Teaching Statistical Reasoning in Elementary Schools using Age-appropriate Methods

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1. Introduction

Statistical literacy is a necessity as modern society requires that citizens be able to effectively manage increasingly large amounts of information. Decisions on financial matters, health affairs, and social interactions are universally required. The extent that individuals are able to process, aggregate, summarize, relate and interpret information in the context of variability will impact their lives. The field of statistics is being increasingly recognized as an essential tool. However, how, what, when and to whom we statisticians provide such valuable knowledge is not so clear. Many societies do not offer the concepts of probability, uncertainty, variability and thus statistics, until high school or university education.

This paper argues that statistical reasoning can be effectively imparted to elementary school children if done in an age-appropriate manner. Concepts such as variability, probability distributions and expected values, as well as advanced notions such as the sampling distribution of the mean, can be successfully understood by children in elementary schools. Evidence is based on a case study of the actual implementation of age-appropriate methods for children 7-10 years old.

2. Games in 2nd grade (ages 7 and 8)

Children in 2nd grade in the USA are taught the basics of counting and arithmetic, yet rarely encounter statistical concepts. However, they enjoy coloring and playing games. Given the birth of probability from the desire to learn how to win at games of chance, I suspected games would be an age-appropriate methodology to reach very young children. One ancient game of the Mogul king Akbar I of India in the 16th century offered me the possibility of teaching the concepts of discrete probability distributions, variability, and goodness of fit, as well as such analytical tools as frequency bar charts and composition bar graphs.

The game of *chaupar* or *soktabaji* is a board game that gave origin to the well-known board game (see Figure 1) called Parcheesi (Pachisi) or Ludo. In it, each of four players moves his/her playing pieces (*soktas*) around a path of squares, avoiding being forced to re-start the path, and safely reaching 'home.' The advance along the path is based on the sum from the roll of two dice or roll of 5 cowry shells, and the winner is the first to have all pieces safely reach 'home.' The ancient game's path followed a specific number and pattern of squares that had to be traversed, and the dice rolls determined the possible outcomes and thus the strategy of the gaming. The dice used were oblong rather than square so that effectively only one of four sides in each die was possible. Most dice had the numbers 1, 3, 4, and 6. Thus, for example, advancing 11 squares was not a possible outcome and one could assume a certain level of safety if one's piece was 11 squares ahead of an opponent's.

Now, being an ancient game that has been modernized, the old version is difficult to find. While the board can be hand-drawn, the four-sided dice are no longer made. The dice were originally made of ivory, and thus impossible to obtain today, and new games sold now contain the

common six-sided dice, which affects the gaming strategy. The lack of dice to play stimulated me to teach statistical concepts to 2nd graders. After teaching the game to the children and getting them excited about playing, I confessed on the lack of proper dice to play. The desire to find a set of homemade dice that were 'fair' enough to play with got the students excited about participating in an 'experiment' that not only rated the fairness of the homemade dice, but along the way taught them concepts of variability and expected value.

Fig. 1 Chaupar board

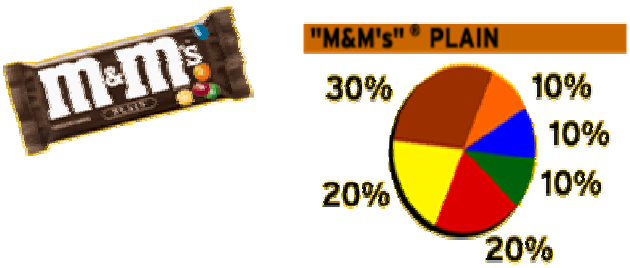

Fig. 2 M&M color distribution

Figures courtesy of http://web.ukonline.co.uk/james.masters/TraditionalGames/pachisi.htm
http://www.m-ms.com/factory/history/faq1.html

3. Candy in 4th grade (ages 9 and 10)

Children in 4th grade in the US are learning about fractions, but not about statistical thinking. Sampling is a difficult concept to get across to many researchers, and thus teaching it to young children may be considered difficult at best. However, all children love candy, and this suggested another age-appropriate methodology.

The American candy M&M is a small milk chocolate tablet covered with a colorful sugar coating that 'melts in your mouth, not in your hands.' It is sold in packages of various sizes. The company M&M Mars, Inc., has rarely changed the colors or their distribution, but a series of marketing campaigns in the 1990's examined which distribution of colors the public desired. The company's consumer affairs department claimed that the color ratio in packets of M&M's was 30% brown, 20% yellow, 20% red, 10% orange, 10% green, and 10% tan (now blue as in Fig. 2 above). The published color distribution by the company provided the stimulus for me to teach the concepts of goodness of fit, variability (always a good one) as well as the difficult concept of the distribution of the sample mean, and how larger samples produce less variable estimates than smaller samples. A 'hands-on' class activity, where Rule #1 was "Do not eat your data," got the children excited and clamoring for more such 'fun mathematics.'

4. Discussion

This paper will present the actual methods used for the above two age-appropriate teaching modalities, and the results from implementation in a real school setting in a public school in Chapel Hill, NC. The evaluation of the efficacy of the teaching consisted of teacher satisfaction reports with the methodology and the concepts transmitted, as well as informal accounts from students. While not a formal evaluation of the effectiveness of the teaching method, the fact that some of the students recalled the classes and the concepts several years later, is encouraging. Teaching middle-school children (ages 12-13) through cooking – 'variability is the spice of life' – is being contemplated.