# QUANTITATIVE LITERACY FOR THE 21ST CENTURY

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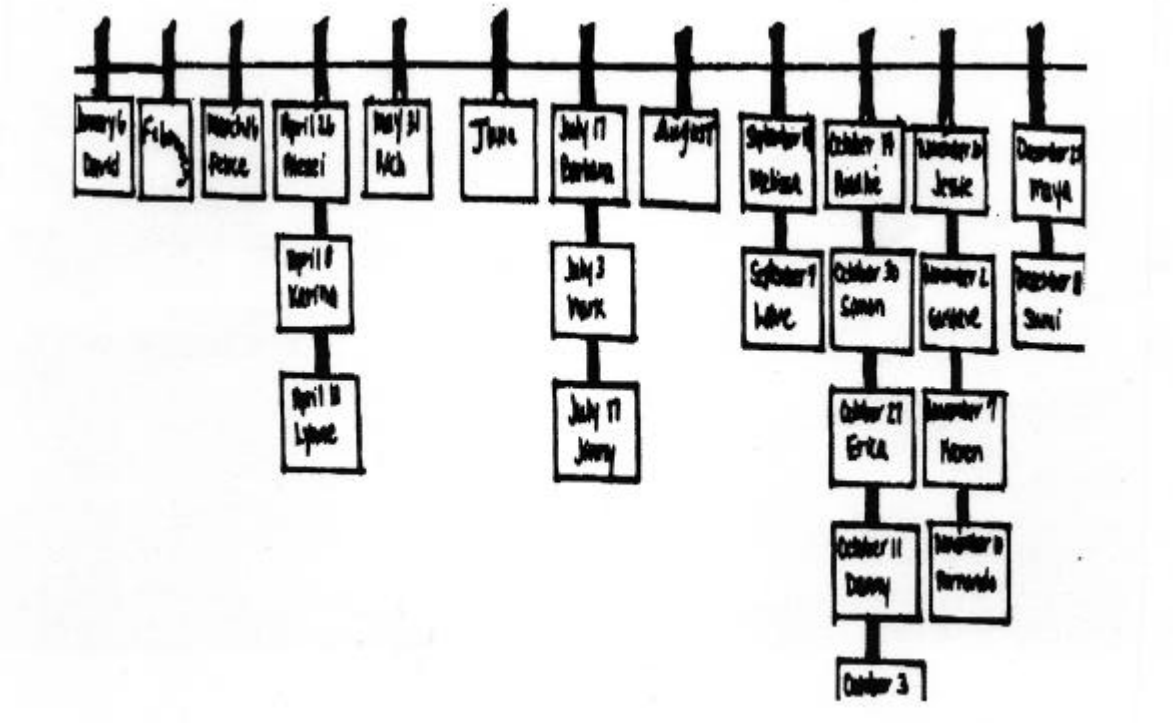
Rapidly expanding technology, information and the consequent collection of data are the basis of contemporary society. The society that does not recognize the importance of technology will be left behind. To assimilate the vast amount of data generated today, members of society must be trained from an early age to handle and manipulate data; collect, organize, describe and interpret data; and, make predictions and decisions based on the data. In other words the individual must become quantitatively literate. One natural and basic tool to become quantitatively literate is to master some essential concepts of statistic and probability.

I say naturally because at one level the human mind unconsciously uses statistical methods for problem solving. Babies learn by collecting and using data. When a child first sits on a high chair to eat, usually something drops to the floor. Generally someone picks it up and puts it back within the reach of the child. This is the first step toward handling and manipulating information. The next step is "research." The child will deliberately throw something on the floor with the expectation that it will be returned. When it is returned, the child is well on her way to collecting data and using unconscious statistical methods for decision making. It is this unconscious skill in collecting and manipulating data that society must mold and strengthen early in the individual's training. That skill is included in the concept of Quantitative literacy. The concept of statistical method can be introduced into the school curriculum as early as kindergarten and first grade.

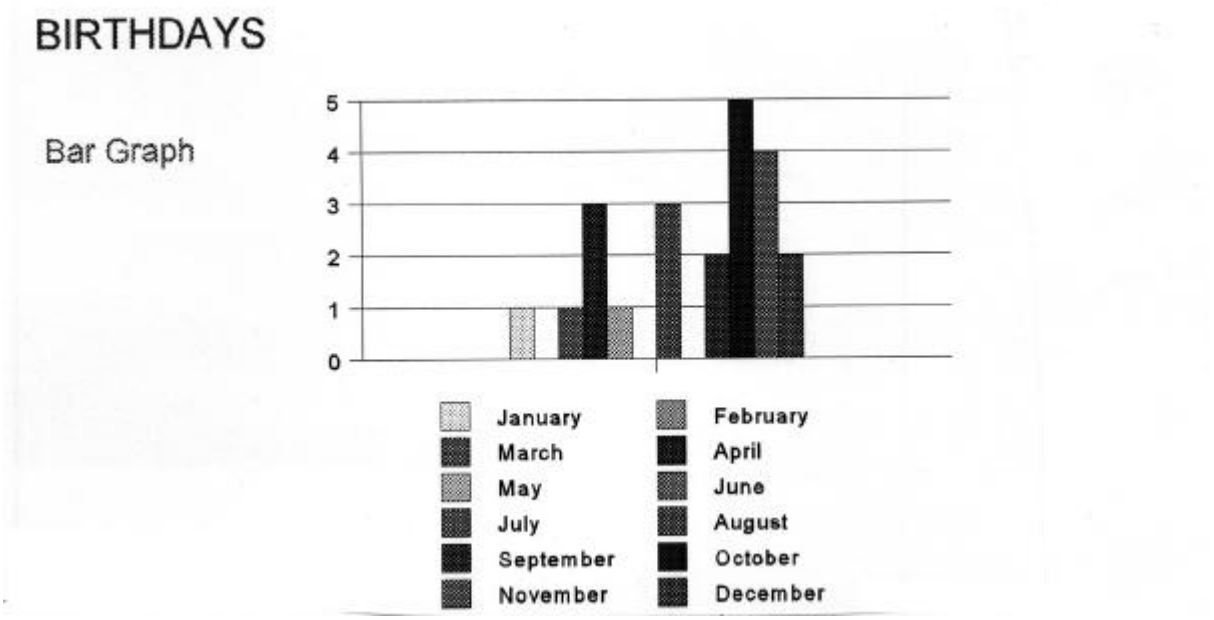
One method for introducing statistical methods into the kindergarten curriculum is the "clothesline method." The first step is for the teacher to elicit the month and day of their birth, from each child. That information, along with their name, is put on a 3x5 inch card. Once done for each child, the cards should be "hung up" by Month. The cards should be hung up by month but not in order, nor should the dates be ordered. Through questions from the teacher it can be shown by the children that there are some months that have no birth date, etc. The teacher should also elicit a response from the children that will put the cards in order of the month, as shown in the following chart (Russell, 1990):

They can then be ordered by date, as well.
The student will gain the following experiences from this activity (Russell, 1990):

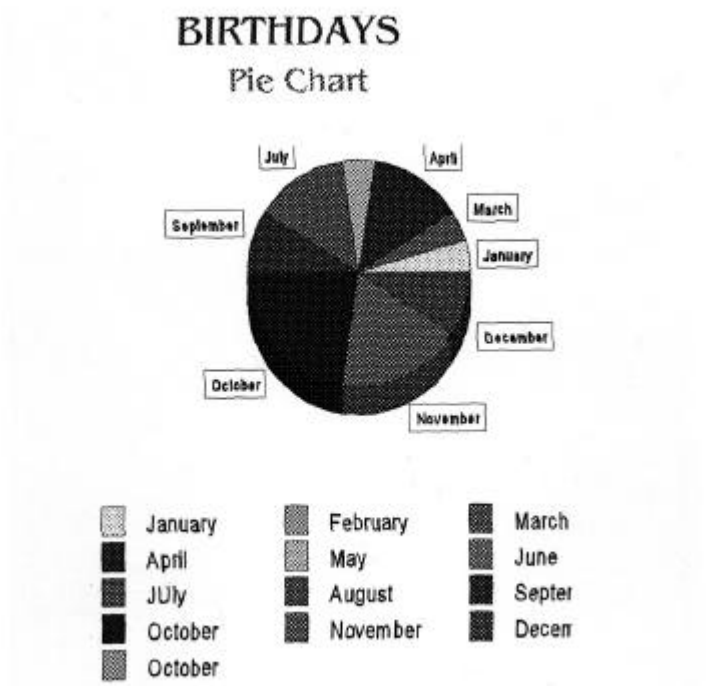
1) Finding out information by themselves;
2) Counting to provide information about groups of things;
3) Developing counting strategies;
4) Matching one to one;
5) Matching many to one;
6) Presenting what has been counted;
7) Describing data;
8) Comparing quantities;
9) Visualizing quantities;
10) Comparing several categories of data;
11) Displaying information about several categories.



The student should then be able to transfer their activity to a bar graph or a pie chart, as shown:




As we can see the traditional bar graph and pie chart can be introduced into the curriculum at an early age. Newer statistical techniques in data analysis that are simple and quick to use and the plots are easier to interpret have recently been introduced in the field of statistics. The new methods are easy to interpret and can be used with young children. These statistical techniques have been developed only recently and are becoming very popular. Two examples of these newer techniques are the stem-and-leaf plot and the box plot.




A stem-and-leaf plot is often better than the bar graph because constructing it is easier, all original data values are displayed and can be ordered. For example, consider the following data: 19, 20, 31, 41, 05, 12, 21, 44, 03, 15, 02, 35, 29, 24, 35, 49, 17, 25, 36, 27, 18, 26, 37. The smallest value is “2" in the ten’s place and the largest value is “4" in the ten’s place. Therefore, we choose the stem to represent the digits from “0" to “4"; separate each value into a stem and a leaf and arrange the leaves of the plot to the right of the stem. The following plot on the left represents a stem-and-leaf plot and the one on the right represents a stem-and-leaf plot when the leaves are arranged in order from smallest to largest.

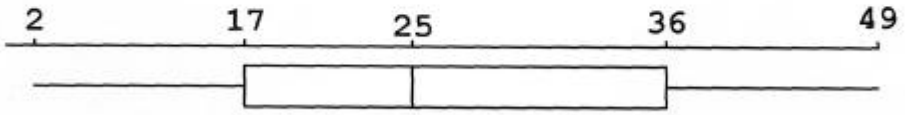
| Stem | Leaf |
|---|---|
| 0 | 2 3 5 |
| 1 | 2 5 7 8 9 |
| 2 | 0 1 4 5 6 7 7 |
| 3 | 1 5 5 6 7 |
| 4 | 1 4 9 |

| Stem | Leaf |
|---|---|
| 0 | 2 5 3 |
| 1 | 9 2 5 7 8 |
| 2 | 0 1 4 5 7 7 6 |
| 3 | 1 5 5 6 7 |
| 4 | 1 4 9 |

To make a box plot using the above data, which comprises 23 scores, the first task is to order the scores from the smallest to the largest in a straight line with 2 the smallest and 49 the largest. The median score is the 12th number, number 25. The scores above the median are called the "upper half." The median of the upper half is called the "upper quartile," which is 36. The scores below the median are called the "lower half." The median of the lower half is called the "lower quartile," which is 17.

Mark dots for the median, quartile and the extremes below the number line. Draw a box between the two quartiles. Mark the median with a line across the box.

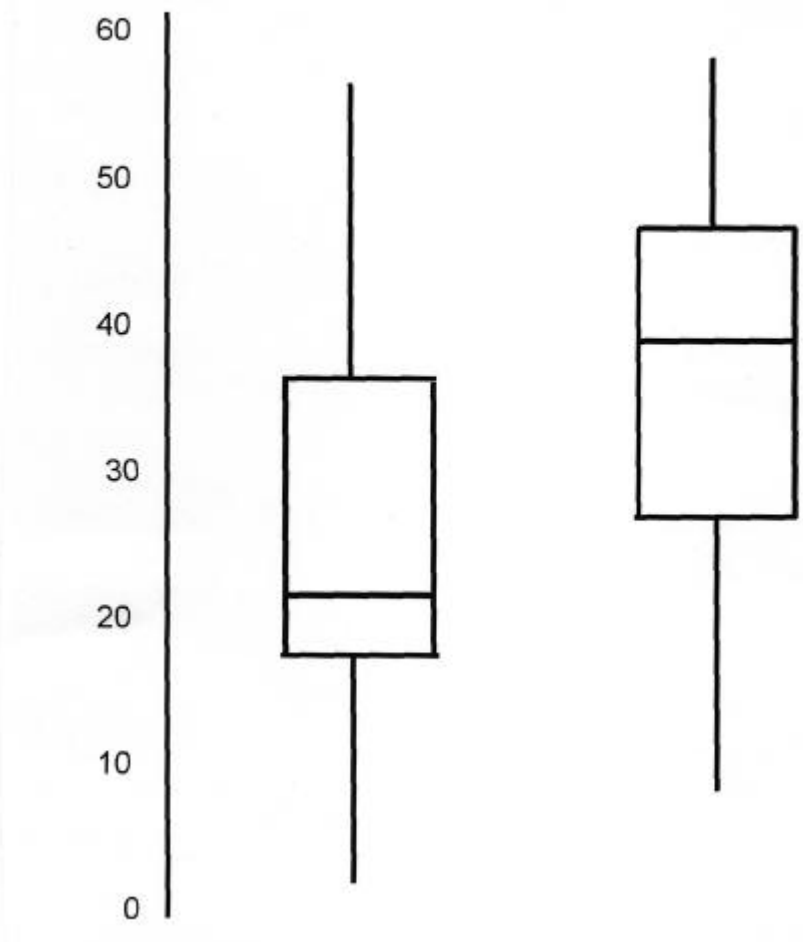
**BOX PLOT**




The lines at each end of the box are called "whiskers."
The following is a back-to-back stem-and-leaf plot comparing two sets of data.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 9 | 0 | 2 | 3 | 4 | 5 | | | | | |
| | | | | | 8 | 8 | 1 | 5 | 6 | 7 | 8 | 9 | 7 | 6 | 8 | |
| | | | 6 | 6 | 3 | 2 | 2 | 0 | 3 | 4 | 6 | | | | | |
| | | 8 | 6 | 5 | 5 | 5 | 3 | 6 | 6 | 8 | | | | | | |
| 8 | 7 | 6 | 5 | 5 | 5 | 5 | 4 | 4 | 8 | | | | | | | |
| | | | 9 | 8 | 7 | 6 | 5 | 6 | 7 | | | | | | | |

The following box plots compare two sets of data.




Using the above methods early in the educational process will prepare the student to:

1) Collect, organize, and describe data;
2) Construct, read, and interpret table, charts, and graphs that summarize data from the real world situation;
3) Make inferences and convincing arguments that are based on data analysis;
4) Evaluate arguments that are based on data analysis;
5) Use curve fitting to predict from data;
6) Understand and apply measure of central tendency, variability, and correlation;
7) Understand sampling and recognize its rate of statistical claim;
8) Design a statistical experiment to study a problem, conduct the experiment, and interpret and communicate the outcome.

All of the above are necessary to be quantitatively literate.

The next step to be considered is probability theory. Probabilty can be introduced in the upper elementary levels. Problems in probability can often be approached in more than one way, either theoretically or by simulation.

The following problem combines experimental, simulation and theoretical approaches for problem solving for the older student using probability. For example, if we want to find the various probabilities of the number of male offspring in a family of three children. In order to solve this problem the following steps can be taken by the student.

The first task is to let each student flip three coins ten times.
Each coin represents a potential child in a specific family. The student will record each flip of each coin. If the coin comes up heads that will be recorded as a "boy" and if tails comes up it will be recorded as a "girl." Each student will count the number of boys and record the count. The following table summarizes the result that approximate the probabilities.

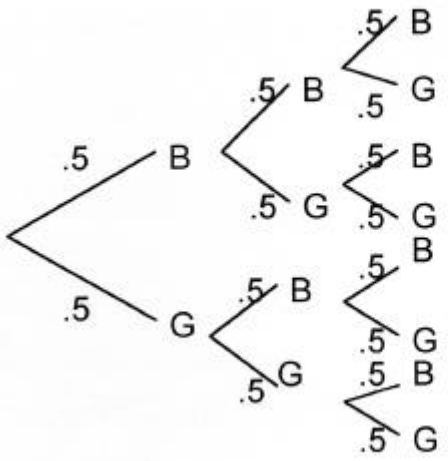
Solution by Experimentation

| # of Boys | Count | P (# of Boys) |
|---|---|---|
| 0 | 39 | .130 |
| 1 | 115 | .383 |
| 2 | 111 | .370 |
| 3 | 35 | .117 |

Next we can use simulation to approximate probabilities by generating 1000 random numbers of three digits using a calculator or computer. Each of the digits of the three digit number will be converted to either a "B" or a "G." The odd numbers will be converted to "B" and the even numbers will be converted to "G." The following table summarizes the results.

| # of Boys | Count | P (# Boys) |
|---|---|---|
| 0 | 122 | .122 |
| 1 | 373 | .373 |
| 2 | 379 | .379 |
| 3 | 126 | .126 |

The method for actually finding the probability is the following "Tree Diagram."




| # BOYS | P(BOYS) | % |
|---|---|---|
| 0 | .125 | 12.5 |
| 1 | .375 | 37.5 |
| 2 | .375 | 37.5 |
| 3 | .125 | 12.5 |

Students can achieve the following skills in the use of probability theory, which is another component of being quantitatively literate.

1) Model a situation to decide and carry out experiments of simulation to determine probabilities;
2) Construct a sample space and make predictions based on experimental or theoretical probability;
3) Use experimental and theoretical probability to present and solve problems involving uncertainty;
4) Describe and interpret some probability distribution;
5) Apply the concepts of random numbers to generate and interpret Probability distribution.[1]

## Recommendations

In developing a mathematics curriculum for elementary and secondary schools, the concepts and skills of statistics and probability needed for quantitative literacy should be included. These concepts and skills should not be taught as a separate unit. They should be introduced whenever appropriate to illustrate and expand upon the standard concepts in mathematics. These concepts should form interdisciplinary links for the student. Calculators should be used extensively after elementary school. Computers should be used as tools of learning whenever they are available. Other useful teaching principles are suggested by The Joint Committee of the American Statistical Association and National Council of Teacher of Mathematics[2].

## Conclusion

Questions of how can we teach statistics when we also have to teach Algebra, Geometry and Calculus are always present. The use of statistics in the information age is as important if

[1]National Council of Teachers of Mathematics, 1989
[2]Landwehr and Watkins, 1987

not more important than traditional mathematics. The United States has recently mandated the teaching of statistics, in public schools. It is now considered to be a fundamental subject in elementary and secondary education.

Statistics and probability units can be incorporated into the curriculum of Algebra, Geometry and Calculus. This will not only give the students the ability to become quantitatively literate but it will also enhance their appreciation of the consistency and beauty of mathematics. It is our duty to teach our students what is important today.

If our children can understand and grasp the concepts we have just discussed, they will be quantitatively literate. They will be prepared for the 21st century - the information society.

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