

Steppin' Out

(Statistics)

Objective

Students will construct box and whisker plots to analyze and compare data sets.

Overview of the Lesson

Pose the following question: Do longer legged people run faster than shorter legged people? To investigate this question, students first find the measurement of their legs. They then line up in order from the shortest legged student to the longest legged student. The class discusses box and whisker plots while simultaneously creating a human box and whisker plot. They then locate the median, upper and lower quartiles, upper and lower extremes and outliers. Cash register tape is wrapped around the students to create the box portion of the box and whisker plot. Students then go outside to the track and take turns running sprints. The median divides the students into two groups, the longer legged students and the shorter legged students. The times it takes for each of the students in each group to finish the race are measured. Using a computer and graphing program, this data is organized to create two box and whisker plots. The two box and whisker plots are compared and analyzed. Based on these comparisons, students reach their conclusions and are prepared to explain their reasoning.

Materials

- ① Meter sticks or tape measures
- ② One Roll of Cash Register tape
- ③ Scotch tape
- ④ Index cards
- ⑤ Track or area where students can run (approximately 60 yards)

- ⑥ Stop watch
- ⑦ Tag board labeled: Upper Extreme, Lower Extreme, Upper Quartile, Lower \ Quartile, Median, 2 Outlier

Optional Materials

- ① Lap top computer
- ② Computer graphing program such as *Statistics Workshop* by Sunburst
- ③ Printer
- ④ 1 transparency per group

Procedure

Pose the following question to the class: *Do people with longer legs run faster than people with shorter legs.*

By a show of hands, have students vote on their opinion: yes they run faster, no they don't run faster, or the length of the leg makes no difference.

Next, ask students how this might be investigated. It is expected that suggestions would include "conducting an experiment". This experiment would involve measuring the length of their legs, timing how long it takes them to run a specified distance, analyzing the data and arriving at a conclusion.

Distribute a meter stick or tape measure to each pair of students. Have each student, assisted by their partner, measure the length of their leg to the nearest centimeter. So that everyone measures from the same point, have students measure from the hip joint to the heel. Each student records this measurement on an index card.

Inform students that this data will now be used to organize them into a human box and whisker plot. Have students line up in order from those with the shortest legs to those with the longest legs. To find the median length, have students count off, starting at both ends of the line until they reach the student who is in the middle. The length of this student's leg represents the median length. This student should be given the tag board label which says "median." Those students who are above the median form the "longer legged" group, and those below the median form the "shorter legged" group.

Discuss each of the parts of the box and whisker plot with the students as it is being constructed. First find the median of each half of the data. The median of the upper half of the data is the upper quartile and the median of the lower half of the data is the lower quartile. Each of these students should be given a sign which labels them as the upper and lower quartiles, respectively.

The student who has the longest legs is given a sign which says “upper extreme” and likewise the student with the shortest legs is given a sign which says “lower extreme.”

To complete the construction of this human box and whisker plot, wrap students from the lower quartile to the upper quartile in cash register tape. This will create the box portion of the box and whisker plot. The whiskers are merely the ranges of data from the lower extreme to the lower quartile and from the upper extreme to the upper quartile. There may also be some outliers. (*See Mathematically Speaking...*) You may want to draw and label a box and whisker plot on the board so that students have a concrete picture.

Next, take students to the track or an area in which they can run. They should still be divided into two main groups: the longer legged students and the shorter legged students. The data to be collected should be based on these two groupings so that students are able to compare the data (running times) of the longer legged students to that of the shorter legged students. Starting with the group of longer legged students, have each one run the designated distance. Several students from each group should be assigned the tasks of timing each other and recording the information. Use a stopwatch to determine their running times to the nearest hundredth of a second. Record this information. Use a similar procedure for the shorter legged students.

Note: If a laptop computer with a graphing program is available, this would provide a nice opportunity to use technology as a tool. The data could be entered into the computer as soon as it becomes available and the box and whisker plot generated.

When all of the running times have been recorded, return to the classroom. Share the total class data with each student. Place students in small groups. Their task is to construct two box and whisker plots and, based on their analysis, decide if longer legged people run faster than shorter legged people. If the computer generates the box and whisker plots, students would only be required to compare the two box plots to reach a decision about who runs faster.

In order to help students compare the plots, you may wish to print one plot on paper and the other on a transparency. In this way students can place one plot over the other to make comparisons.

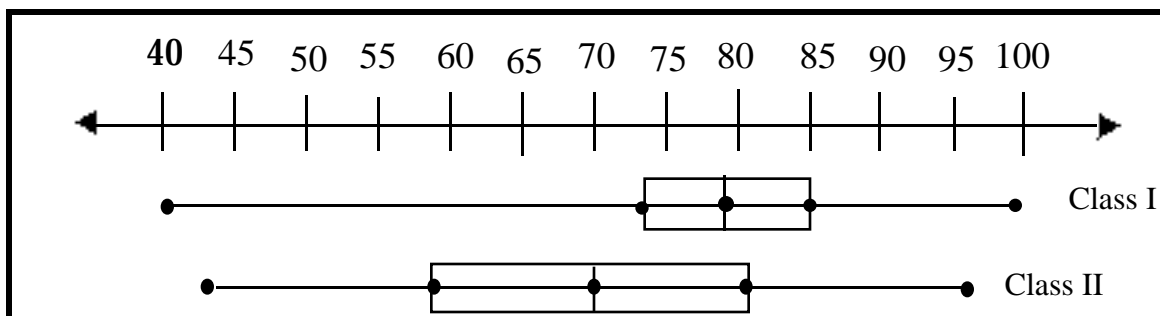
Once students have reached their decisions, have them write paragraphs which justify their conclusions.

Mathematically Speaking...

Box and whisker plots provide a format for displaying the median, quartiles, and extremes of a data set. Following is a list of steps to be followed when constructing a box and whisker plot:

- ☛ Write the data in numerical order
- ☛ Find the median, lower and upper extremes, the lower and upper quartiles, and the outliers (if any).
 - The median is the middle number if there is one or the average of the two middle numbers when the data are arranged in numerical order.
 - The upper quartile is the median of the upper half of the data and the lower quartile is the median of the lower half of the data.
 - The upper extreme is the highest value in the data set and the lower extreme is the lowest value in the data set
 - The outliers are values which are widely separated from the rest of the data. In general, so that identification of outliers is not solely based on observation, an outlier is any value more than 1.5 inter quartile ranges above the upper quartile and/or more than 1.5 inter quartile ranges below the lower quartile. The inter quartile range (IQR) is the difference between the upper quartile and the lower quartile.
- ☛ Construct a number line which will accommodate the range of data.
- ☛ Graph the five identified values from the data set below the number line.
- ☛ Draw a box from the lower quartile to the upper quartile.
- ☛ Draw a vertical line for the median.
- ☛ Draw the whiskers from the box to the extremes of the data set. Check for outliers.

An example of two box and whisker plots used in a comparative study is illustrated below. Notice how both of the five values are plotted in conjunction with the same number line.



Some possible observations may include:

- Class I has a greater median. This means that the top half of Class I, generally scored higher than the top half of Class II.
- Class I has a greater range, but the middle 50% of Class I's scores are closer together.
- Class I's lower quartile is greater than Class II's median. This means that about 75% of the students in Class I scored higher than half the students in Class II.

Extensions & Connections

The lesson only provides one investigation for arriving at an answer to this question. Solicit ideas from students for additional ideas on how this question may be addressed. For example, students may want to research to discover if the longer legged world class runners produced faster running times than their shorter legged counterparts. Students may want to pay attention to some of the other variables which probably affect the results, such as age, gender, and weight.

Have students discuss reasons why a shorter legged person could be a faster runner than a longer legged person and vice versa. Have them gather examples to support their reasoning.

Resources

Quantitative Literacy Series: *Exploring Data*. Dale Seymour Publications. (1987)
Palo Alto, California.

Ideas for Online Discussion

(Some ideas may apply to more than one standard of the NCTM Professional Standards for Teaching Mathematics.)

Standard 1: Worthwhile Mathematical Tasks

- ❶ “What students learn is fundamentally connected to how they learn it” (p. 21)
Do you agree or disagree with this statement. Share a vignette that supports your viewpoint.

Standard 4: Tools for Enhancing Discourse

- ❷ What did you think about the human box plot? How have you used your students to "act out" mathematical concepts and ideas?

Standard 6: Analysis of Teaching and Learning

- ❸ Middle school students have been known for their enormous amount of energy. Engaging them in physical activities tend to be a real “turn-on” for them. Reflect on techniques you use to ensure a smooth transition from students being engaged in some type of physical activity to the basic seat work and discussion-type activity. How successful are you in managing lessons that include a variety of activities?
- ❹ Suppose in your class, there were several students who did not want to run or were very self-conscious because of their weight, or shape, etc. How would you modify this lesson to accommodate all of your students?