Lacing Together
For a great many students, mathematics is a vast, loosely connected collection of facts, procedures, and routine problems (Fey 1990, NCTM 2000). Native American students, in particular, may find that their educational experience lacks relevance (Williamson 1987). Historically there has been a cultural mismatch between the traditional school math perspective and the cultural orientations of Native American Indians. This mismatch has created a very real dilemma for many students who have been raised in a different cultural tradition (Cajete 1999, p. 5). The problem, then, becomes how to develop a culturally rich curriculum.

We drew on the cultural traditions associated with the Shoshoni-Paiute tribes to design a lesson to engage students in problem solving and making arguments for their strategies.

THE SETTING
The Western Shoshoni and Northern Paiutes are an indigenous people who traditionally inhabited parts of what are now southern Idaho, northern Nevada, and Oregon from time immemorial (Shoshoni-Paiute Tribes 2014). The reservation school is in an isolated rural community 100 miles from any other larger town. The lead author taught the school’s only sixth-grade class, composed of twenty students, eight boys and twelve girls.

Before the lesson was designed, we needed to learn more about traditional mathematical practices of the Shoshone-Paiute tribes. After receiving approval from the tribal council, the lead author interviewed elders of the tribe to learn about the different ways that mathematics was used in traditional day-to-day living. It became clear that the Shoshone-Paiutes have a rich mathematical heritage. For example, measurements are often determined by making comparisons with known quantities, and the food gathered is measured according to different-size handmade bags. During an interview, one tribal elder explained that making clothing is an essential
part of the traditional ways. A pattern is made for each garment using the recipient as the model. From that pattern, the garment is constructed specifically to fit that individual. She explained that moccasins are a very traditional item created from the traced foot of the person for whom they are intended. This information sparked the main idea for the lesson.

LESSON: USING MOCCASIN PATTERNS TO FIND AREA
Our goal was to create a culminating lesson using a cultural context that could be used at the end of a unit on area. The objective of the lesson was for students to find the approximate area of a moccasin pattern (that they created) by decomposing the figure created by that pattern into rectangles and right triangles. The lesson was designed to span three days. The first day, students created a Shoshoni-Paiute moccasin pattern (see fig. 1). On the second day, students calculated the area of their patterns. On the third day, students used their patterns to make their own pair of moccasins out of fleece fabric.

Students worked in groups of four to promote peer interaction and mathematical discussion.

Day 1: Making the Moccasin Pattern
- Goal: Students will take several measurements to create a pattern for their own moccasins.
- Materials: Pencil, butcher paper, ruler, scissors

A tribal expert taught students how to create a Shoshone-Paiute moccasin pattern (see fig. 1). After she explained and demonstrated the directions for each step, students completed that step. The authors and the tribal expert circulated around the room, helping groups, clarifying steps, and ensuring that each student was ready for the next step.

Day 1 involved substantial work with measurements, as figure 1’s directions show. Students measured 1/4 inch from their original pattern to create the sole pattern. They retraced the sole pattern and marked centers, drew lines from the widest points, marked measures of center, and drew 1/2 inch around the existing sole pattern to create the top pattern. At the end of the first day, a brief
whole-class discussion was held about the mathematical skills involved in making the patterns.

Day 2: Finding Area

• Goal: Students will estimate the total area of the pattern by decomposing the pattern into rectangles and triangles.

• Materials: Pattern, pencil, 1/2 inch grid poster board, ruler, calculator

Directions for Making Your Own Moccasin Pattern

Making the pattern for the soles:
1. Have a friend trace your foot on a piece of butcher paper.
2. Round the edges to make a smooth figure (see the diagram at right).
3. Mark 1/4 inch around the foot figure. This will be the sole pattern. Cut out.
4. Flip the pattern and trace it. This will be the sole pattern for the other foot. Cut out.

Making the pattern for the tops:
1. Use a new piece of paper. Measure 1/2 inch from the bottom.
2. Lay the middle of the heel of the sole pattern at that 1/2 inch mark and trace the sole pattern.
3. Measure from the middle of the sole pattern to the outside of the line created from the widest point and compare that with the other side, creating a line of equal distance on the opposite side along the bottom of the paper. (See the lines in the diagram at right.)
4. Measure 1/2 inch around the new figure. Cut out this new piece. Fold the top pattern piece in fourths lengthwise. Then fold the pattern in half widthwise. Mark in the middle at the fold and 1/2 inch from the fold toward the top of the pattern on the quarter folds. Cut from the bottom of the pattern to the 1/2 mark and to each of the marks on the quarter fold (see the diagram at right).
5. To sew the moccasins, stitch the left sole to the left top piece, then turn the completed moccasin inside out so that the stitching does not show.

To begin day 2, we posed the question, “How much fabric would be needed to make a set of moccasins for each student?” Students’ answers varied from “We need double” to “About that much,” illustrated by one student stretching out her arms. The instructors explained to students that it was important to know the area of each set of moccasin patterns so that enough fabric could be purchased. Students began tracing their moc-
which they had done previously (on a much smaller scale) in tasks at the beginning of the unit. One group of students continued to use this strategy to find the total area. However, one student in that group began using rectangles to mark off groups of unit squares. He counted the unit squares within each rectangle (using dots to mark as he went) and recorded the number of units (see fig. 2). After he had finished counting all sections, he added the sums to find the total number of unit squares. He divided his final calculation of 559 square units by 4 to determine the equivalent total of 139.75 in.² for this pattern piece.

Four students continued to use a counting strategy to determine their areas. Other students wondered if there was an easier way to calculate the area of their figures. Each group discussed different ways to decompose their figures into rectangles and right triangles. The next two strategies described illustrate the different approaches that students used to decompose their figures.

Decomposing into repeated measures: The moccasin pattern figures were not conveniently separated into rectangles and triangles as students had experienced in other lessons, so students had to decide how to decompose their figures themselves. During the discussion, one student suggested making manageably sized congruent rectangles and right triangles inside the figure and calculating those areas. The students who used this strategy could see the benefit of marking rectangles and right triangles in the figure, measuring them, and using mathematical formulas for area instead of counting each unit square in their large composite figure (see figs. 3a–3b). Students recognized that finding several congruent shapes made this work even more efficient because they then needed to compute the area only once for each
Figures 3a and 3b illustrate how one student used repeated measures and recorded the area for each region. She began in the bottom-right corner (see fig. 3a) and measured a rectangle 2.5 inches wide and 2 inches in length. The area of that region was 5 in.². She continued by marking off three more regions with the same dimensions. For the curved regions, she created right triangles by replacing curved edges of the figure with straight lines. In the triangle just to the right of the uppermost rectangle in figure 3b, she marked the perpendicular side lengths as 1 inch and 1.5 inches and noted an area of 0.75 in.². She calculated the total area of her patterns as 203.25 in.².

Optimal decomposing: Some students began to consider other ways to reduce the amount of work and calculations needed to find the total area of their pattern figures. One student asked if she could make the largest rectangles and right triangles possible in the figure and then make smaller ones until all the area was used (see fig. 4), saying, “It would save time and be easier to do.” The students were beginning to understand the beauty and benefit of using formulas for calculating area. Figure 4 shows how this student took efficiency a little further. She recognized that the area for the left sole pattern would be the same as for the right sole, so she calculated that left-sole area and doubled it. The total area for her pattern was 185.25 in.².

After completing the task, each student explained how he or she calculated the area of his or her pattern. One student recorded the total areas from each person on the interactive white board, and then a total area for the entire class was calculated. The students’ final area calculations ranged from 140.9375 in.² to 233.875 in.². During the student presentations, we discussed calculations that appeared to be outliers. One student’s calculation, at 233.875 in.², was much higher than all the rest. The class decided that this number made sense because this student had larger feet compared with classmates, so her pattern would have a larger area. Another student’s calculation, at 102.75 in.², initially came in much lower than all the others. After discussion, it was found that this student did not account for all the rounded portions of the pattern. One student’s suggestion led to a revised total of 153.75 in.². At the end of the lesson, students converted the total class yardage to square yards and added a fixed amount per student for the tongue and laces. They determined that 7 1/4 square yards of fabric were needed.

Lesson 3: Sewing Moccasins
• Goal: Students will pin their patterns on the fabric, cut out the pieces, and sew their moccasins.
• Materials: Pattern, fabric (fleece), pins, scissors, needle, thread

Moccasins are traditionally made from tanned buckskin, which is then beaded before sewing. For this activity, we used fleece (because of the limited supply and cost of buckskin) and omitted the beading. Students fit their patterns on the fleece and cut two of each of the sole and the top for the right and left moccasins. The
Students made several measurements to create the moccasin pattern.

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tribal expert showed students how to sew the two back flaps on the top pattern piece together to form the heel. Then students marked the center front and back of the top and the sole and placed the pieces together at the markings, inside to inside. They were instructed to sew from the center of the back to the center of the front and make a knot. They repeated this process on the other side.

Once the sole and the top piece were sewn, students turned the moccasins inside out. They were almost complete. The next step was to create a tongue and laces. Students measured the width from the slits from each of the 1/4 inch marks, cut a strip of cloth, and sewed it to the moccasin. A hole was cut in each flap of the moccasin and a string was tied to close the moccasin. They repeated the process for the other moccasin.

REFLECTIONS

At the conclusion of the first day, a whole-class discussion was held to debrief, ask questions, and clarify misunderstandings. Students were asked if they were surprised how much math was included when making their moccasin patterns. One student commented, “We didn’t do math today.” It was interesting that this student (and others) had not made the connection, at this point, that what they were doing in creating a moccasin pattern involved mathematical skills and concepts. This provided a great opportunity to discuss the steps that students had taken to make their pattern and the mathematics involved, namely, measurement, ideas of symmetry, and the concept of a midpoint.

During the primary mathematical portion of the lesson (day 2), each student was able to work productively in a way that made sense to him or her. Within their groups, students determined how to calculate area using the skills and formulas that they had learned in previous lessons. Each group was monitored to assess student work and check for accuracy. Students persisted in making sense of the problem and considering multiple ways to find the area of their pattern pieces. They monitored their own progress and changed their approach if they decided another method was more efficient. During the class discussions, students demonstrated ownership of the strategies that they used and explained their reasoning. This lesson also gave students additional practice using the formulas for the area of rectangles and triangles in a way that was motivating and engaging.

During all three days, every student stayed engaged throughout the lesson. They appeared motivated to complete each step because of their anticipation of the final outcome and of their curiosity about how moccasins related to mathematics. One student commented that it was “hard and a lot of work” but stayed involved and completed all steps, which was quite significant considering that this particular student was not regularly engaged during lessons. Students were all proud of their accomplishments because they were able to complete each part and wear their moccasins. The lesson gave students a way to demonstrate their knowledge in a culturally relevant context (Neel 2005).

Each student completed an exit survey at the end of day 3 (see the sidebar). One student stated, “I enjoyed this lesson; it was fun seeing how many different ways you can find area and still be right.” Although this lesson seemed to demand intense attention to detail and in some cases more work than what was normally required in class, every student was successful and indicated that he or she really enjoyed the lesson. This could be, in part, because not one of the students had previously created a moccasin pattern. Many of the students were experts at beading; they could now apply those skills when creating their own personalized moccasins from buckskin.

This lesson was critical for students’ understanding of the principles of finding area. It gave them the opportunity to learn about different strategies for decomposition that can be used to find solutions to related problems, such as determining the area of a floor plan (cf. Joram and Oleson 2004). Students were successful in
Completing each step, which gave them confidence and a feeling of pride.

Because we were using a local cultural tradition in making an article of clothing, it was essential to request involvement from the tribal community. Out of respect for the Shoshone-Paiute people, the inquiry began with the tribal council. After receiving the council's approval and guidance, we were able to reach out to the community. Building relationships with community elders was essential to building the bridge that brought relevance to the students' educational experience.

In summary, this experience has been a reminder of the importance of encouraging students to recognize and understand mathematics in many cultures, especially their own, and feel good about their mathematical learning. As teachers, we are expected to use the Common Core State Standards for Mathematics as a curriculum guide, but we also have the power and flexibility to address these standards by creating lessons to meet the needs of our students. We agree with D'Ambrosio that an important component in today's education should be to reaffirm, and in some instances to restore, the cultural dignity of children (2001, p. 1). Our experiences demonstrate that this was not as difficult as one might assume.

Exit Survey: Area in the Real World

1. What was your favorite part of this lesson?
2. What part did you do well?
3. What was one struggle you had?
4. What surprised you the most?
5. Did you enjoy the lesson? (Explain why or why not.)

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REFERENCES


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Any thoughts on this article? Send an email to mtms@nctm.org.—Ed.

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