother said that the women were named after that fire in the centre of the tipi, which brought that warmth and comfort. In the Cree language, the centre, the fire, is iskwuptew. “Woman” in our language is iskwew, more than one woman, iskwewuk. We were named after that fire, iskwuptew, and that is very powerful, because it honours the sacredness of that fire.

In our language, for old woman, we say, Notegweu. Years ago we used the term Notaygeu, meaning when an old lady covers herself with a shawl. A tipi cover is like that old woman with a shawl. As it comes around the tipi, it embraces all those teachings, the values of community that the women hold. No matter how many children and great grandchildren come into that circle of hers, she always still has room. And if you put it up right, the poles never show on the bottom, and that tipi stands with dignity, just as, years ago, women always covered their legs with the skirt, which also represents the sacred circle of life. And when you put the flaps up, it teaches you how we embrace life itself. It’s like a woman standing there with her arms out, saying “Thank you” to everything.

That is what the tipi is - it is the spirit and body of woman, because she represents the foundation of family and community. It is through her that we learn the values that bring balance into our lives. That is why, when you construct a tipi, it involves ceremony: because the ceremony of making a tipi represents the value of women’s teachings.

TIPI CEREMONY
When I make a tipi, when it goes up the first time, it has to face the east, because a tipi to me is not just a symbol, it’s a ceremony. The doorway is very important in ceremony. For ceremonial purposes, the Cree face the doorway east because that represents the beginning of creation.

Today, people forget that. That is why, when I am asked to make a tipi for someone, I take them through the ceremony so that they can embrace the true meaning and teaching of the tipi. I hope that it is a way to touch their spirit and provide guidance for them on their journey.
Before making a tipi, I offer tobacco. I don’t just stand and let that tobacco fall; I sit on the ground with humbleness, because I am offering something for something I will use from Mother Earth. Because it’s not ours; everything we take is borrowed; we’re borrowing time; we’re borrowing all the things we need to make a tipi.

I also ask whoever I am building the tipi with to offer tobacco with humbleness. I usually ask the women in that family to offer the tobacco, because the tipi is a woman’s symbol; and the ceremony is a woman’s teaching. The men can be part of the ceremony and can help to put up a tipi but they can’t hold the teachings, because they are not women. The men need the women to be present during the making of the tipi to take in those teachings and to offer that sacred tobacco to Mother Earth because that is all part of the ceremony.

I learned this through doing it, and through the instruction of my mother, who taught me that tobacco must be given for each stage of the process. So when I go out to the land and cut down the tipi poles, I make offerings of tobacco each time. This is how we honour the resources and gifts of our Mother Earth. She has gifted us for a very long time.

Today, people use tipis more or less for symbolic reasons. But I have made the commitment to share the teachings of the tipi each time I put one up. I do this because the tipi is a ceremony that reminds us of the balance we must bring to our lives and of the powerful teachings that the women have.

**TIPI STRUCTURE**

Today I make tipis that stand twenty-two feet high, but years ago, tipis were maybe twelve or thirteen feet. They didn’t have the material for large structures because they used hide instead of canvas and rocks instead of ground pegs. That is why today you can still find circles of rocks, or tipi rings, on the land. It wouldn’t make sense to have your tipi too high, because the winds and storms would catch it.

As time passed, the rocks were replaced with chokecherry ground pegs because they were one of the harder woods once they were dry. Today I cut and peel spruce for the tipi poles and I use sticks to adjust the front flaps of the tipi entryway. My mother used a bone from the moose leg to close the tipi in the front.

My mother never used a measuring tape, or mapped things out mathematically – she just cut out her tipi and made it. And each time it was perfect.

The Cree people use 15 poles to make the structure of the tipi. For every pole in that tipi, there is a teaching. So there are 15 teachings that hold up the tipi. Other Nations use 16 poles, and maybe more, I don’t know. All I know is what I know I was taught and that is the teachings for 15 poles.

The tipi does not have to face east all the time; it can rotate in any direction. It is only the first time that I request that the tipi face east, because of the opening ceremony.

To start, we take three poles and bind them together to make a tripod. Each pole also has a very specific meaning. These three together fortify the structure. They are obedience, respect and humility. Notice the poles, the way they stand. If they stood straight up and down, they couldn’t support a tipi. But balanced properly together, they are able to reinforce each other. There’s a teaching in that. In order to make a family, you need three: the two parents and the child, to make that balance.

The tops of the poles have many teachings. Each one points in a different direction. We are like those poles. We all need the strength and support of our families and communities, but we accept that we all have different journeys and point in different directions.
The poles also teach us that no matter what version of the Great Spirit we believe in, we still go to the same Creator from those many directions and belief systems; we just have different journeys to get there. And where the poles come out together at the top, it’s like they’re creating a nest. And they also resemble a bird with its wings up when it comes to land, and that’s another teaching: the spirit coming to land, holding its wings up.

TIPI POLES

We could talk about each of these poles for a long time; each one holds many teachings, and takes a long time and much experience to truly understand. I will give you some words on each pole, to give a beginning idea of what the poles represent.

OBEYDENCE: Obedience means accepting guidance and wisdom from outside of ourselves, using our ears before our mouth. We learn by listening to traditional stories, by listening to our parents or guardians, our fellow students and our teachers. We learn by their behaviors and reminders, so that we know what is right and what is wrong.

RESPECT: Respect means giving honor to our Elders and fellow students, to the strangers that come to visit our community, and to all of life. We must honor the basic rights of all others.

HUMILITY: We are not above or below others in the circle of life. We feel humbled when we understand our relationship with Creation. We are so small compared to the majestic expanse of Creation, just a “strand in the web of life.” Understanding this helps us to respect and value life.

HAPPINESS: After the tripod is up, the fourth pole completes your doorway. This fourth pole teaches us happiness. We must show some enthusiasm to encourage others. Our good actions will make our ancestors happy in the next world. This is how we share happiness.

LOVE: If we are to live in harmony we must accept one another as we are, and accept others who are not in our circle. Love means to be good and kind to one another and to our selves.

FAITH: We must learn to believe and trust others, to believe in a power greater than ourselves, whom we worship and who gives us strength to be a worthy member of the human race. To sustain our spirituality, we need to walk it every day. Not just sometimes, but every day. It’s not just once a week; it’s your life.

KINSHIP: Our family is important to us. This includes our parents, brothers and sisters, who love us and give us roots that tie us to the lifeblood of the earth. It also includes extended family: grandparents, aunts, uncles and cousins, and their in-laws and children. They are also our brothers and sisters and give us a sense of belonging to a community.

CLEANLINESS: Today when we talk about cleanliness, most people think hygiene, and that’s very important. But years ago, when old people talked about cleanliness, they meant spiritual cleanliness. When I used to sit with the old Kookums in their tipis, spiritually, they were so powerfully clean. Clean thoughts come from a clean mind and this comes from our spirituality. With a clean mind and sense of peace within we learn not to inflict ills on others. Good health habits also reflect a clean mind.

THANKFULNESS: We learn to give thanks: to always be thankful for the Creator’s bounty, which we are privileged to share with others, and for all the kind things others do for us.

SHARING: We learn to be part of a family and community by helping with the provisions of food and other basic needs. Through the sharing of responsibilities we learn the value of working together and enjoying the fruits of our labor.

STRENGTH: We are not talking about physical strength, but spiritual strength. That was instilled in us when we were young people through fasting. We must learn to be patient in times of trouble and not to complain but to endure and show understanding. We must accept difficulties and tragedies so that we may give others strength to accept their own difficulties and tragedies.
GOOD CHILD REARING: Children are gifts from the Creator. We are responsible for their wellbeing, spiritually, emotionally, physically, and intellectually, since they are blessed with the gift of representing the continuing circle of life, which we perceive to be the Creator’s will.

HOPE: We must look forward to moving toward good things. We need to have a sense that the seeds we are planting will bear fruit for our children, families and communities.

ULTIMATE PROTECTION: This is the ultimate responsibility to achieve the balance and well being of the body, mind, emotions and spirit for the individual, the family, the community and the nation.

CONTROL FLAPS: The control flaps on a tipi teach that we are all connected by relationship and that we depend on each other. Having respect for and understanding this connection creates and controls harmony and balance in the circle of life. When we don’t know how to use the flaps, it gets all smoky inside the tipi, and you can’t see, which is like life – because if we can’t live in balance, we can’t see clearly where we’re going.

CONCLUSION - POLES

For every time that a pole is added, a rope goes around to bind that pole into place. You have to be there and see it to appreciate that teaching. That rope is a sacred bond, binding all the teachings together until they are all connected.

I have shared these teachings with you with the hope that they will help keep the women strong and will help our communities to nurture healthy, balanced people.

The *lateral surface* of the cone (i.e. the surface area of the cone *excluding* the base) can be thought of as all of the line segments (s) connecting the apex to the base. From the illustration below you can see that, for a right circular cone, all of these line segments will be of the same length.

In an oblique circular cone, the length will vary. For this reason, whereas we can use the same formula for finding the volume of an oblique circular cone as for a right circular cone, the formula used for finding the *surface area* of a right circular cone will not work for an oblique circular cone. In fact, there is no simple formula for finding the surface area of an oblique cone.

The surface area is the area that describes the material that will be used to cover a geometric solid. When we determine the surface areas of a geometric solid we take the sum of the area for each geometric form within the solid. The volume is a measure of how much a figure can hold and is measured in cubic units.

To find the volume of a prism (it doesn’t matter if it is rectangular or triangular) we multiply the area of the base, called the base area B, by the height h. \( V = B \cdot h \)

To find the volume of a cylinder we multiply the base area (which is a circle) and the height h. \( V = \pi r^2 \cdot h \)