Human Histogram

An Engineering Statistics Lesson
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Lesson Title: Human Histogram

Academic Objectives:

1. Introduce ideas of central tendency and variation
2. Calculate median and identify mode
3. Illustrate mean visually
4. Introduce probability
5. Introduce the graphing technique of a histogram

Homework for Students (to ensure preparation):
No homework since this is done the first day of class

Team Size/Composition: This is a full class exercise. Though, if the class is too large, you might divide the class in half and make two histograms. I have divided a class into a quarter before and created the histogram in one section of the class only while the other students watched. I have done the exercise with up to 60 or 65 students. Fewer than 24 and the birthday probability becomes too low.

Length of lesson:
20 minutes

Handouts and Overheads:
The following information is an optional handout on the birthday probability (I do not provide this to the class the first day, I address this same probability again when I cover basic probability.):

Birthday Probability

(Sheldon Ross, 1988, *A First Course in Probability*, 3rd edition, Macmillan Publishing Company, New York, NY, pgs. 160-162.)

The probability of an event (E) is the number of ways the event can occur over all of the possible outcomes. All possible outcomes that can occur are known as the sample space. The number of ways the event can occur is a subset of the sample space (S). The equation for the probability of an event is: $P(E) = \frac{\text{number of outcomes in E}}{\text{number of outcomes in S}}$.

The easiest way to calculate the probability of two people in the room having the same birthday is to first calculate the probability that no two people in the room have the same birthday and subtract this from one (based on one of the propositions of probability that states that all possible probabilities in an event must sum to one). To calculate the probability that no two people in the room will have the same birthday, we first need to know the number of people in the room (n). Since each person can celebrate his/her birthday on any of 365 days, the total number of possible outcomes for those n people is $(365)^n$ (this is the sample space and the denominator of the equation). The numerator is the number of

outcomes for the event and is equal to (365)(364)(363)…(365-*n*+1). Since no two people in the event can have a birthday on the same day, the first person can have his/her birthday on any of the 365 days in a year. The second person can only have their birthday on any of the remaining 364 days in a year. The third person can have their birthday on any of the remaining 363 days in a year, and so on. The total number of possibilities in the event is the product of all of these. Therefore, the probability that at least two people in the room celebrate the same birthday is:

$$P(\geq 2 \text{ same birthdays}) = 1 - \frac{(365)(364)(363)...(365-n+1)}{(365)^n}$$

For example, when there are 23 people in the room, there is just over a 50% chance that two or more people in the room celebrate their birthday on the same day. In fact, the following table can be used to know the probability of this occurring if the number of persons in the room is known;

Probability of 2 or more birthdays on the same day	Number of people in the room
50.73%	23
87.82%	39
89.12%	40
90.32%	41
91.40%	42
92.39%	43
93.29%	44
94.10%	45
94.82%	46
94.57%	

47 96.09% 48 96.57% 49 97.04% 50
Other materials needed: NONE
How is Individual Accountability ensured? We actually leave the classroom and go outside. Everyone participates since everyone has a birthday. I have been in a situation with younger children where a teacher thought that a child did not know his birthday, but that child placed himself as if he did know his birthday.
How is Positive Interdependence ensured? One single individual cannot be a histogram alone. In fact, the larger the number, the better the histogram.

STEP	Instructions to Students
1	A brief introduction including questions to promote the discussion of probability in every day life is given. This could include asking students where they see statistics or probability in their day to day lives. Typical answers focus on probability and include the weather forecasts or lotteries.
2	Ask students how many believe that there are at least two persons born on the same day in the room and twins or multiple births do not count. Use a show of hands to determine how many students believe that there will be at least two people born on the same day. (Note that year does not play a role in this question!)
3	Ask the students to form a human histogram by forming 12 bins based on the months of their birth. To avoid utter chaos, have students form the histogram one month at a time while you call out the month. Then, ask the students to order themselves within the bins with the first of the month at the bottom of the bin and the last of the month at the top of the bin. This allows the students to make the birthday discovery on their own. ALTERNATIVE: If the class is too large use the first 6 months or use a portion of the class for the full 12 months.
4	Once all students are in their bins and ordered, ask the students to identify the people who share the same birthday. Explain that as long

	as there is a minimum of 23 persons participating that there was over a 50% chance that two people would share the same birth month and day. As you do this multiple times, you will find that probability will catch up with you and at some point there will be a time when there are not 2 birthdays. This is a good learning/teaching experience as well.
5	Have students count off. Discuss the median. Ask for someone to tell you where they think the median is. Find the actual median using the equations; Odd – the person's birthday located at (n+1)/2 or Even – the midpoint between the persons' birthdays located at n/2 and (n+2)/2. Have that person raise both hands in the air so that students can physically see the location of the median.
6	Ask for the definition of the mode. Remind students that another word for mode is maxima and they are looking for the bin with the maximum amount of birthdays in it. You can discuss bi-modal and tri-modal as well. Opportunity sometimes knocks with the actual occurrence of one of these situations.
7	Explain that the mean is another measure of central tendency and it would be located where a fulcrum would balance a platform that contained all of the students if weight was the variable we were measuring.
8	Have the students look around at how the class is distributed between the different months. Talk about the fact that variation is a measure of the spread of the data.

Assessment: Students should have a general idea of mean, median, mode, and variance. This is an introductory lesson only. Homework, projects, quizzes, or exams on the basic descriptive statistics can follow.
Team Skills Needed: Communication

Picture taken during Human Histogram Exercise at the University of Oklahoma in the Spring of 2001

I post the picture on our website each semester.