

## **Probability and Statistics as Helpers in Real Life**

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### **INTRODUCTION**

The theory of mathematical probability is a little over three hundred years old. Since its discovery by Pascal and Fermat in the seventeenth century, it has become an integral part of our everyday lives. At one time or another all of us have made decisions by taking chances, throwing dice, or drawing cards. Frequently we have made judgments based on the likelihood or probability that a certain event will happen. Developments in the theory and applications of probability range from simple informal activities to important fields as the physical sciences, genetics, the social sciences, economics, industry, engineering, and insurance. Because of its widespread use, the theory of probability should be presented in elementary mathematics classes.

Graphing, statistics, and probability are important topics in mathematics. All these content areas play a significant role in a student's education from kindergarten through all the upper grades. This is essential to experiment in order to understand the applications and concepts of probability and statistics.

The two areas of statistics and probability are related but, at the same time, are distinct. Data are frequently gathered for situations whose exact outcomes cannot be predicted but have a probabilistic or chance nature. Some information about past occurrences is used to make those predictions. For example, if we toss a coin, we know that the probability is 50% for each side; however, if we toss it ten times, we will not always get 5 heads and 5 tails. During this curriculum unit, we will give sample activities for the development of the concepts. Teachers can use them as models to create further activities in each area, and because the data for the activities come frequently from other content areas (like science or social studies), this is a great opportunity to integrate different kinds of knowledge. Probability and statistics are also a good pair of tools to capture a wide spectrum of students' interests. Students can collect data from any area of interest to them, and, then, analyze, interpret, and share this data with all their classmates.

Graphs can be used to illustrate information and enhance comprehension of the problem solving as they are applied in the whole curriculum. Many situations in life are based on the mathematics of this chapter. Numerous professions and businesses are dependent on the basics of probability and statistics. Technology is making the exploration and application of these topics more an integral part of our life through newspaper graphics, tables, and charts. Therefore, the mathematics curriculum must emphasize these topics across the curriculum.

### **OBJECTIVES AND ACADEMIC SETTINGS**

These units of study have some basic objectives. At the end of the unit, the students must:

- Understand the concepts of probability and statistics and their uses in the real world.
- Improve their mathematic vocabulary and adopt some terms related to these areas.
- Decide and elaborate different kinds of graphs looking for the best way to show their conclusions.

Furthermore, this curriculum unit will try to integrate the concepts of probability and statistics in students' real life activities, following the Texas Essential Knowledge and Skills objectives (TEKS). In this unit the students will experiment with probability devices (coins, spinners, dice, and games of chance). They will become familiar with concepts like chance, certainty, and likelihood. In addition of this, they will analyze many examples of probability in daily life and will make connections to other content areas like science and social studies (e.g. weather and changes in science or immigration statistics, or health statistics for social studies).

The Curriculum unit will take around 8 to 10 days. The students will review these probability and statistics concepts, and they will develop math, science, social studies, and language arts projects. In mathematics, they will create a board game where the players will have to use their math skills. For science, they will make experiments using different kinds of variables and predicting the results. In the social studies connection, they will analyze some issues related to their environment and will use probability to find the best solution. Finally, in language arts, we will improve vocabulary and the way that the students communicate the results of their projects (presented using a power point).

I teach bilingual students, most of them with limited English proficiency and from low-income families. It is an important fact to consider since there is some research about math achievements for native and non-native English speakers. A study investigated math achievement differences between English language learners (ELLs) and fully English proficient (FEP) students on a literacy-based performance assessment (LBPAs). It has been assumed that LBPAs are superior to standardized multiple-choice assessments, but it has not been determined if LBPAs are appropriate for measuring the math achievement of ELLs. The most salient characteristic of LBPAs is that students read multi-level questions and explain how they solve math problems in writing. Thus, LBPAs place great literacy demands upon students. Because most ELLs have underdeveloped literacy skills in English, these demands put ELLs at a great disadvantage. The conclusion is that LBPAs, together with the current assessment-driven accountability system, seriously undermine equal treatment for ELLs (Brown). For this reason, it would be better for the bilingual students, especially in lower grades to explain the procedures and algorithms in their native language (Brown).

## **TEACHING PROBABILITY, STATISTICS, AND COLLECTING AND ANALYZING DATA**

### **Probability**

This is the branch of mathematics which analyzes the chance that some particular event occurring. The theory concerns basically how to predict the likelihood that something will or will not happen. In order to get that, we must consider the number of actual outcomes and the total number of possible outcomes:

$$\text{Probability of an event} = \frac{\text{number of actual outcomes}}{\text{total of possible outcomes}}$$

However, probability is useful only in situations in which outcomes can be specified with a high degree of accuracy for large number of occurrences, but not for an individual occurrence. For example, in a large number of coin tosses, heads and tails will occur each about 50% of the time. In tossing two six-sided dice, seven occurs one-sixth of the times, but we cannot know with certainty the outcome of a specific dice toss.

I am sure that we, as teachers, have heard the question: how is that going to be useful for me? Studying probability will help children to develop critical thinking skills and to interpret the probability that surround us daily. Students should begin by doing simple experiments like the coin and dice toss. A good one is to toss a coin 30 times and record how many heads and how many tails you get from a set number of tosses. After that, the students must represent the

occurrences as a fraction. For example, if the outcome was 14 heads, the fraction 14/30 would be the ratio of heads to the number of tosses and 16/30 would be the ratio of tails to the number of tosses.

Other activities for kids from K to 5<sup>th</sup> grade would be:

- Place five cards with the numbers 0 through 4 on them in a cardboard box. Calculate what is the probability of drawing a card with a number less than 5 on it. What is the probability of drawing a card with a number greater than 4? The students must learn with this activity that if an event is sure to happen, the probability is 1, and if the event is sure not to happen, the probability is 0.
- Draw a tree diagram showing the outcomes of draws from a bag containing twelve red marbles and four black marbles. Marbles are drawn from the bag with replacement. Three draws are made. What are the possible outcomes?
- Get a pencil and measure its length. Draw parallel lines on the paper that are 1.5 times as far apart as the length of the pencil. Drop the pencil onto the paper from a height of about 1 meter. Record on a chart how many times the pencil touches a line or does not touch a line. After a certain number of trials figure the probability that the pencil will touch a line when dropped. Does it make a difference if the pencil is longer or shorter? What would happen if the pencil does not land on the paper?
- Determine how many arrangements can be made from the letters in the word “figure.”
- How many different numbers we can make using the first 4 digits.
- We have a bag with ten color tiles. There are six blue, three red, and one yellow. If you draw from the bag one time, predict the color you would get and why you would think this happen.

### ***Applications***

Probability has different applications. Some of them are:

- Permutations: A *permutation* is an arrangement of a group of objects in a particular order. There are many problems involving permutations. For example, we want to seat 4 students (A, B, C, and D) in 4 different seats. How many different ways could we seat them? To solve this problem, students can do it in an experimental way or explaining to them the concept of *factorial*. Factorial ( $n!$ ) is a series of multiplication of consecutive integers. Then,  $4! = 4 \times 3 \times 2 \times 1 = 24$  We also must precise that  $0! = 1$ . Some activities about permutations could be: How many three-letter arrangements could be made with the word *probability*? A number of students are competing for three prizes, how many ways can the medals be awarded? How many 7-digit phone numbers can be made using all the digits just once?
- Combinations: Unlike permutations that require a specific arrangement and an order, a *combination* is a group of objects in which the order or arrangement of the objects is disregarded. The formula for combinations is as follows:

$$nCx = nPx / x! = n! / x!(n-x)!$$

where  $n$  is a number of objects and  $x$  is a number of objects taken from  $n$ .

Some exercises with combinations would be: Place eight different books over a table. How many pairs of books may be selected (order does not matter)? Find the number of combinations of five objects taken from a group of nine objects. How many diagonals can be drawn in an octagon? In how many ways can seven questions out of ten be chosen on an examination?

- *Sample Space*: To perform experiments scientists must select individuals or samples from a population. A random sample is one in which each member of the population has an equal chance of being selected. If selections favor certain individuals or events, the sampling is said to be biased. The result of each experiment is called an event or outcome, and the set of all possible outcomes is known as a sample space. For example, let's suppose a bag contains ten red marbles and ten green marbles. If we take two marbles, there are 4 possible outcomes: R-G, R-R, G-R, or G-G. All the sets of possible outcomes is called the sample space.

### New Terms

In addition to the applications explained before, the students must know some concepts to understand the different situations in which probability could be useful.

Among those terms we have:

- *Independent Events*: Two or more events are independent if the occurrence of one event does not affect the occurrence of any of the others. If one coin is selected at random from a box containing dimes and quarters and is replaced, the result of this selection would not affect the result of a second selection. These two drawings are independent events.
- *Dependent Events*: Two events are dependent if the occurrence of one of the events affects the probability of the occurrence of the other. Consider a box that contains seven white, five green, and four blue pieces of chalk. If two pieces of chalk are drawn from the box, and the first piece is not replaced before the second piece is drawn, the outcome of the first selection affects the outcome of the second drawing. The probability of drawing a piece of blue chalk the first time is  $4/16$  or  $1/4$ . If a piece of blue chalk is drawn first, then three of the remaining pieces of chalk are blue, and the probability of getting a piece of blue chalk on the second draw is  $3/15$  or  $1/5$ .
- *Mutually Exclusive Events*: Mutually exclusive events are two or more events that cannot occur simultaneously. If one dice is thrown and comes up three, it cannot come up six or any other number at the same time. If a coin is tossed and comes up tails, it cannot come up heads on the same toss. If a person weighs 125 pounds, he cannot have any other weight simultaneously. The probability of one or the other of two mutually exclusive events happening is the sum of the separate probabilities of these events.

### **Statistics**

The study of statistics is important in the elementary grades because society frequently organizes and expresses data numerically (Hoel 88). Students need to be aware of how statistics can be manipulated to say whatever one desires. Media experts can use statistics to mislead consumers. Reports of medical information or opinion surveys must be examined carefully before drawing conclusions. Students should be aware of how statistics shape our lives and influence our decisions. There are many misconceptions about data because key questions have not been asked: How many people were in the sample, how was the population sampled, who conducted the survey, and how were the data summarized? We must learn how to process this information accurately and effectively.

One of the first concepts in statistics encountered in daily life is *average*. We heard that word from doctors, teachers, politicians, etc. The average is a measure of central tendency of data, or an attempt to describe what is typical in a set of data. There are three measures that are commonly used to describe ways of viewing what is typical in a data set. They are mean, mode, and median.

When the term average is used, it most is used to denote the mean. However, the mean is frequently not the best measure to use. Now, we have to keep in mind that an average is a single

value that is used to represent all the values in a set. Clearly, no single value can do that perfectly but different kinds of averages represent the set in different ways. Each conveys a particular meaning and is appropriate for certain situations. We will define three different averages: mean, mode, and median:

- **Mean:** The mean or *arithmetic mean* is most commonly used to describe the “average” of a set of data. The mean is computed by dividing the sum of the numbers by the number of members in a set. For example if we measure the height of 4 students and we get: 1.54, 1.60, 1.38, and 1.28, our mean will be  $1.54 + 1.60 + 1.38 + 1.28 = 5.80$  divided by  $4 = 1.45$ . Students must practice with different sets of numbers obtained by themselves and apply the algorithm to understand how to get the arithmetic mean. Three examples of these exercises would be:
  - Keep a record of your test scores for one marking period. At the end of the marking period find the arithmetic mean of the test scores.
  - Measure the height of each student in the class. Find the average height of the students in the class.
  - On a vacation, Jack bought gasoline as follows: 10 gallons \$1.29 per gallon, 15 gallons \$1.19, and 12 gallons \$1.23. What was the average price per gallon?
- **Mode:** The second measure of central tendency is the mode. Because an extremely high number or an extremely low number can distort the picture of the tendency shown by the mean, the mode is frequently used. The mode of a set of numbers is that numbers that occur most frequently in the set. If there is not a more frequent number then there is no mode, if there are two numbers with the highest frequency, then the set of data is bi-modal. For example, in the set following set of numbers: 4, 55, 21, 4, 2, 8, 12 the mode would be 4. In this set: 1, 2, 3, 4, 5 all the numbers show up the same number of times, then the set does not have a mode.
- **Median:** This is the third measure of central tendency. The median of a set of numbers is the middle number of the set. The algorithm to find the median is to order the numbers from the least to the greatest, and choose the position of the middle score. For example, if the numbers are 14, 6, 8, 8, 5, 12, 34, 23, and 2 we will have to arrange them: 2, 5, 6, 8, 8, 12, 14, 23, and 34. Then we will look for the middle position, in this case the fifth position is the number eight. If the total amount of numbers is an even number, we should add the two numbers in the middle position and divide them by 2. That will be the median for that set of numbers. For example, if the numbers are 2, 6, 6, 3, 14, 23, 10, 5, 8, 9, after arranging them we will have: 2, 3, 5, 6, 6, 8, 9, 10, 14, and 23. The two numbers at the middle are 6 and 8. If we add them and divide 14 by 2, the median will be 7.

Although not as common as those mentioned previously, other statistical measure is:

- **Range:** The range of a set of numbers is the difference between the highest and lowest numbers in a set. The range tells us the spread of a set of data. However, range is frequently not a good measure of distribution because it includes the extremes and it can give us a distorted picture of the data. For example, if we consider these two different sets of numbers:
  - A: 2, 6, 7, 9, 23
  - B: 4, 5, 14, 17, 25In both cases, the range is the same (21) but the numbers shown are completely different.

## Collecting and Analyzing Data

### Tables, Charts, and Graphs

Tables are displays of information arranged in rows and columns, charts are—more generally—any orderly display of information; graphs are plots of information against some scale. All of these forms can be adapted for every level of the elementary school.

#### Tables

A table can be a simple listing of items with a single number attached to each one, such as tables of temperatures of various cities. When the students understand how to read and construct, tables could be used for more complex information. Because of this potential complexity, it is best to begin by learning to read available tables like sports, weather, science and social studies information. Addition and multiplication tables also contain information of interest for the students. The organization and purposes of tables can be best established by presenting some information in table form and help students to learn to read the table. Sometimes the amount of information is too much, so it is impossible to ensure that everyone is looking at the same entry on a table in the handout or the textbook. Having tables on overhead projector transparencies overcomes this difficulty and is an excellent aid in modeling the reading and interpretation of tables. The next table (a very simple one) could be used with 3<sup>rd</sup> or 4<sup>th</sup> graders as an example.

*Table 1. Stock and price of Hi-fi stereos*

Brand and Model	Price (\$)	Quantity
Sanyo C-44	180	54
Sony AX-987	237	50
Advance 7774	205	65
Toshiba 32-98	198	72
Premier 321	195	88
San Sui A12	155	52
Maytag TG-4	185	51
Sharp WS-541	180	42
Panasonic 432-11	210	94

The table above could generate the next questions: What is the title or the subject of the table? What kind of information does it contain? How is the data presented? Which model is the most expensive? Which is the cheapest? What is the mean, mode, median, and range in the table? Which one would you choose and why?

There are still more questions to explore, including simple entries from the table. The teacher should model the reading and interpreting the table, assessing with other table created by the students. Furthermore, the teacher could show other table with some variations and encourage the students to read the table drawing conclusions that make sense.

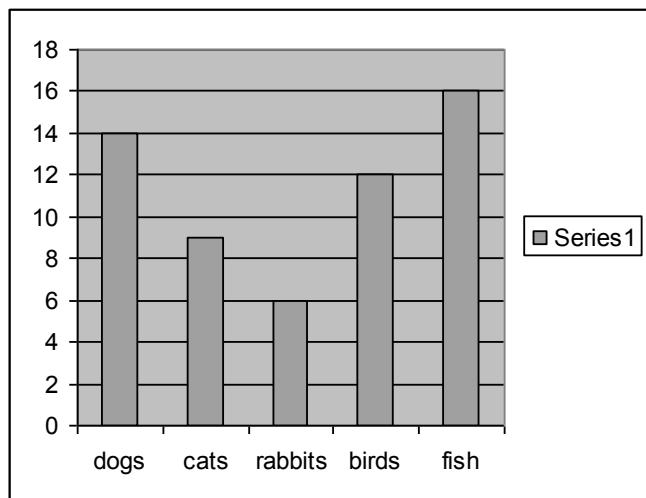
It is extremely important to find tables that get the interest of the students and present data in different formats and styles. There are many sources for tables: magazines, newspapers, almanacs, encyclopedias. The teacher must choose data at an appropriate level for the students to try to create their own tables. Although the student tables initially will be based on data given by the teacher, later on they can use their own data extracted from some written source. It must be

clear to the students that there is more than one correct format, but at the same time, they must know that some types of format are better for some kind of information than others.

### Graphing

Graphing must start really early (K or 1<sup>st</sup> grade), but it should be based on concrete information obtained from a table (Burns 155). Obviously, the table must be easier than the one showed above. Not all students' graphs are successful, and the students must understand that the graph is a way to get the information in a faster and easier way. Then, their graphs should be easy to interpret. Once a graph is constructed, it should be discussed by the class, encouraging the students to make positive comments about each of them saying what they can learn from them or what the characteristic they like the most is.

#### My Favorite Pet



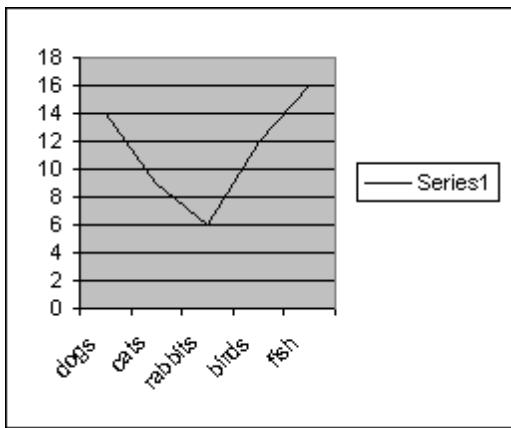
The students will make several comments after viewing this chart. First, they will mention the obvious: dogs got 14 votes; cats, 9; and so on. But after that, they will realize that not looking at the numbers, but looking at the bars, they can know which pet was the favorite and which is not. At the end, the teacher could ask: what would you do to improve this graph? The students will have different ideas: use of different colors, put them in order from least to greatest or vice versa, write also the numbers between the scale, etc. They must use those different suggestions in their next

graphs, and they will be able to compare and contrast charts with a variety of features and conclude which really improve the understanding of the chart.

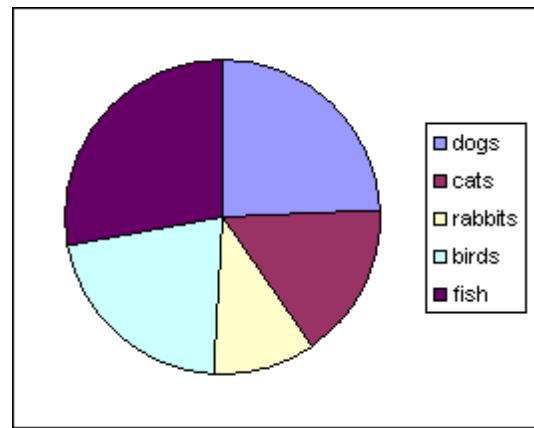
Some recommendations when the teacher works with the students are: the graphs must be concrete, data should be gathered by the students, the data should not be aggregated in the final chart (there must be the same number of entries in the table and in the chart), and the topic should be interesting for the kids.

The transition to more complex graphs might consist of alternative representations or the use of lines and dots instead of bars. The students must learn the different kinds of graphs: pictograph, histogram (also called bar graph), pie chart, line graph, and box and whiskers plot.

The first four graphs are the most common and also the easiest to elaborate. In the pictograph you have to show a drawing or a picture of the subject. Examples of a pie chart and a line graph are shown below:



*Line graph*



*Pie graph*

## APPROACHES TO SOLVING THE PROBLEMS

It is very interesting to analyze the different approaches that the students have to solve the problems about probability, statistics, or—specifically—average. We will consider five approaches:

- Students that consider average as the mode. They tend to interpret data based on the mode. As a consequence, they do not have too much flexibility to consider other kinds of strategies and are able to build a distribution without consider the most frequent observation. They frequently use egocentric reasoning in their conclusions.
- Students that consider average as an algorithm. They use a variety of useless and circular strategies that confuse the average, data, and the total. They have limited strategies to determine the reasonableness of their solutions.
- Students that consider the average as reasonable. These students use the average for making sense of the data. Choose different averages, from a mathematical perspective and other from a common-sense perspective. They use their own experience to conclude if an average is reasonable. They believe that a mean of a particular data set is not one exact value, but an approximation that can have one of several values.
- Students that consider the average as midpoint. They use the average as a tool to make sense of the data and choose an average that is representative of the data from both perspectives (mathematical and common sense). Usually, they look for a middle to represent a set of data and use symmetry when constructing a data distribution around the average. Finally, they use the mean as a way to check the answers as if mean and middle are basically equivalents.
- Students that consider the average as mathematical point of balance. They use average to make sense of the data and look a point of balance to represent the data. They break problems into smaller parts and find “small means” to solve more difficult average problems.

## EXTENDED ACTIVITIES

There are several activities in addition of those that will be mentioned in the lesson plans. Most of these are addressed to elementary grades.

- Make their own pictographs with sand paintings: the students will use materials from nature like leaves, bark, stones, and shells. This activity is interconnected with science

because the students must analyze the precedence of their material, if it is recyclable or not. The students will practice the concept of classification, and they will define the criteria to do this.

- Make picture graphs with school-community activities, emphasizing the concept that one picture may represent many students.
- Use sports to do bar graphs: be sure that the students get prior experience working with two different axes (x and y). The activities must include some point in which the students must decide a label for each axes. Increments should be in consecutive whole numbers. Upper grades, like 4<sup>th</sup> grade and upper, can create increments counting by twos, fives, and tens.
- To create line graphs: usually it is more complicated for the students to interpret a line graph than a bar graph. They also struggle deciding when to use a bar graph and when a line graph. Basically, for elementary grades, the students must understand that line graphs are used when the variable in the axis x has a sequence in the time (for example, months or years). Line graphs are more used with science concepts. They can be used to draw the height or length of a plant through some period or how a variable changes in two or three months.
- Compare two different kinds of graphs: the students must compare three different charts (bars, line, and pie) based on the same table, and they must realize that although the data is the same, some charts contribute more to a better and faster understanding than others.
- Activities about probabilities: toss a die and create tables with dice tosses. The students can work in small groups using cards, coins, or dice. They will analyze what the theoretical probability is and what happens in the real life. They will try to explain if there is a difference, what the possible causes are.
- Permutations: the students can try to put in pairs and count how many different pairs they can form. They will have to understand that in some cases the order is important and in others, like this, it is not.
- Exploring combinations: a typical activity is that the students form groups of 3 or 4 members, and they will pick up 8 different books from the bookshelves. They will have to determine how many different pairs they can select.

## LESSON PLANS

### Lesson One

This activity will be about how students can view and make their own histograms. We must remind the students that a histogram is a bar graph that shows frequency data. We must also remind them the different steps and the sequence of the process.

#### *Objectives*

This lesson must illustrate the idea of averages following different methods: the numerical method and the graphical way. The student will also develop or improve their estimation skills, predicting the final results based on partial amounts and evaluating the mode, media, mean, and range. The students must learn the concept of a histogram and practice their skills of how to read one. They will also elaborate their own histograms based on a previous established table. Finally, in the process the children will learn the concept of classification, separating the data they will obtain from their relatives.

#### *Materials*

Survey sheets, poster boards, construction paper

### **Activity 1**

The class will determine four different topics to collect data. The point is that those data must come from their family environment. For example, those topics could be:

- Favorite fast food, in this case we must establish the age groups.
- Number of members in each family by age groups.
- Establish the favorite TV show. The students must set the parameters for this question (which TV shows they are going to consider).
- Number of times that a member of the family needs to go to a health care service.

Once the students get all that data, they will decide which criterion will be used to classify the data. They will start to elaborate the tables, considering the concept of variable and looking for a title for the table. The teacher must check if the tables reflect the data collected by the students. After this, they will start drawing the bar graph, establishing the scale and which variable will go in each axis. Check frequently if the marks in the axis represent equal increments and if the data corresponds to the data in the table. Encourage the students to draw conclusions from the chart, compare the different graphs, and look for students' ideas of how they could improve each graph.

### **Activity 2**

Based on the data obtained in the previous activity, the students will discuss if they can find some way to interconnect two tables. For example, is there a relation between the age of the people and the number of times that they need health care service? They can elaborate a hypothesis and try to prove it elaborating the graph and analyzing the results.

*Assessment:* The questions must be to encourage the students to think and not only to obtain a grade. We must look for higher-order-thinking activities. For example: ask them if we change the vertical and horizontal scales, are the results the same? Can we arrive at the same conclusion as before? Is there a better way to write the data in axis X or Y? How do variations in the horizontal scale change the appearance of the graph? We realize that there is not only one correct answer for these questions, but we must be more interested in the process of reasoning than in the final answer.

## **Lesson 2**

The students will play with different manipulations in order to understand, learn, and predict some new concepts about probability. They will formulate their own questions about the data they will collect, organize, and display.

### **Objectives**

The students will learn vocabulary words and the concept of probability. They will be exposed to words such as *likely*, *unlikely*, *certain*, *impossible*, *probable*, and they will understand that the likelihood can be represented as a number from 0 to 10. Finally, the students must be able to predict the probability that certain outcomes happen.

### **Materials**

A paper bag (or any opaque bag) and a total of 10 marbles of different colors

The students must have paper and pencil to take note of the outcomes.

### **Activity 1**

First, the students will understand the word “impossible.” We will show to the students an empty bag and let them see that there is nothing inside it. We will put four yellow marbles inside the bag, and we will ask the students to take out a blue marble. They will realize that that is impossible, and we will mention that the probability of that outcome is zero.

### ***Activity 2***

The students will empty their bags, and they will put inside 9 yellow marbles and 1 blue marble. We will ask them what will happen when we take out a marble. Before the next step, we must be sure to put the marble back in the bag. After they have done this several times, they must answer questions like what will happen next. Is it impossible to take a blue marble now? What is more likely, to take out a yellow marble or a blue marble? Which is more unlikely? We must explain that the probability to take one yellow marble is  $9/10$  and that the probability to take a blue one is  $1/10$  and compare those numbers with their results and show them that those results are similar with the numbers we calculated.

### ***Activity 3***

We will let the students fill their bags with different colors of marbles, elaborate their own questions, and answer them. They will give this bag (closed), the questions, and the correct answers to other group of students. This second group must figure out how many marbles from each color we have in the bag, based on the information the first group gave them.

### ***Assessment***

The students will receive worksheets with pictures that represent different situations. They must write the probability of each marble in each bag. A second section of the sheet will ask for the inverse process: we will give them a probability and they will have to draw a bag with marbles inside that correlates to the given number.

### ***Lesson 3***

This lesson will integrate two different content areas: math and science. This activity allows the students to conduct probability experiments with traditional probability devices as a spinner or a dice and evaluate how the processes in the Earth are a cycle.

#### ***Objectives***

#### **Science**

The students will understand and learn the rock cycle. They will understand how important it is for the formation of the different kinds of soil. They will recognize what a cycle is and all its parts. They will also recognize the different kinds of rocks as the result of a natural process: metamorphic, sedimentary, and igneous.

#### **Mathematics**

The students will learn what is probability applied to a real life process. They will make inferences about what would happen if the results obtained would be real. They will think if the way that the board is built permits that the results are similar to the reality.

#### **Materials**

A die; three sets of cards that mention characteristics about metamorphic, sedimentary, and igneous rocks, and the next step in the rock cycle; a chart to make notes about how many times a rock follows the different processes; and a board with 60 consecutive squares

In each square, there must be an instruction about what to do when you land on that square and the type of rock it represents. Thirty of those squares must be metamorphic rocks; twenty, sedimentary, and 10 igneous.

### Activity 1

Two to four students can play simultaneously, and each one must have a chart on which they will indicate where and how many times they landed and what the next step was. Each one will throw the die and will advance as many squares as the die indicates. For example, if they fall in square number 4, and it says “metamorphic,” they will take a metamorphic card, read the characteristics of the rock (must be brief) and—if the card instructs so—move to other square as part of the rock cycle. The same student will annotate in his/her chart what kind of rock it was and will accumulate how many times he has landed on it. The students can establish who is going to be the winner, for example the first one to complete two rounds. At the end of the game each student will have enough data to calculate the probability of formation for each rock. Finally, they will compare these results with what happens in the real rock cycle.

### Activity 2

As a suggestion, I would recommend that this activity should be done on another day so the students will not get confused with the concepts of probability, graphs, and tables. The students will organize their data in tables and will draw different kind of charts (bars, line, pie, and pictographs) discussing which one is the best to present the results and why.

### Assessment

Following with the high order thinking questions, the students must explain why certain kind of rock shows up more times than the other rocks and why the results are similar in the real world.

## **ANNOTATED BIBLIOGRAPHY**

### **Works Cited**

Brown, Clara L. “Equity of Literacy-based Math Performance Assessments for English Language Learners.” *Bilingual Research Journal*. 29 (Summer 2005). <[http://brj.asu.edu/content/vol29\\_no2/art5.pdf](http://brj.asu.edu/content/vol29_no2/art5.pdf)>. This article is about representing and reasoning with probabilistic knowledge in ESL students.

Burns, Marilyn. *About Teaching Mathematics: a K-8 Resource*. Sausalito, CA: Education Associates, 1992. This is a very good book for elementary grades. Activities very simple for little kids.

Hoel, Paul G. *Elementary Statistics*. New York, NY: Wiley, 1966. Basic topics for upper grades.

### **Supplemental Resources**

Ash, Robert B. *Real Analysis and Probability*. New York: Academic Press, 1972. Presents good and simple charts and tables.

Billstein, Rick, and Shlomo Libeskind. *A Problem Solving Approach to Mathematics for Elementary School Teachers*. Boston, MA: Addison-Wesley, 2001. Great variety of problems with answers and procedures.

Brainerd, Charles J. *Children's Logical and Mathematical Cognition: Progress in Cognitive Development Research*. New York, NY: Springer-Verlag, 1982. How a child acquires and elaborates the number word sequence, chance, and probability.

Broyles, Robert W. *Fundamentals of Statistics in Health Administration*. Sudbury, MA: Jones and Bartlett, 2006. Basic and advanced concepts about statistics.

Chava, Frankfort-Nachmas, and Anna Leon. *Social Statistics for a Diverse Society*. Thousand Oaks, CA: Pine Forge Press, 2006. Reasons to apply statistics to social issues.

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- Kutz, Ronald. *Teaching Elementary Mathematics*. Needham Heights, MA: Allyn and Bacon, 1991.  
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Analysis of the importance of teaching math from the first school years.
- Mendenhall, William. *Introduction to Probability and Statistics*. Belmont, CA: Thomson, Brooks & Cole, 2006.  
Basic concepts, appropriate for elementary grades.
- Nuffield Mathematics Project. *Probability and Statistics*. London: J. Murray, 1969.  
Useful for middle and high school.
- Port Arthur Public Schools. *Mathematics: A Teaching Guide for Teachers*. Port Arthur, TX: Port Arthur Public Schools, 1970.  
Summary about the results of math courses in Port Arthur, TX.
- Sgroi, Laura S. *Teaching Elementary and Middle School Mathematics: Raising the Standards*. Belmont, CA: Wadsworth and Thomson Learning, 2001.  
A very good collection of problems and activities for math students.