What are the Chances?

Unit Summary

After exploring basic probability concepts, students take on the role of game designers to design a fair game for a toy company. They describe the rules for play, explain how probability affects the fairness of the game, and present their game to the toy company's board of directors trying to persuade them to sell their game.

At a Glance
Grade Level: 3-5
Subject: Mathematics
Topics: Probability, Statistics
Higher-Order Thinking Skills: Implementation, Prediction
Key Learnings: Degrees of Likelihood; Predicting Skills; Understanding Probability; Determining Fairness
Time Needed: Seven 45-minute lessons

Things you Need
Assessment
Standards
Resources

Curriculum-Framing Questions

- **Essential Question**
  What's fair?
- **Unit Questions**
  Why is understanding probability important when playing a game?
  How does probability affect fairness?
- **Sample Content Questions**
  What is probability?
  How can you measure the likelihood of an event?
  How do you predict probable outcomes?

Assessment Processes

View how a variety of student-centered assessments are used in the What are the Chances? Unit Plan. These assessments help students and teachers set goals; monitor student progress; provide feedback; assess thinking, processes, performances, products; and reflect on learning throughout the learning cycle.

Instructional Procedures

Prior to Instruction

This unit of study makes use of the *Visual Ranking Tool*. Examine the *Visual Ranking Tool* as you plan instruction to learn about the tool and how to use it with your students.

Setting the Stage

Ask students if they have ever been in a situation where they had bad luck or good luck. Pose the Essential Question: *What's fair?* Break students into small groups and have them discuss the Essential Question and record their initial responses. Encourage them to talk about why they think life is fair or unfair, as well as what they mean by fair and what luck has to do with fairness. Ask several students to share their responses to the Essential Question and then tell them that they will begin a unit on probability. In this unit they design a fair game and learn how to use probability to determine how to increase their chance of winning. Introduce students to a learning log. The learning log is used to assess student thinking and give them an opportunity to reflect on activities and important questions.

Tapping Prior Knowledge

To address the Content Question, *What is probability?* introduce the idea of probability by discussing the likelihood of events occurring. Encourage students to focus on the language of probability as they use their life experiences to recall events that are certain, impossible, likely, and unlikely to happen. Record these events and introduce students to a probability scale, ranging from zero to one.

Determining Fairness

Bring in a variety of mathematical-based games. Discuss the rules of each game and brainstorm a list of characteristics

that make the game fair. Post these in the classroom to refer back to later in the unit.

What are the Chances? Activity
1. Overview of activity:
Students use the probability scale to determine how likely an event is to occur. They use prior knowledge to make inferences about the likelihood of an event.

2. Materials needed:
- Ribbon or string (about ten feet in length)
- Three large index cards with the following titles: 1-CERTAIN; 0-IMPOSSIBLE;1/2
- Trash can and ball of paper

3. Activity procedures:
Stand ten feet away from the trash can and hold the ball of paper in your hand. Ask the students, "What is the likelihood that I will be able to throw the paper into the trash can on my first try?" Focus the discussion on vocabulary such as likely, unlikely, probably, maybe, certain, impossible, and highly unlikely.

Revisit the term "probability" with the class and review its meaning. Probability can be defined as the chance of an event occurring. Ask students to name the instances that they have heard the term used in their everyday lives.

On the board, list the words likely and unlikely. Ask each student if they think it is likely or unlikely you will make the basket and tally their responses. Throw the ball of paper into the trash can. Have a discussion related to the outcome of your throw and if you threw the ball of paper again, *Would it result in the same outcome? Does the probability of it going in the trash can increase or decrease each time?*

To discuss the Unit Question, *How can you measure the likelihood of an event?* tell the class that probability can be expressed on a probability scale. Explain to the students that we will examine how you measure likelihood by using this probability scale. Place a long piece of ribbon or string on the floor representing the scale. Ask the students to name a number that would best represent an event that is impossible (0). Choose a student to stand at this position on the scale and hold a card marked, "0 IMPOSSIBLE". Ask students to name events that are impossible, for example: there will be 12 hours in the day tomorrow, there will be 13 months in the year next year. List student responses on a piece of chart paper.

Now ask students to name a number that would best represent an event that is certain (1), for example: there will be 24 hours in the day tomorrow, there will be 60 minutes in the next hour. Encourage students to name events that are certain and record their responses. Mark 1/2 on the scale and have a student stand halfway between 0 and 1 and hold the card "1/2". Ask the students to make a prediction about the weather for tomorrow and come up and stand on the position on the walk-on probability scale that best represents the likelihood of their weather prediction coming true. Students need to explain their reasons for standing at a particular spot.

As a check for understanding, have students create their own graphic organizers, making a probability scale and putting events at designated places along the scale. Also, have students reflect on the following Unit Question in their learning logs: *How do you measure the likelihood of an event?*

Use Visual Ranking to Rank Events from Most Likely to Least Likely
Before proceeding with the next activity, click here to set up the What Are the Chances? project in your workspace.

Introduce the *Visual Ranking Tool* using the demonstration space at Try the Tool. Show students how to rank and compare lists, and how to describe items and explain their relative merit using the comments feature.

The following questions are addressed in the Visual Ranking activity:
- What are the chances it will happen?
- How do you predict probable outcomes?

Students prioritize and rank the likelihood of certain personal events. The tool activity should spark lively discussions among group members and apply criteria to evaluate the lists.

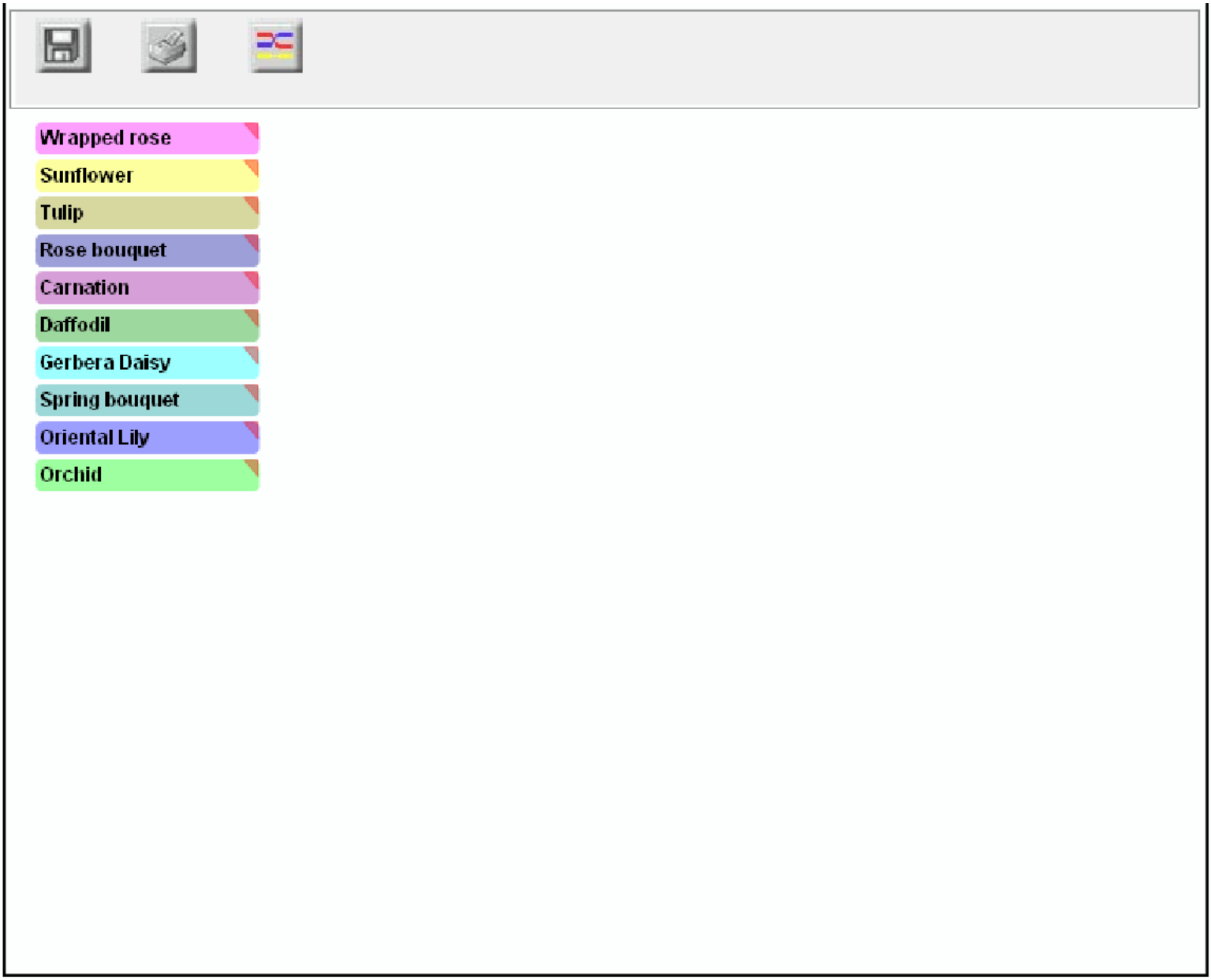
Have students log in to their *Visual Ranking* team space. Review with students the prompt for this project: *Which of the events are more likely to occur and why?* Rank the following events with the one that is most likely to occur on top. As students rank their events remind them to explain their reasoning for each item by using the comments feature of the tool. As students sort their lists, listen to their discussions and ask questions to help groups negotiate, make choices, and express their thinking. Questions such as the following can prompt students to elaborate on their thinking:
- *Why have you ranked the bottom 3 and the top 3 the way you have?*
- *What are the chances the event will happen?*
- *How did you decide that this event is more likely than that one?*

After students finish the exercise, have them compare their lists with the lists that were ranked by the other student groups. Direct students to read each other's comments about the relative merit of each factor. Have students discuss why their lists are alike and different. Suggest that they identify the groups that ranked items most and least like they did. Have similar and dissimilar groups meet to discuss their rankings and rationale behind the order. Encourage groups

to revise their thinking based on the things they learn from other groups.

Examine the Visual Ranking Activity
The Visual Ranking Tool space below represents one team's ranking on this project. The view you see is functional. You can roll over the red triangle to see the group's comments and click the compare button to see how different groups ranked the items.

Project Name: **What are the Chances?** (Click here to set up this project in your workspace)
Question: **Which of the events are more likely to occur and why?**



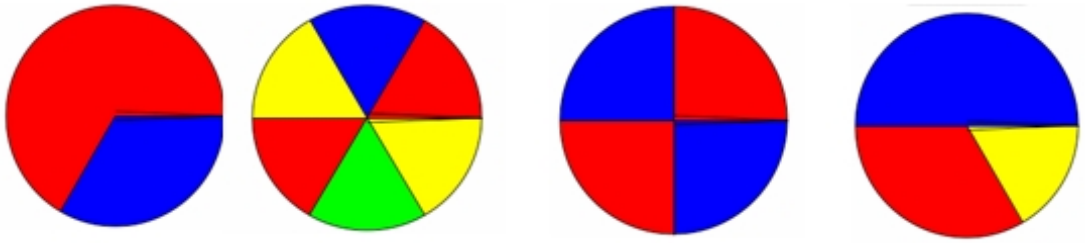
Whole Group Discussion
Using a projector system and networked computer display the lists and discuss general themes that appear. Ask students to consider: *Is any factor consistently in the top of the ranking? At the bottom of the ranking? How is where the factors are located (at the top or bottom) related to their degree of likelihood?*

Students have gained some understanding of how likely or unlikely an event is to occur. To gauge prior knowledge, have students respond in their learning log to the questions, *How can you be sure you've placed the factors in the correct order?* and, *How do you think you measure the likelihood of an event?* Review the entries and differentiate instruction based on student responses.

Secret Spinners: What are the Chances?
Tell students that today's lesson will focus on the exploration of the Content Question: *How do you predict probable outcomes?* In this activity students will be making inferences to predict outcomes and drawing conclusions about possible results. Create a spinner like the example below (you can use card stock, a brad (brass tack) and a paper clip) and ask them to name all of the possible outcomes (green, red, blue). Have students predict what color the spinner is most likely to land on and justify their responses.

Put students into groups of three or four and give each group a "secret spinner" (that you have created) in an envelope. Tell the students these are NOT to be shared with other groups, as they are top secret. Give each student a copy of the Secret Spinner handout.

Examples of secret spinners:



After predicting the results of their upcoming experiment, instruct the students to spin the spinner 30 times and keep track of their results on a frequency table.

Each group then shares the results of their probability experiment with the rest of the class. Based on the data presented, the class will predict what they think the group's secret spinner looked like. The group then reveals their secret spinner for the class to see. Discuss the results.

Ask students to conduct a think-pair-share to address the following question: *How do you predict probable outcomes on such things as spinners?*

Collect the Secret Spinner handouts. Have students respond in their learning logs to the following questions; *How do you predict probable outcomes?* and *How can understanding probable outcomes help you change your luck?* Review the entries to assess students' acquisition of key concepts and modify instruction as necessary.

Rolling Dice: What are the Chances?
To reinforce inferring skills and allow students to experience another probability lesson, conduct the following activity. Introduce the activity by displaying a large square number cube that has the numbers one to six. Ask students to name all of the possible outcomes that they could roll using the number cube (1,2,3,4,5,6). Ask students to determine if one number has a better chance than another when rolled and to explain their reasoning. Tell students that they will continue with the exploration of the Content Question, *"How do you predict probable outcomes?"* by examining dice in today's lesson.

Use the computer software program at What are your Chances?*

This program simulates the rolling of a number cube. Display the software program (see Internet resources) so that students can look at 1,000 rolls of a number cube and analyze the results.

Then ask what the possible sums are if the two dice are rolled. To tap prior knowledge, present the following scenario:

> Mario and Amanda are playing a dice game. Each time the dice are rolled, they find the sum of the dots. Mario gets a point every time a 10 is rolled. Amanda gets a point every time an 8 is rolled. Mario thinks he will win because he predicts a 10 will occur most often. Amanda disagrees and thinks she will win because she thinks an 8 will occur most often.

Ask students to write in their learning log whether they agree with Mario or Amanda or if they think some other sum will occur most often. Ask them to give their reasoning for their prediction.

Then have students work in groups to investigate the chances for rolling a particular sum. Have each person in the group create a number line for the possible sums (2,3,4,5,6,7,8,9,10,11,12) and place "x's" each time the sum is rolled. Have students roll the dice 15 times. Create a classroom frequency distribution graph (a number line with the "x's" to represent how many times each sum occurred). Ask students to compare their own group data to the whole class data. Ask students if the chances are the same for all of the sums, and if not, which ones are more likely to occur and which ones are least likely to occur.

Introduce students to the idea that a table can be a useful tool in showing the possible outcomes (mathematically) of the sums of two dice. After modeling how to fill in the table, have students complete it:

Second Die \ First Die	1	2	3	4	5	6
1	2	3	4	5	6	7
2	3	4	5	6	7	8
3	4	5	6	7	8	9
4	5	6	7	8	9	10
5	6	7	8	9	10	11
6	7	8	9	10	11	12

Ask students the following questions as you circulate through the room making observations and taking notes:

- *How many times does each sum appear in the table?*
- *Which sum is most likely to occur on the next roll of dice? Least likely?*
- *How many total possible outcomes? (36)*
- *What does this tell us?*
- *Who is most likely to win the dice game? What number would you pick?*

Introduce the probability game, Is this Game Fair?

> Ivan and Rhonda found some chips with odd markings and decided to make up a game using them. They played the game a few times, but Rhonda said it wasn't fair. Play their game and then decide if you think it is fair (each player has an equal chance of winning).

Materials:
1 chip with an **A** side and a **B** side
1 chip with an **A** side and a **C** side
1 chip with a **B** side and a **C** side

Rules:
Flip all 3 chips at once.

Score:
Ivan gets a point if there is a match.
Rhonda gets a point if there is no match.

Break students into pairs and have them play the game and tally the points in a T-chart. Ask each pair to share their tallies with the whole class and record them on a large sheet of paper. The students will decide that the game is unfair after seeing the class results. Then combine the pairs of students into groups of four or five and ask them to make up a fair game using these three chips so that Ivan and Rhonda would agree that they each have an equal chance of winning. Have the groups share their revised games with the whole class.

Now that students have had additional experiences with probability and gained new knowledge, have them revisit these questions in their learning log:

- *Why is understanding probability important when playing a game?*
- *How do you predict probable outcomes?*
- *How can understanding probable outcomes help you change your luck?*

Create and Present Your Own Game
Students apply what they have learned as they take on the role of game designers to create a new game for children ages eight through ten. Create an environment that fosters cooperation and decision making, by inviting local business owners to share in the product development process and by having students give feedback to one another. Providing opportunities for students to receive input from others will allow them to investigate alternatives they may not have considered themselves. Each team of designers creates a game using spinners, number cubes, or chips, and

- describes the fair rules for play
- explains why the game is fair
- uses probability language
- lists the possible outcomes for each player

Hand out and discuss the project rubric and the student checklist. Check for student understanding of project expectations and make sure students are using the checklist to guide the creation of the project.

Once students have designed and tested their games they need to create a multimedia presentation that will explain

their game to the audience at Game Night. In the presentation students address the Curriculum-Framing Questions, *How does probability affect fairness?, How can you measure the likelihood of an event?,* and *What's fair?*

To help students with the planning and implementing of their game idea and multimedia presentation remind them to use the student checklist to monitor their progress and the project rubric to assess their work. Check for student understanding of project expectations and make sure students are using the checklist to guide the creation of the project. To help students become self-directed learners, pose the following questions to guide their work:

- *What information do I need?*
- *What resources do I have?*
- *What are the smaller tasks within this big project?*
- *What do I have to do in a particular order and what can I do any time?*
- *What problems might come up and how do I handle them?*

Game Night
Invite parents, school faculty, and the toy and business representatives to attend a Game Night to recognize student work and learning. Students present their slideshows to the participants and then have time to play the games. Ask guests to give students feedback about their game.

Wrapping- Up
Return to the Essential Question: *What's fair?* Ask students to think about how they responded to the question at the beginning of the unit. Have them write their thoughts about fairness, chance, and probability in their learning logs. Encourage them to write about what they have learned about these things over the course of the unit and to provide as much detail and examples as possible. Have students complete the self-reflection about their work on the project.

Prerequisite Skills

- Basic fractions
- Addition
- Familiarity with multimedia presentation software

Differentiated Instruction

Resource Student

- Make modifications as dictated in the student's IEP.
- Provide visual aids and examples (documents, visuals and examples from this Unit Plan can be helpful).
- Supply an outline of the tasks and timeline for the final project (including milestones).
- Select group best suited to work with this student.
- Provide extra time as needed to complete individual assignments.

Gifted Student

- Students can bring to class games of their own and explain how they demonstrate the concept of fair games. Have the students consider whether it is a game of strategy or chance and explain their reasoning. Have students analyze the game for fairness and probability.
- Students can investigate games from different cultures and analyze them for fairness and probability, strategy or chance.

English Language Learner

- Provide visual aids and examples (documents, visuals and examples from this Unit Plan can be helpful).
- Try to use example games from student's native culture in an effort to link the unit to student's prior knowledge and experiences.
- Utilize the hands-on work of spinning spinners and rolling dice as well as the visual organizers (frequency graph, tables, visual reasoning) in helping students understand and conceptualize the content.

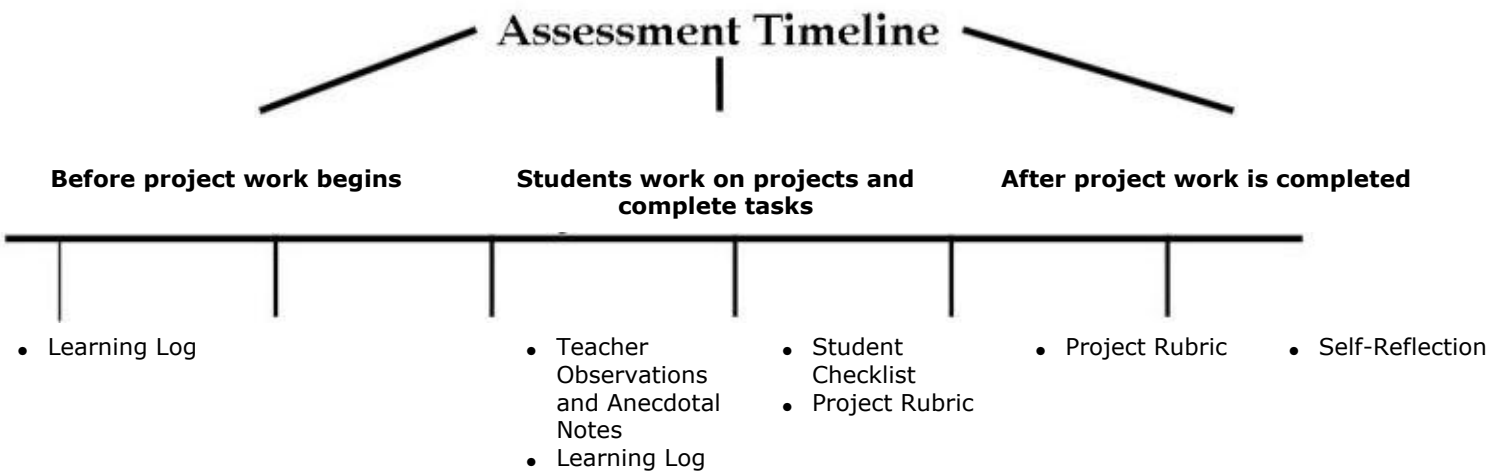
Credits

A teacher contributed this idea for a classroom project. A team of educators expanded the plan into the example you see here.

Visual Ranking Tool: What are the Chances?

Assessment Plan

Assessment Plan



Throughout the unit monitor and listen carefully to student thinking, ask probing questions such as, *How do you know that works?* and *Are those all the possibilities?* Preview drafts, and give students feedback as they work through project activities. Have students check work with their group members and make appropriate revisions. Use student learning logs to assess student thinking (inferring, drawing conclusions, prioritizing, predicting) and to monitor their mathematical understanding as they move through the unit.

Students use the final project rubric and student checklist to self-assess their work before submitting work to the teacher for assessment. Upon completion of the unit each student completes a self-reflection of their progress in this unit.

Visual Ranking Tool: What are the Chances?

Content Standards and Objectives

Targeted Content Standards and Benchmarks

Targeted NCTM Content Standards

Probability and Statistics Standard for Grades 3-5

In grades three through five all students should:

- Understand and apply basic concepts of probability.
- Describe events as likely or unlikely and discuss the degree of likelihood using such words as certain, equally likely, and impossible.
- Predict the probability of outcomes of simple experiments and test the predictions.
- Understand that one can measure the likelihood of an event—represented by a number from zero to one.

Problem-Solving Standard for Grades 3-5

In grades three through five instructional programs should enable all students to:

- Solve problems that arise in mathematics and in other contexts.
- Build new mathematical knowledge through problem-solving.
- Apply and adapt a variety of appropriate strategies to solve problems.
- Monitor and reflect on the process of mathematical problem-solving.

Connections Standard for Grades 3-5

In grades three through five instructional programs should enable all students to:

- Recognize and use connections among mathematical ideas.
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole.
- Recognize and apply mathematics in contexts outside of mathematics.

Student Objectives

Students will be able to:

- Make predictions about whether a given game is fair or unfair
- Carry out investigations
- Display data in a chart
- Draw conclusions based on the data
- List the mathematical possibilities for all possible outcomes
- Compare the results of the investigations to the true mathematical probabilities

Visual Ranking Tool: What are the Chances?

Resources

Materials and Resources

Printed Materials

- Cushman, J. and Weston, M. (1991) *Do you wanna bet?:Your chance to find out about probability*. Boston, MA: Clarion Books.

Supplies

- Number cubes
- Square box labeled with numbers 1-6
- Spinners (teacher-made or purchased)
- Ribbon or string
- Index cards

Internet Resources

The Shoder Foundation Web site offers technological tools for probability experiments and analyses. This site offers computer simulated probability experiments with pre-set spinners, make your own spinners, and dice sums allowing students to experiment with large numbers of spins or rolls and analyze the frequency table of results. This is a great site for exploring and learning that large numbers of trials produce better estimates of relative frequencies of events. Below are direct links to specific activities:

- www.shodor.org/interactivate/activities/prob/index.html*
  Pre-set spinners, Make-your-own spinners, and Dice sums with frequency tables
- www.shodor.org/interactivate/activities/race/index.html*
  Racing game with one die
- www.shodor.org/interactivate/activities/racing/index.html*
  Racing game with two dice
- www.shodor.org/interactivate/activities/dice/index.html*
  Two dice and a table
- www.shodor.org/interactivate/activities/chances/index.html*
  Games of chance
- www.shodor.org/interactivate/activities/spinner/index.html*
- www.shodor.org/interactivate/activities/spinner3/index.html*
  Adjustable Spinners

Other sites that offer probability software include:

- The National Library of Virtual Manipulatives
  http://nlvm.usu.edu/en/nav/frames_asid_186_g_2_t_5.html?open=activities*
  This site is the National Library of Virtual Manipulatives and includes spinners that students can create and spin for results.

- The National Center for Education Statistics
  http://nces.ed.gov/nceskids/Probability/dice_handler.asp?NUMROLLS=16*
  This site is the National Center for Education Statistics and involves rolling dice virtually. Students can choose how many times to roll two dice and the results are shown graphically as well as in a list form for die one and die two.

Technology – Hardware

- Computer to use the tool and complete assignments
- Projector to show students examples and model expectations
- Internet connectivity to use the *Visual Ranking Tool*

Technology – Software

- Multimedia presentation software to create student slideshow presentations
- Word Processing software for teacher-created materials
- Internet browser to use the *Visual Ranking Tool*

Project Rubric

What are the Chances?

CATEGORY	4	3	2	1
Content Understanding	I include an explanation of the probable outcomes, measures of likelihood, and what makes a game of chance fair or unfair.	I include an explanation of probable outcomes, measures of likelihood, and what makes a game of chance fair or unfair, but I may have overlooked or misunderstood some supporting ideas or details.	My explanation of probable outcomes, measures of likelihood, and what makes a game of chance fair or unfair is incomplete or unclear.	My explanation does not include probable outcomes, measures of likelihood, or what makes a game of chance fair or unfair.
Accurate Measures	I use accurate measures of likelihood and mathematical possibilities for all possible outcomes to demonstrate my game's fairness.	I use some accurate measures of likelihood or mathematical possibilities for all possible outcomes to demonstrate my game's fairness.	I make errors in measures of likelihood or mathematical possibilities for possible outcomes in demonstrating my game's fairness.	I do not use measures of likelihood or mathematical possibilities when creating my game.
Visual Representation	I use clear and elegant organized lists, tables or other visual displays to represent and communicate about probable outcomes.	I use appropriate and accurate organized lists, tables, or other visual displays to represent and communicate about probable outcomes, but they may not be clear.	I make some errors in using an organized list, table, or other visual display to represent and communicate about probable outcomes.	I do not use visual representations or I have major errors in my organized list or table when I try to represent and communicate about probable outcomes.
Self-direction	I use all of the following processes to plan and complete the project: I think about the information I need, the resources I have, the important pieces to work on first, and the problems that might arise and how I will deal with them.	I choose some processes that help me plan and complete the project.	I need assistance in choosing processes to help me plan and complete the project.	I do not use processes to help me plan or complete the project.
Completion	I successfully complete all parts of the task.	I complete most parts of the task.	I complete some parts of the task.	My work is incomplete.

Mathematical Communication	I effectively share my ideas, ask appropriate questions, show my work, explain my process and reasoning, and justify my answers.	I usually share my ideas, ask appropriate questions, show my work, explain my process and reasoning, and justify my answers.	I need reminding to share my ideas, ask appropriate questions, show my work, explain my process and reasoning, and justify my answers.	I fail to do most or all of the following: share my ideas, ask appropriate questions, show my work, explain my process and reasoning, or justify my answers.
Presentation and Organization	I design my presentation to persuade the toy company to choose my game to sell. I use original and inventive ideas. My presentation is direct, lively, and delivered with feeling. My information is presented in a way that captures the audience's attention.	I design my presentation to persuade the toy company to sell my game. I attempt to be direct, lively and full of feeling, but it doesn't come across as natural. My information is presented in a way the audience can understand my main points.	I design my presentation to share my game but am not effective in persuading the toy company to choose my game to sell. I don't think about how I can persuade the audience with my presentation. My information is out of order making it hard for the audience to understand my main points.	I do not match my presentation to the topic, audience or purpose. My Information is disorganized.

Secret Spinners

1. List all of the possible outcomes for your spinner (all the possible colors you could land on).

2. Predict how many times the spinner will land on each of the outcomes if you spin the spinner 30 times.

OUTCOMES	PREDICTED FREQUENCY (How many times will it land on the color?)

3. In your group, take turns spinning the spinner 30 times. Record your results in the chart below.

OUTCOMES	FREQUENCY

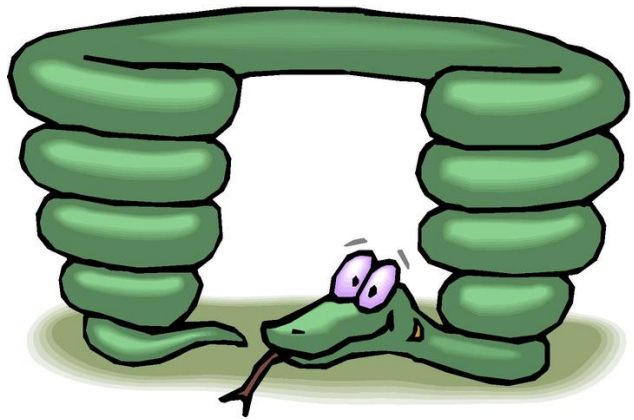
What are the Chances?

Use this checklist to guide your work.

Game	Yes
We've created a title for our game.	
We've created a list of materials needed to play the game.	
We've stated the objective of the game.	
We've stated the rules of the game.	
We've created all the pieces to successfully play the game.	
Audience	
We have listed at least 3 reasons why we think the toy company should choose our game.	
We considered the audience and the purpose while creating our presentation.	
We put our best effort into creating high-quality work.	
Multimedia Presentation	
We've created a title slide that includes team members.	
We've included our guidelines for creating a new game for a toy company.	
We've explained how probability proves our game is fair.	
We've answered the Unit Question: *How can you measure the likelihood of an event?* • Created a visual representation of why our game is fair • Included at least 2 visual representations of the games possible outcomes • Explained the likelihood of winning the game by using probability	
We've used probability language.	
We've offered our opinions in response to the Essential Question, *Can you change your luck?*	

Snake

A new game for your toy company

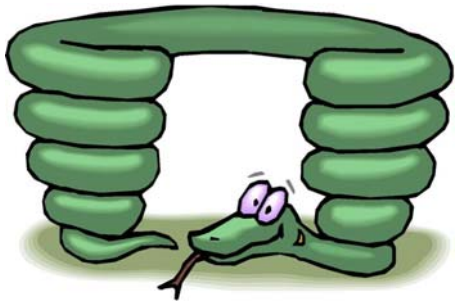


Presentation by Toy Designers:

Shawntee

Max

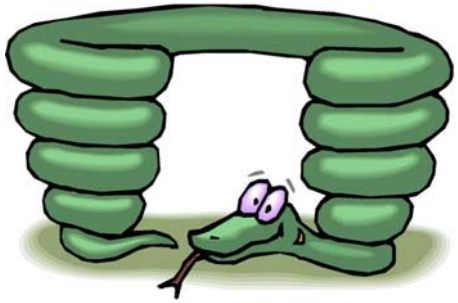
Ashley



Snake

As game designers, we believe that
the new game for your company should:

- Be equally likely, giving each player an equal chance of winning
- Be a game of chance
- Appeal to kids 8-10 years old
- Be fun
- Require you to know a little probability to win



Snake

Our proposed new game for ages 8-10, *Snake*:

You will need:

- Two dice
- Scoring Pad
- Pencil with eraser

Player One	Player Two

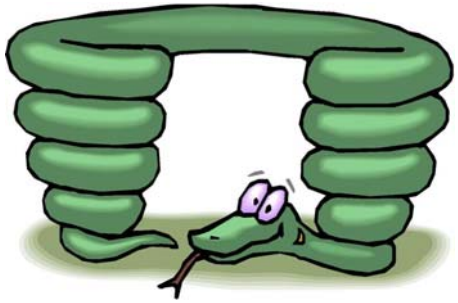
Snake Rules

Object of the Game: To get to 100

Rules of the Game:

- Roll the dice to see who starts: the player with the highest sum goes first.
- Roll the dice and add them up.
- On your turn, you can keep rolling as long as you want…
- BUT, if a 1 comes up on the dice, you get 0 points for that turn and your opponent gets his/her turn.
- If a 1 comes up on both dice, your total goes back to 0 (Even if you are at 98!), and you also lose your turn.
- The next player rolls the dice, adds them up, and keeps rolling as long as they want with the same consequences if a 1 or two 1's come up.
- The first player to get 100 wins the game.


But is Snake Fair?



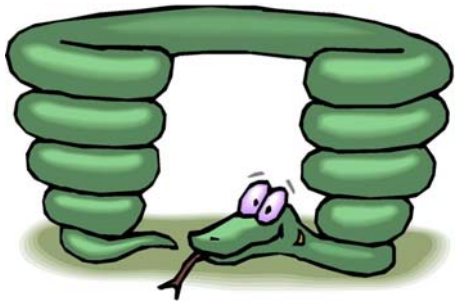
Snake

*It **IS** a fair game because:*

- Each person can roll the dice as much as he or she wants to until they get a 1 or two 1's (snake eyes).
- Rolling the dice is a game of chance that gives each player the same opportunity to roll snake eyes.

BUT knowing probability, can increase a player's luck:

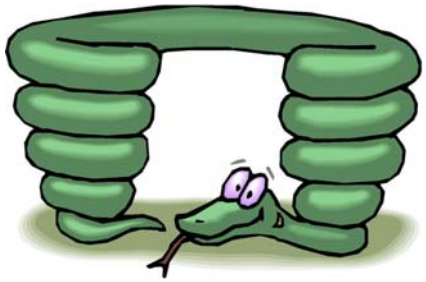
- It helps if you can predict how often 1's will come up.



Snake

The total possible sum outcomes when rolling two dice are as follows:

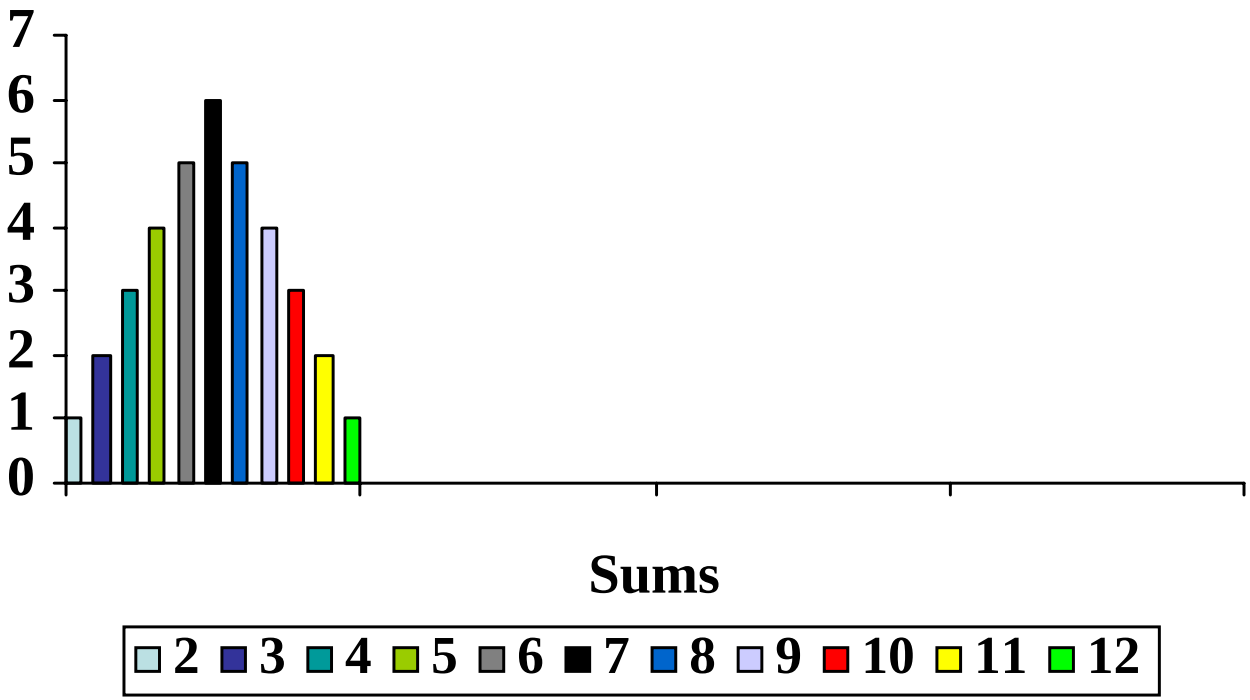
Second Die \ First Die	1	2	3	4	5	6
1	2	3	4	5	6	7
2	3	4	5	6	7	8
3	4	5	6	7	8	9
4	5	6	7	8	9	10
5	6	7	8	9	10	11
6	7	8	9	10	11	12

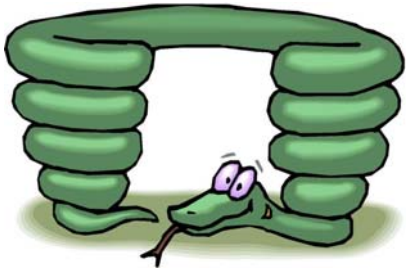


Snake

As you can see from the graph if you add up the number of times each sum appears:

Snake's Possible Outcomes

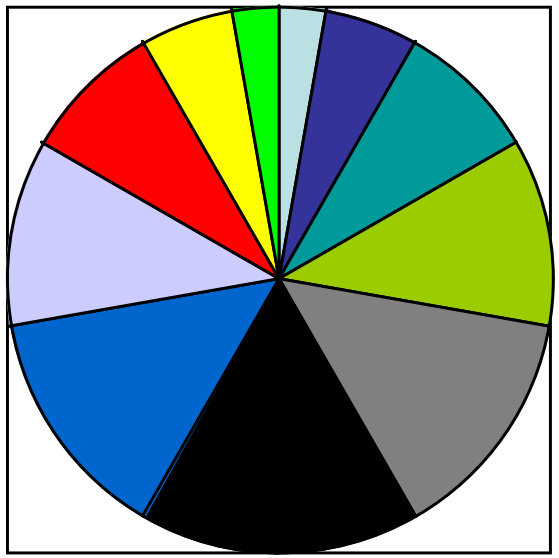




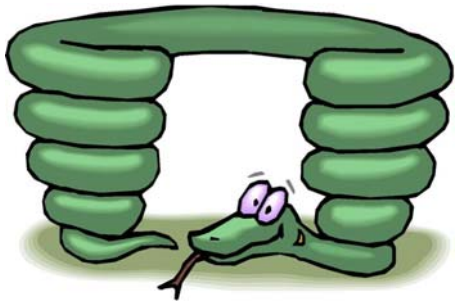
Snake

You can also see all the possible outcomes with a circle graph.

Snake's Possible Outcomes



2 3 4 5 6 7 8 9 10 11 12



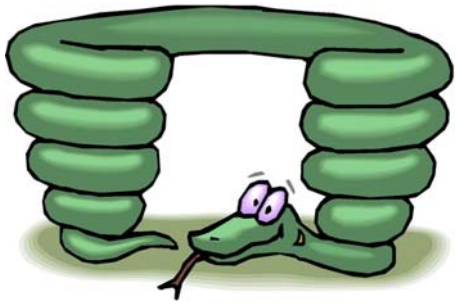
Snake

If you look closely at the table you can see where the possibilities for getting one 1 on a die or two 1's on both dice (snake eyes) in red.

- *There are 10 possibilities for getting one 1.*
- *There is only 1 possibility for getting snake eyes.*
- *All of the rest of the sums left is your possibility of NOT getting a 1.*

First Die

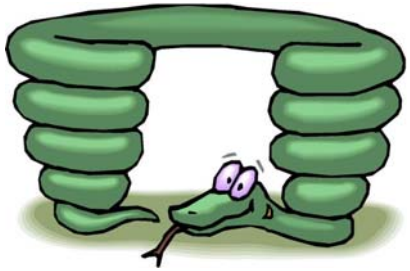
Second Die	1	2	3	4	5	6
1	**2**	**3**	**4**	**5**	**6**	**7**
2	**3**	4	5	6	7	8
3	**4**	5	6	7	8	9
4	**5**	6	7	8	9	10
5	**6**	7	8	9	10	11
6	**7**	8	9	10	11	12



Snake

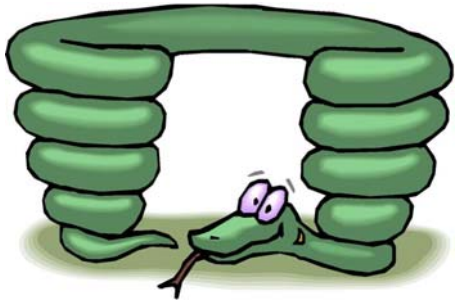
So, in order to make a decision about when to quit rolling, you need to know the chances of getting one 1 or snake eyes:

- To get one 1, your chances are 10 out of 36 possibilities--or **unlikely** because you have 26 out of 36 chances of NOT getting a 1 on either dice. Pretty good odds that you won't get a 1, but it is still possible!
- To get two 1's your chances are 1 out of 36 possibilities--or **very unlikely**! (but not impossible)



What's fair?

- We know that sometimes things in life aren't always fair. Many games we play are made to be fair and are based on probability. If the rules of the math game are fair and you know probability, you have a better chance of winning.
- As long as each person has an equal chance, then you can say, it's fair!



Conclusion

We believe that you should choose our game because:

- It is fun.
- It involves some knowledge of probability. If you know probability, your chances of winning are better and you can increase your luck.
- It is a fair game because each player has an equal chance to win.
- It will be a game that 8-10 year olds will love to play.
- It won't cost you much to make it, so you can make a lot of profits.

In Conclusion:

It is our hope that you choose Snake to represent your company and that it will help you make a lot of money.

Name:_____ **Date:**_____

Self-Reflection

Answer the following questions in complete sentences.

1. Why is understanding probability important when playing your game?

2. How did you predict probable outcomes?

3. How did you make sure your game was fair? How did the game give each player an opportunity to win?

4. How does skill play a part in your game? How does luck play a part in your game?

5. How did the class activities help you design your game?

6. What did you like best about this project? What would you change?

Learning Log Questions

The following are additional sample questions for student learning log entries. Various questions and prompts are embedded within the Unit Plan.

1. What strategies did you use to make your game appealing to the toy company? Did any of your strategies not work?

2. What problems came up as you invented your game and how did you handle them?

3. Notes from the experts: What suggestions would you give someone else inventing a game? Give ideas and hints for a student doing this project next year.

4. What did you learn from this project that will help you in future work?

5. How did you solve problems during this project?

6. Who did you help and how?

7. Who or what helped your group create a good game and presentation?