E-C.2 Stick Games and Theoretical/Experimental Probability

Grade 6

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Based on patterns observed on Saskatchewan First Nations Pow Wow regalia, students decorate six identical popsicle sticks on one side in order to investigate the theoretical and experimental probabilities that underscore a popsicle stick drop activity. Then by playing the more challenging Blackfoot Confederacy Stick Game with four authentically decorated popsicle sticks, students solve probability problems and develop combinatory logic in order to solve a mystery surrounding the traditional Blackfoot game's scoring system. Greater in-depth learning about theoretical probability results from the game's follow-up analyses.

Curricular Knowledge

Outcome SP6.2: Demonstrate understanding of probability by: differentiating between experimental and theoretical probability; determining the experimental probability; and comparing experimental and theoretical probabilities.

Outcome N6.9: Research and present how First Nations and Métis peoples, past and present, envision, represent, and use quantity in their lifestyles and worldviews.

Combinatory reasoning and problem solving

Indigenous Mathematizing and Perspectives

- *Traditional Regalia* is created by the dancer participating in a ceremony that includes fasting in order to receive guidance in creating the regalia for their selected dance. The vision quest type of ceremony guides the dancer to selected colours and patterns for their regalia. In current time, regalia patterns are being created without the dancer attending traditional ceremony and contemporary regalia can express, for example: a dancer's personal feelings; a dancer's family identity; or a dancer's relationship with a winged or a four-legged being. At one time, regalia was not to pass hands or be shared. Now regalia is designed and sold like clothes in a clothing store.

- Just because a regalia *pattern* reminds us of a pattern familiar in math class (e.g., a triangle), it does not mean the pattern **is** a triangle. Instead, it will have a First Nations meaning indicated by the First Nations word that identifies the pattern. To know what that meaning is, we might ask the dancer (if possible), "What does that pattern represent?" Given this respect for the First Nations meaning of a pattern, students will **not** name the regalia pattern mathematically, but they will name it either with its Indigenous name (if possible) or by a short English descriptive expression.

- *Pow Wows* are a way for people to join in dancing, singing, visiting, renewing old friendships, and making new ones. A Pow Wow is an event that celebrates all there is on Mother Earth. The dances are to give thanks to the elements (water, wind, fire, rock), the plants, and animals that sustain life for the human beings. The Pow Wow gathering renews Indigenous cultures and preserves the rich heritage of First Nations peoples. Find out more about Pow Wows in Appendix A.

Time 3.5 - 4 hours

Student Assessment

Indigenous math and Indigenous perspectives expressed accurately during activities, discussions, and quizzes/tests.

Formative assessment: Group work, class discussions, and 3-2-1 exit cards.
Write 3 things you learned in today's lesson.
Write 2 things you liked or interesting facts gained from the lesson.
Write 1 question you still have related to the lesson.
Appendix B, Pages 1-2. Appendix C, Page 2, Questions 1-4; Page 4, quiz

Summative assessment: Appendix B, Page 3.
Appendix C: Pages 1, 5, and 6 (Questions 5-9); Page 3 – Step 4 results

Teacher Resources

A. Background information on Saskatchewan Pow Wows: Appendix A and https://calendar.powwows.com/events/categories/pow-wows/pow-wows-in-saskatchewan/
B. Equipment to show videos from the internet.
C. A 1:52 minute video introduction to Saskatchewan Pow Wows, a Global TV News item: https://globalnews.ca/video/4605738/fsin-powwow-draws-thousands-to-saskatoons-sasktel-centre
D. Pow Wow dancing videos (show one of these, or parts of two of these)
   a. https://www.youtube.com/watch?v=ZPpg1ae6tfM
      Men's Fancy Dance, First Nations University of Canada Pow Wow, 2011 (2.23 min)
   b. https://www.youtube.com/watch?v=iArcG-S3_QM
      Pow Wow Women's Jingle Dress Dance (2:47 min)
E. Indigenous Games
   Aboriginal Perspectives, University of Regina. The main source drawn upon for the Blackfoot Confederacy Stick Game is:
   http://www.aboriginalperspectives.uregina.ca/games/game7.shtml
   Enrichment activities: Cole Wilson, Saskatchewan Physical Education Association. A compilation of many Turtle Island traditional games.
   https://www.speaonline.ca/uploads/3/8/2/9/38299825/indiginous_games_handout_by_cole_wilson.pdf
F. White bristol board

Student Materials

A. Popsicle Drop Activity

- Popsicle sticks: six per student for the first activity. Break the pre-wrapped sticks into individual sticks ahead of time for quick distribution.
- Coloured (black, red, green, etc.) temporary markers, pencils, or crayons to make a pattern on one side of the popsicle sticks.
- Student handouts for recording data and answering questions:
  Appendix B, Pages 1 - 3. Each page is handed out at different times.

B. Authentic Blackfoot Confederacy Stick Game

- Popsicle sticks: four per student pair, or four for each pair of teams.
- Popsicle sticks: two per student pair, used in Step 4 in Appendix C.
- Coloured (black and red only) temporary markers, pencils, or crayons.
- Toothpicks used as counting sticks, 12 per student pair or per pair of teams. Ahead of time, make packages of 12 (e.g., in snack-size ziploc bags).
- Student handouts: Appendix C, Pages 1 - 6. *Each page is handed out at different times*.

Popsicle Stick Drop Activity

Lesson – Introduction

1. As an introduction, show the Global TV News item (1:52 minute video) about Saskatchewan Pow Wows. It includes interviews with the participants and observers.
2. Hold a *short* discussion about: Who has been to a Pow Wow? What do you know about Pow Wows? What is the name of the outfit that each dancer wears (regalia)? Add any other information of interest to your class. See Appendix A for more background information to mention to students throughout the lesson.
3. Explain to students that preparation for the activity requires them to decorate one side of six popsicle sticks with a pattern each student found on a regalia. Individually, they will choose a ***simple*** pattern seen in a Pow Wow video and then repeat that pattern once on one side of all their popsicle sticks.
4. Show one of the videos or a segment of two videos (e.g., male and female dancers perhaps).
5. Distribute six popsicle sticks to each student. Give them about 10 minutes to repeat their chosen First Nations pattern *only once* on one side of each stick in any colours they want. A rough depiction of the pattern will do. This is not an art project.

Lesson – Popsicle Stick Drop Activity

6. Plan ahead of time where students in groups of two to four students will be dropping their popsicle sticks. An empty room would be ideal. The activity can be a bit noisy. Also plan ahead on how to restrict the time the students have for each part of the activity.
7. Demonstrate the stick drop activity. Then *hand out only page 1* of Appendix B.
8. Ask the rhetorical question: "A popsicle stick can end up either pattern-side-up or blank-side-up. What's the most likely chance for how the six popsicle sticks will end up after being dropped from should height?" The answer (1/2, 50%, or three out of six, with their pattern-side-up) is the first thing each group needs to figure out.

   [Once they begin the activity, suggest that their answer (i.e., their "prediction") logically fits throughout the first data column in both Part I and Part II (Page 1 of Appendix B). Moreover, the question, "What is the chance?" introduces the *concept* of probability by using everyday language. The term "theoretical probability" will be introduced after students have collected their data. They will experience theoretical probability in the context of experimental probability and then label both. The teaching strategy here is for students to *understand* ideas (i.e., the meaning of theoretical and experimental probability) *before* learning their technical names.]
9. Organize students as to where they should do the activity and with whom.
10. Answer their questions before they move into the activity.

    [Looking ahead to the post-activity section on page 3 of Appendix B, the second row in the table will *eventually* be filled in by students with theoretical data and experimental data after they analyze their data by calculating the probability of *how their own sticks behaved* (experimental probability).]
11. The **students now start the activity**. Give students about 15-20 minutes to complete it as they enter the results in their data table "Parts I and II Results" (Appendix B, page 1).

    [An alternative set up for this activity is to hand out 10 popsicle sticks and get students to drop them 10 times – instead of six sticks si9x times. This alternative requires much more time but has the advantage of students more easily converting their probability fractions into a percentage.]

Lesson – Post Activity: Making Sense of the Data

12. *Hand out page 2 of Appendix B* (Data Analysis). Work through the Part I analysis as a class. A key process for them to learn is: *How to find the TOTAL number of outcomes in general.* Use the example of the chance of winning a lottery. What are the total outcomes?
13. Get students to work through the Part II analysis individually. Assistance may be needed. As students do this, get one student from each group to write their group's average probability for Parts I and II on the board. You will soon use the data to calculate the whole class' average.
14. Give students time to answer Questions 1-5 to be handed in. Question 3 begins by telling students of the unusual structure of Question 3.
    As students begin to work on the questions, *calculate the class average for Parts I and II, and put the answer on the board*. It is needed by students right away (Question 2).

Questions	Answers
1. What were the differences, if any, between your PART I results and your PART 2 results?	Most classes note a slight difference with greater randomness occurring with the vertically held popsicle sticks.
2. Summarize the results of the whole class. Are you surprised? Explain your answer.	Accept any answer that approximates this research question: "Does the position (horizontal or vertical) from which the popsicle sticks are dropped make a difference to the probability outcome?"[1]
3. ("Here's the answer, what was the question?" This is how Question 3 goes.) Comparing your Part I Analysis results to your Part II Analysis results, write a question that these results answer.	A class average is appropriate to compare with individual experiences. It should be on the board as a result of the teacher's calculation (italicized note above in point 14). Some students' reasons for being, or not being, surprised are worth listening to.
4. If you were going to make up a game that involved dropping popsicle sticks, which way would you have people drop the sticks in your game? Explain your reasoning.	One would expect students would choose the method that yields a probability closest to 50% in order to make the game fair. Again, the important point of this question is the students' reasons they give.
5. You chose a First Nations pattern for your popsicle sticks. What did you like about that pattern?	Answers are totally personal. This gives voice to students' esthetic or intercultural understandings, for instance. You will learn a little bit more about each student.

Lesson – Post Activity: Introduction to Theoretical/Experimental Probability

15. *Hand out Page 3 of Appendix B* (Conclusion).
16. In the first row of the table, have students fill in the two lines with either their own results or the class average result.
17. In the second row of the table, address the question "**What type of probability is this?"** with sufficient drama to etch the answers into students' memories. Mathematicians call them Theoretical Probability and Experimental Probability respectively (see footnote 1).
18. Have students print the two answers in the space in the second row.
19. Come to a class decision on a sensible definition for each expression ("Theoretical Probability" and Experimental Probability). Students should write those definitions directly under the table.

[1] This is a typical scientific research question that guides a scientific experiment. Parts I and II, taken together, comprise a scientific experiment. Perhaps the curriculum term "experimental probability" is more accurately "empirical probability." The latter suggests a collection of data from which to calculate a probability. Data collection is a process *within* an experiment; it is not an experiment on its own, as experimental probability wrongly suggests.

Lesson – Blackfoot Confederacy Stick Game

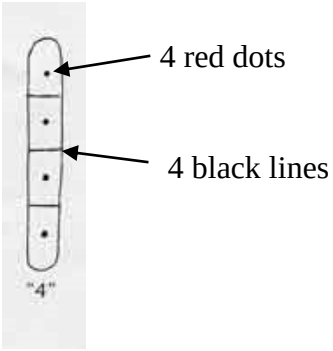
See Appendix A for background information on the Blackfoot Confederacy with which to introduce their stick game. The purpose of this second part of the lesson is to use the concepts of theoretical and experimental probabilities in the context of analyzing the Blackfoot game's scoring system. The game is played in pairs.

The main source for the game comes from Aboriginal Perspectives, University of Regina, http://www.aboriginalperspectives.uregina.ca/games/game7.shtml. Originally, the game was played with buffalo bones (especially ribs) and with counting sticks (for keeping score). Popsicle sticks and toothpicks, respectively, are used here. Have them counted out ahead of time ready for students to get them; for example, stored in ziploc bags.

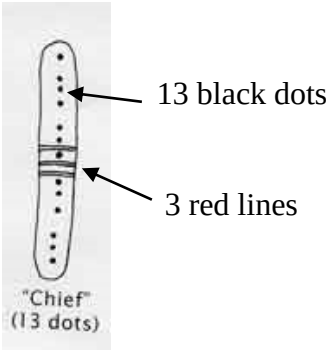
There is no information on the original positive consequences of winning. But because Grade 6 students were more highly motivated when a reward came to the winners, it is suggested that you devise such an award relevant to your students. Winning is based on the probability of getting certain pattern-side-up and blank-side-up combinations of four sticks (see Figure 1 below).

Lesson – Introduction

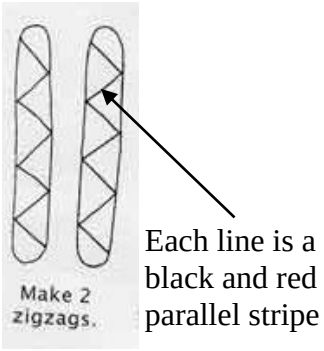
1. Ahead of time, draw these Blackfoot patterns in colour on bristol board or a white board for students to copy onto their popsicle sticks. Include the patterns' names (4, Chief, and zigzag). Why not use their names throughout the rest of the lesson?



4 is a sacred number



13 moons per year



The pattern's meaning is unknown

2. Organize students into pairs of players.
3. Distribute four popsicle sticks and 12 toothpicks (counting sticks) per pair of students (or pair of teams). Give the pair of students about five to 10 minutes to repeat each Blackfoot pattern on one side of each stick using only black and red markers, pens, or crayons[2].
4. Students should place the 12 counting sticks (toothpicks) in a pile safely away from the popsicle stick dropping action. The toothpicks will be used to keep score between the two players (or teams). See points 6.c, 6.d, and 6.e, just below.
5. The first player holds the four sticks vertically stacked just like in the popsicle stick drop activity (pattern sides facing the same way). Demonstrate this for students.
6. The student drops the bundle from shoulder height. Then a score is determined before another drop is made. The scoring system is shown in Figure 1[3].

[2] https://www.google.com/search?q=Blackfoot+Stick+Game&tbm=isch&source=univ&client=firefox-b-d&sa=X&ved=2ahUKEwi04q-zrrnhAhUWoYMKHbGLDLsQsAR6BAgIEAE&biw=1198&bih=626#imgdii=q8Kl8RZ8BhIfXM:&imgrc=Wt0XAxcIBlNdhM.

[3] https://www.google.com/search?q=Blackfoot+Stick+Game&tbm=isch&source=univ&client=firefox-b-d&sa=X&ved=2ahUKEwi04q-zrrnhAhUWoYMKHbGLDLsQsAR6BAgIEAE&biw=1198&bih=626#imgrc=Wt0XAxcIBlNdhM

a. If a student gets a score of zero on a drop, then the other student takes a turn. (The same applies to a whole team when pairs of teams are playing.)
b. There are *only three* combinations that produce points (represented by counting sticks). All other combinations are worth zero points.
c. If a player earns points from their first drop, then that player gets to drop the sticks one more time right away in the same turn. Therefore, a player can make more than six points in a turn if they are really lucky.
d. Players keep track of their score with the counting sticks (toothpicks). The game begins with a communal pile of 12 counting sticks. If a student earns, let's say six points, they take six counting sticks (toothpicks) from the communal pile and store them in their personal pile of counting sticks.
e. In the event that the communal pile runs out of sticks, the student takes counting sticks from their opponent's pile of counting sticks. For example, in the midst of the game, suppose the communal pile has four sticks. If one player earns six points in a turn, they take all four sticks from the communal pile AND then two sticks from their opponent's personal pile.

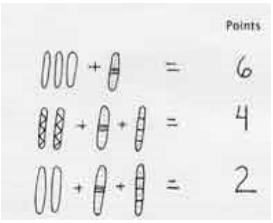


Figure 1. Scoring System. All other combinations score zero.

7. **The winner** is the first player (or team) to accumulate all 12 counting sticks. If this happens rapidly, just get the pair to play a second game of Blackfoot sticks.

8. *Hand out Page 1 of Appendix C* (Data Collection).
   It tells students:
   > "Keep track of your progress in the tables below. After each turn, enter the number of toothpicks (game points) in your possession even if it is zero."

   This number will likely fluctuate up and down during the game.

9. **Students begin playing at this point.**

10. The players' observation tables on Page 1 of Appendix C accommodate 15 drops, but there is room on the page to add more data if students want to. Some of these games are short lived while others can last quite awhile. Establish a time limit for your class. The student with the most counting sticks when time is called wins. For students who want to continue to play the Blackfoot Confederacy Stick Game out of class, this should be arranged if feasible.

[The game helps students forge a personal connection with the point system. This motivation is important in order to get some students to delve into the probability problems: "Is there any probability reason that this outcome is worth six points, the highest score in the Blackfoot game's scoring system (6, 4, 2, and 0)?" This is a good reason for students to get in the habit of naming the three combinations of sticks that yield points.]

Lesson -- Blackfoot Confederacy Stick Game: Putting Probability to Use

11. *Hand out Page 2 of Appendix C* (Data Analysis).
    At the top, it describes in general terms what students will be working on. It begins with detective questions that define a theme for Appendix C. Then Appendix C proceeds to lead students toward answering those questions in a five-step process.

12. You may wish to go through Step 1 as a whole class, because it draws heavily on the concepts of theoretical and experimental probability introduced in the stick drop activity.

Step 1

13. The meaning of the number that represents the TOTAL number of outcomes becomes extremely important in Appendix C. Step 1 gets students to review its meaning established in Appendix B (Page 2, Data Analysis). Make sure every student understands *how* to arrive at that number.
    An example for *single* sticks (from Appendix B):
    > The number of times a pattern-side-up *plus* the number times a blank-side-up could occur (theoretical probability) or did occur (experimental probability).

    Looking ahead, an example for *combinations* of four sticks (to be addressed in Step 5):
    > The number of times all possible combinations of four sticks could occur (theoretical probability). The combinations are defined by the specific pattern-sides-up and blank-sides up result from dropping the sticks (see Table X on the page just before Appendix A).

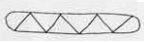
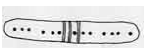
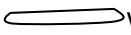
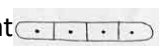
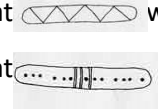
Step 2

14. This step begins by showing students how to figure out "how many chances are there that a specific pattern could possibly show up in one drop of the four sticks." The specific pattern used in the example is the blank-side-up result. There are four blank sides in a group of four sticks; therefore, it is possible that all four dropped sticks may turn up blank – four chances.

    This QUESTION/ANSWER approach teaches students how to answer Question 1.a to 1.c.

15. Questions 1 to 3 (repeated just below in smaller font with answers) lead students to the answer for Question 4: the TOTAL number of outcomes. (They add the answer from #14 plus the answers from Questions 1-3 to get a total of eight. But remember, the thinking is restricted to individual sticks. The questions also give students feedback on how well they are prepared to continue on successfully.

QUESTIONS: Students answer these questions on a separate sheet of paper and hand it in to you.

		ANSWERS
1.a.	How many chances are there that  will land pattern-side-up?	1 chance
b.	How many chances are there that  will land pattern-side-up?	2 chances
c.	How many chances are there that  will land pattern-side-up?	1 chance
2.	What is the TOTAL number of *chances* for all four sticks landing either pattern-side-up or blank-side-up?	4+1+2+1 = 8
3.	Are your answers to questions 1.a to 1.c about *theoretical* probability or *experimental* probability?	Theoretical
4.	Now that you know the total number of possible outcomes when you drop a bundle of four Blackfoot game sticks, you are ready to talk probability talk.	
a.	What is the probability that  will turn up in a stick drop?	$^4/_8$ or ½ or 50%
b.	What is the probability that  will turn up in a stick drop?	$^1/_8$ or 12.5 %
c.	What is the probability that  will turn up in a stick drop?	$^2/_8$ or ¼ or 25%
d.	What is the probability that  will turn up in a stick drop?	$^1/_8$ or 12.5 %

Step 3

16. Students are told that the issue in Step 3 is changing from "*What happens to one individual stick*" **to** "*What happens to a combination of the four sticks*," because that is what the scoring system in the Blackfoot game is all about.

17. Get students to talk about the two different perspectives so they differentiate the two in their minds. Perhaps a student will have a better wording when comparing the two perspectives.

Step 4

18. In a concrete way, this step teaches students a reasoning strategy known as *combinatory reasoning*. The strategy is needed in order to address the detective questions that surface again in Step 5.

    [This content is **not** about the high school math's permutations and combinations. However, it **is** about a *concrete* way to figure out systemically the number of combinations that are possible. Thus, students are developing their capacity for combinatory reasoning and problem solving.]

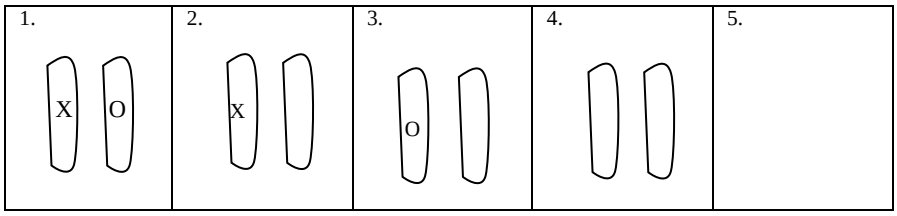
    Combinations of two sticks is much easier to deal with than combinations of four sticks (the topic of Step 5). Thus, Step 4 is a practice run for Step 5 on a simple example.

    [Teaching the combinatory logic strategy first by using a simpler situation turns out to be the transition most students require.]

19. There are two closely related parts to Step 4:
    (1) A manipulation of two popsicle sticks (one marked with an X on one side, and the other with an O on one side) to find out how many possible combinations could occur if they were dropped. Students are told to use any manipulation process including dropping them. Just putting them into different positions will be faster.
    (2) In a table, drawings will record the results discovered during students' manipulations.

20. *Hand out Page 3 of Appendix C* (Data Analysis) and *two popsicle sticks* per group.
    Students should work in groups of two on both Steps 4 and 5.

21. The students' table should look something this:

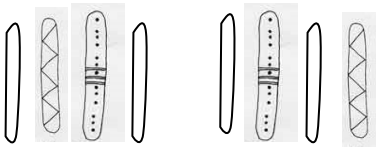


Check their answers and decide if they go on to Step 5 or not. In other words, students need to master Step 4 before moving on.

Step 5

22. *Hand out Page 4 of Appendix C* (Data Clarification).
    Some students will confuse the idea of combination with the idea of permutation without using that word. This page clarifies "combination" for them via a quick quiz.

    Students who confuse the two ideas will think that these two groups of sticks are different.



    The quiz catches them and sets them straight. Without this clarification, the final activity is impossible.

23. For students who show they understand the mathematics concept of combination:
Hand out Page 5 of Appendix C (Data Exploration) and have pairs of students solve the puzzle.

The bottom half of Page 4 of Appendix C, Data Clarification describes this final activity for students, the solution that leads to answering the detective questions. This description for students is repeated in the textbox here, but it will not make much sense unless you are looking at *Page 5 of Appendix C* (Data Exploration).

> On the next page, draw all the combinations that could possibly result from dropping the four popsicle sticks in the Blackfoot game.
> - You are given a head start by having five of the outcomes (or possible combinations) completed for you.
> - Your sketches will fill in some of the blank spaces on that page, but not necessarily all the blank spaces.
> - The lines on the right-hand side are for recording how many outcomes are sketched in that row. Two of the rows already have two possible outcomes sketched for you.
> - Take advantage of any other hints you notice.
>
> When you have finished, answer the CONCLUSION statement at the bottom of the next page.

[Students are given some help. Page 5 of Appendix C starts students off with five outcome combinations shown. The page can be interpreted by students as having a table format indicating trends. Let your students figure out for themselves what hints are being provided. They find the challenge intriguing. Let them discover on their own a fundamental math strategy: c*ombinatory reasoning and problem solving*. Different students may come up with different strategies. The Grade 12 combination formula ${}_nC_r = (n!) \div [r!(n-r)!]$ is too abstract for Grade 6. The formula, by the way, does not work for the Blackfoot game due to its two identical sticks. The formula only works for specific ideal situations.]

24. The solution to the puzzle is found in Table X on the page just prior to Appendix A. Collect students' completed Page 5 of Appendix C for assessment. The number 12 is key to students answering their next set of questions.

25. Have a short class discussion about the different strategies students discovered and the advantages of some over others.

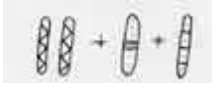
26. As students finish the puzzle on Page 5 of Appendix C:
Hand out Page 6 of Appendix C (More Questions) to students **individually** for summative assessment. The questions' numbering continues from Questions 1-4 on Page 2 of Appendix C. There is a place for students to write their answers on the handout page that they will hand in for assessment. Remind student.

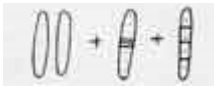
Question 5:

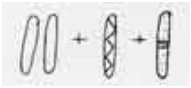
5.a. Underneath the four outcomes or combinations shown just below, on the first line write the **theoretical probability** of getting each outcome or combination.

b. On the second line, write the score you would earn if you got that combination in the game.


(i) ____, ____


(ii) ____, _____


(iii) ____, ____


(iv) ____, ____

ANSWERS:

(i) $^1/_{12}$ or 8.3˙% (ii) $^1/_{12}$ or 8.3˙ % (iii) $^1/_{12}$ or 8.3˙ % (iv) $^1/_{12}$ or 8.3˙ %

6 points 4 points 2 points 0 points

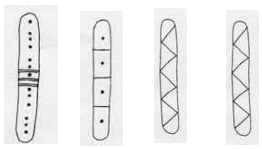
Question 6:
Consider your answers to Question 5. Is there any mathematical relationship between the probability of those four outcomes occurring (low or high probability) and the scoring system for these specific combinations in the Blackfoot game (i.e., receiving scores of 6, 4, 2, and 0, respectively)?
ANSWER: There is none at all.

Question 7:
"What is the short answer to the detective's questions?" ["This combination of sticks was worth six points and not zero points. Is that because it is a rare combination? Or is there another reason it was chosen as the best combination?"]
ANSWER:
There must be another reason for the Blackfoot scoring system. Maybe it has to do with the significance of the names of the sticks' pattern-side-up.

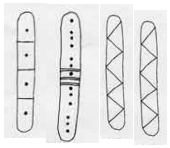
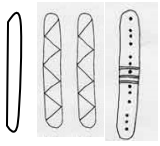
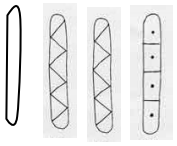
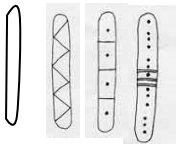
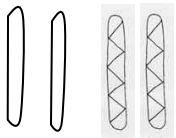
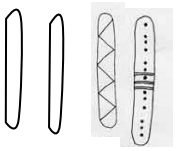
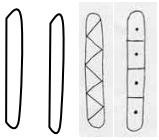
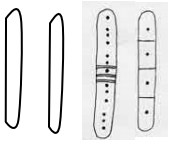
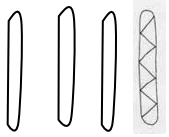
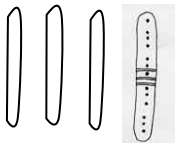
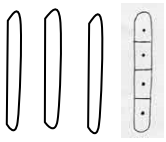
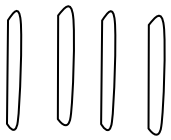
Question 8:
"Personally, would you expect any relationship to exist between a game's point system and the probability of scoring points? Explain your reasoning."
ANSWER:
Look for insightful answers to share with the class. A "no" answer is fine, but a good reason is required. An answer that deals with a difference between an Indigenous perspective and a mathematics perspective would tend to support a "no" answer. A "yes" answer that suggests a traditional Indigenous game would be mathematical in the Western mathematics sense of the word would suggest a student has more to learn about an Indigenous perspective's total independence from a mainstream Canadian mathematics perspective. The two perspectives represent the world very differently. It is not either one **or** the other, it is **both** in coexistence with each other.

Question 9:
"Briefly describe how you could find the experimental probability of the outcomes to the Blackfoot game."
ANSWER:
You could find the experimental probability by keeping a record of what results occurred when playing the game. Then you would calculate the probability for the combinations that did occur. This was the method followed in the first drop sticks activity (Appendix B).

Table X. Representations of all possible combinations: Outcomes from dropping these four popsicle sticks, patterned on one side, blank on the other side.



The blank side of the other four.

	# of outcomes
	1
  	3
   	4
  	3
	1
TOTAL	**12**

The probability of each of these 12 possible combinations appearing in the Blackfoot Confederacy Stick Game is $^{1}/_{12}$ or 8.3˙ %.

Appendix A

Indigenous Perspectives

Cree (Nehiyaw) Pow Wows

- This is an excellent authentic Saskatchewan website: (https://calendar.powwows.com/events/categories/pow-wows/pow-wows-in-saskatchewan/).

- Non-Indigenous people are warmly welcomed to watch a Pow Wow. (https://www.powwows.com/main/pow-wow-visitors-guide/).

These are the teachings that Sharon Meyer has received and her understanding of those teachings.

A Pow Wow is a celebration of all there is on Mother Earth. All dances are about honouring and respecting the four domains of the Medicine Wheel: the plant family, the animal family, and the elements of fire, water, wind, and rock. All Pow Wows infuse a celebration of all life.

A master of ceremonies directs all the action over a loudspeaker, thereby keeping the celebration organized. He cues upcoming types of dances and their accompanying singer/drumming group. He introduces the dance group and singers/drummers just before they begin.

There are several types of dances identifiable by the dancers' regalia, their body movements, and the rhythm of the accompanying drumbeat.

A Pow Wow begins with the *grass dance*. It symbolizes the millennial heritage of the Pow Wow. Long ago the grass dancers got the main (arbor) area ready where the grass grew high. The dancers' role was to pat the grass down and make the ground safe by filling in the gopher holes, so people would not hurt themselves by twisting an ankle. The grass dance's steps and drumbeat express a patting down motion. The grass dancers do not lift their feet very much; there is no kicking. They move in a circular motion to make sure the grass is patted down.

Men's and women's *traditional dances* honour all the relatives from the animal world. At one time, the regalia were made from animal hides decorated with items such as shells, porcupine quills, deer bone buttons, etc. – today commercial items. A traditional dance has a slow beat as it is close to Mother Earth's heartbeat.

Men's *fancy dances* are acrobatic. They specifically represent the fire, water, wind, and rock of Mother Earth, especially her storms, floods, forest fires, and tornados, for example. Their regalia have lots of colour. Some resembles lightening strikes. The dancers do a lot of twists, high kicks, somersaults and other acrobatic moves.

Women's *fancy dance* or *shawl dance* represents the insect and winged world such as butterflies. The dancers' shawls flutter like wings. The dancers' moves include high kicks. The drumming is the heartbeat of Mother Earth.

The newest Pow Wow dance is the *jingle dance*. It has healing properties. The jingles represent the sound that takes people into deep meditation. The jingles are for healing. This dance appeared to an Ojibwe man in a vision. He was shown the steps that heal. Unique to this dance, dancers only touch the ground with the balls of their feet. Their heels never touch the ground.

The women's *traditional dance* honours the keepers of the medicine. Their regalia has grass from armpit level to the ground. It sways rhythmically back and forth as the dancers move in a semi-rotation back and forth. The long fringes of the regalia connect the dancers to the energy of Mother Earth as the fringes touch Mother Earth. The dancers feel closer to the protection of Mother Earth's medicines. The traditional women dancers have a slow gliding step over the ground moving like a ghost gliding on the ground.

Pow Wows are anchored around the big drums each played by at least four or more singers. The minimum of four ensures that the four directions of the Medicine Wheel are always represented. Drums are first cleansed by tobacco smudging. Tobacco is also offered to the dancers; a reciprocal gesture reminding everyone of their reciprocal relationships with everything on Mother Earth. When several drumming groups play at a Pow Wow, they all attend at the same time. They take turns playing for each dance performed as directed by the master of ceremonies. Some people move closer to the group who is drumming. When you stand close, your body feels the drumbeat, the heart of Mother Earth.

Every Pow Wow dance has a different stepping pattern. Pow Wows celebrate Mother Earth in all ways.

The Blackfoot Confederacy (Niitsitapi)

The Blackfoot Confederacy consists mainly of the Kainai, Piikani, and Siksika First Nations whose hunting region traditionally covered land in what today is southern Alberta and land reaching into northern Montana and into Saskatchewan as far as the Great Sand Hills. The literal translation of: (1) Siksika is "black foot;" (2) Kainai is "many chiefs;" and (3) Piikani "scabby robes." The Piikani people divided into two groups. One moved to Montana and became the Blackfeet Nation of Montana. Therefore, today the Blackfoot Confederacy encompasses four First Nations.

In the early 1800s, conflict occurred between the Blackfoot Confederacy and the Saskatchewan Plains Cree (Nehiyawak) due mostly to disputes over hunting territory. A peace treaty was finally negotiated. At the time, both groups were aware of the devastating effects of the Europeans moving westward across Canada. A treaty with those Europeans would strengthen the Blackfoot's and Cree's positions, they anticipated. The peace treaty was signified by the two chiefs exchanging a son. Neither Nation would risk killing one of their own by initiating war.

Today one of the Blackfoot Confederacy's tourist attractions is Head-Smashed-In Buffalo Jump located near Fort Macleod, Alberta. It is a famous World Heritage Site.

Appendix B

Popsicle Stick Drop Activity

Page 1: Data Collection

Student's name: _____

Part I Procedure

- Hold the sticks *stacked flat*, *horizontally in your hand, with all blank sides facing up*. Your finger tips are pointing toward the floor.
- Drop them from shoulder height by spreading your fingers.
- How many *should have* ended up pattern-side-up? How many *did* end up pattern-side-up?
- Record your results in the PART I section of the table below.
- Repeat until you have dropped them 6 times in total.

Part II Procedure

- Hold the sticks *stacked flat, vertically in your hand, pinched by your thumb and finger at the top end of the bundle of sticks*, *with all blank sides facing the same way*.
- Drop them from shoulder height.
- Record your results in PART II of the table below.
- Repeat until you have dropped them 6 times in total.

Parts I and II Results: How many sticks ended up pattern-side-up?

	PART I Horizontal Sticks			**PART II Vertical Sticks**	
	What would be the most logical result in theory? (your prediction)	**What did occur? (your observation)**		**What would be the most logical result in theory? (your prediction)**	**What did occur? (your observation)**
1st drop					
2nd drop					
3rd drop					
4th drop					
5th drop					
6th drop					
My average =			My average =		
My group's average =			My group's average =		

Appendix B – Page 2: Data Analysis

Student's name: _____

PART I Analysis

Summarize your PART I data by filling in the blank cells in the following table.

What did happen in Part I Sticks held horizontally	**How often did it occur?** ***frequency***	**What is the chance of this happening?** fraction or % ***probability***
Number of pattern-side-up?		
The blank-side-up?		
TOTAL number of outcomes:		

PART II Analysis

Summarize your PART II data by filling in the blank cells in the following table.

What did happen in Part II Sticks held at one end vertically	**How often did it occur?** ***frequency***	**What is the chance of this happening?** fraction or % ***probability***
Number of pattern-side-up?		
Number of blank-side-up?		
TOTAL number of outcomes:		

PARTS I and II Analysis

1. What were the differences, if any, between your PART I results and your PART 2 results?

2. Summarize the results of the whole class. Are you surprised? Explain your answer.

3. ("Here's the answer, what was the question?" This is how Question 3 goes.) Comparing your Part I Analysis results to your Part II Analysis results, write a question that these results answer.

4. If you were going to make up a game that involved dropping popsicle sticks, which way would you have people drop the sticks in your game? Explain your reasoning.

5. You chose a First Nations pattern for your popsicle sticks. What did you like about that pattern?

Appendix B – Page 3: Conclusion

Student's name: _____

What Probability Would Be the Most Logical Result in Theory? **_____** (Your reasoned prediction)	**What Probability Actually Did Occur?** **_____** (Your observations and calculations)
What ***type*** of probability is this?	What ***type*** of probability is this?

A definition:

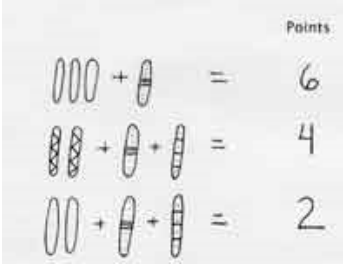
A definition:

Appendix C

Blackfoot Confederacy Stick Game

Page 1: Data Collection

Points earned are represented by the number of counting sticks (toothpicks) you have earned (up to 2, 4, 6, 8, 10, or 12 in one turn) from only the three possibilities of dropped sticks shown in the figure to the right. All other combinations are worth only zero. If you earn points on your first drop, you get to make a second drop once only in a turn.

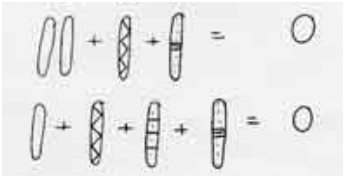


http://aboriginalperspectives.uregina.ca/games/game7.shtml

Keep track of your progress in the tables below. After each turn, enter the number of toothpicks (game points) in your possession even if it is zero.

Remember to print your name at the top of your table.

Most combinations of sticks are worth zero points, for example:



http://aboriginalperspectives.uregina.ca/games/game7.shtml

Player 1's name is:

Turn # →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Number of Counting Sticks at the End of Each Turn														

Player 2's name is:

Turn # →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Number of Counting Sticks at the End of Each Turn														

Appendix C – Page 2: Data Analysis

 This combination of sticks is worth 6 points. Is that because it is a rare combination? Or is there another reason it was chosen as the best combination?

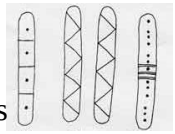
Here's what is happening on this page. These two questions have suddenly turned the Blackfoot game into something more like a detective problem. To solve it will take several steps of investigation on your part. You will be guided through those steps by a few questions and directions to help you ultimately answer the two questions above.

Step 1

You'll begin with something you learned in the Popsicle Stick Drop activity. Review a calculation for activity on page 2 of Appendix B. Remind yourself how you calculated the TOTAL number of outcomes. What did you have to know in order to do that calculation? Write those directions in your own words on your paper.

When you calculated the TOTAL number of outcomes, you were finding your *experimental* probability. Luckily, the same calculation works for a *theoretical* probability such as figuring out if a 6-point reward in the Blackfoot game is a rare combination theoretically.

Step 2

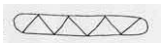
QUESTION: If you dropped these 4 sticks  that were all blank  on the other side, then *how many chances are there that a blank stick will show up*?

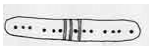
ANSWER: There are 4 blank sides in the group of sticks. So, there are 4 chances that a blank-side-up stick would appear.

Questions

Answer these questions on a separate sheet of paper to hand in to your teacher.

1.a. How many chances are there that  will land pattern-side-up? Explain your thinking.

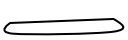
b. How many chances are there that  will land pattern-side-up? Explain your thinking.

c. How many chances are there that  will land pattern-side-up? Explain your thinking.

2. What is the TOTAL number of *chances* (possible outcomes) for all four sticks landing either pattern-side-up or blank-side-up? Hint: Include the information in Step 2 about blank sides of sticks showing up too. Explain your reasoning.

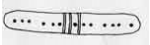
3. Are your answers to Questions 1.a to 1.c about *theoretical* probability or *experimental* probability?

4. Now that you know the total number of possible outcomes when you drop a bundle of four Blackfoot game sticks, you are ready to talk probability talk.

a. What is the probability that  will turn up in a stick drop? Show your calculation.

b. What is the probability that  will turn up in a stick drop? Show your calculation.

c. What is the probability that  will turn up in a stick drop? Show your calculation.

d. What is the probability that  will turn up in a stick drop? Show your calculation.

Answer Questions 5 – 9 *after* Step 5.

Appendix C – Page 3: Data Analysis

Step 3

You have figured out the theoretical probability of each stick landing pattern-side-up or blank-side-up. In your first stick dropping activity (Appendix B), you coloured all your popsicle sticks the same. You counted how many landed pattern-side-up and blank-side-up.

The Blackfoot game, however, was more complicated. Only two sticks are the same and the other two are different.

Step 3 is simply shifting your thinking from:

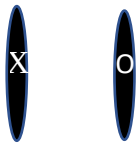
What happens to one individual stick?	*to*	What happens to the *combinations* of the 4 sticks?

The scoring system in the Blackfoot game depends on the *combination* of the 4 sticks. Shift your detective mind to consider this slightly new situation:

"What is the TOTAL number of possible ***combinations***?"

In the Blackfoot scoring system, only 3 combinations award players points. How many combinations are there in total? That's what your detective mind needs to figure out. Step 4's activity will help.

Step 4



You are going to practice your detective thinking on a simpler combination of popsicle sticks than the combination of 4 sticks in the Blackfoot game.
This is an activity with **2** popsicle sticks.

1. Mark 2 popsicle sticks; one with an X and the other with an O on one side only. The opposite sides are blank of course.

2. In pairs you will figure out the TOTAL number of possible *combinations* you can make with your sticks as if you dropped them. ***You can use any method to get your answer***, even dropping them. Stop when you think you have all the combinations there are.

3. In the spaces below, sketch all possible combinations (or outcomes) of sticks that could possibly result.

1.	2.	3.	4.	5.	6.

Students' names: _____

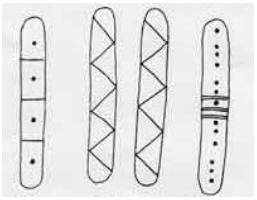
Check with your teacher. Are you now ready to answer the detective's questions?

"Is  worth 6 points because it is a rare combination? Or is there another reason it was chosen as the best combination in the Blackfoot Confederacy Stick Game?"

Appendix C – Page 4: Data Clarification

Step 5

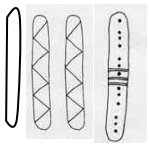
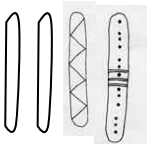
With a partner, you'll sketch a representation of all possible combinations that could possibly result from dropping these four popsicle sticks in the Blackfoot game.

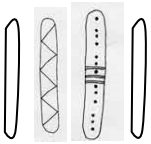
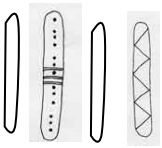


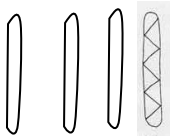
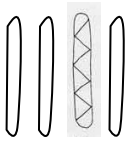
The blank side of the sticks is represented by: 

But first, let's make sure we all have the same idea of what a "combination" means in the world of mathematics? Let's find out! Here's a quick QUIZ!

Different or the same *combination*? At the right, circle the correct answer.

1.  and  Different Same

2.  and  Different Same

3.  and  Different Same

When you get 100% correct, you are ready to continue on in Step 5.

On the next page, draw all the combinations that could possibly result from dropping the four popsicle sticks in the Blackfoot game.

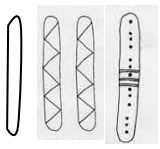
- You are given a head start by having five of the outcomes (or possible combinations) completed for you.
- Your sketches will fill in some of the blank spaces on that page but not necessarily all the blank spaces.
- The lines on the right-hand side are for recording how many outcomes are sketched in that row. Two of the rows already have two possible outcomes sketched for you.
- Take advantage of any other hints you notice.

When you have finished, answer the CONCLUSION statement at the bottom of the next page.

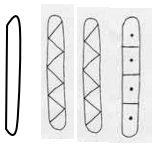
Appendix C – Page 5: Data Exploration

Students' names:_____

# of outcomes



___



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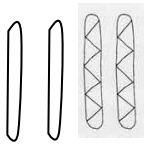
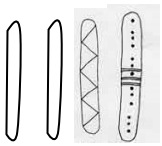
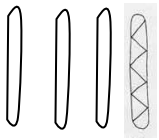




___



___

___

TOTAL ____

CONCLUSION

Fill in the blank in the following sentence.

The probability of each of these combinations appearing in the Blackfoot Confederacy Stick Game is ___.

Appendix C – Page 6: More Questions

Write your answers on this page please. Student's name: _____

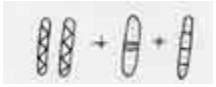
Congratulations! You have completed all five steps. It's time to answer and discuss the detective's questions:

"This combination of sticks was worth 6 points and not zero points. Is that because it is a rare combination? Or is there another reason it was chosen as the best combination?"

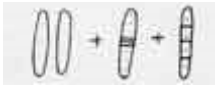
5.a. Underneath the 4 outcomes or combinations shown just below, on the first line write the **theoretical probability** of getting each outcome or combination.

b. On the second line, write the score you would earn if you got that combination in the game.

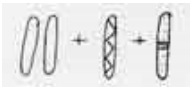
(i) ___, ___



(ii) ___, ___



(iii) ___, ___



(iv) ___, ___

6. Consider your answers to Question 5. Is there any mathematical *relationship* between the probability of those 4 outcomes occurring (low or high probability) and the scoring system for these specific combinations in the Blackfoot game (i.e., receiving scores of 6, 4, 2, and 0 respectively)?

7. What is the short answer to the detective's questions posed at the top of the page?

8. Personally, would you expect any relationship to exist between a game's point system and the probability of scoring points? Explain your reasoning.

9. Briefly describe how you could find the **experimental probability** of the outcomes to the Blackfoot game.