PBS Mathline®

The Middle School Math Project

In A Heartbeat

(Algebra)

Objective

Students will apply their knowledge of scatter plots to discover the correlation between heartbeats per minute before and after aerobic exercise.

Overview of the Lesson

The teacher begins the lesson by engaging students in a discussion about the characteristics of scatter plots. Next, an aerobic instructor shares basic information about the heart with particular focus of the heart rate when the body is at rest and the heart rate following exercise. Students discuss estimating their heart rate in beats per minute (bpm). They discuss the appropriate time interval to be used when they take their pulses, i.e.. 6, 10, 15, or 30 seconds or the full minute. Students take their pulses for the agreed upon time interval, calculate their bpm and record the data. The music is turned on and the students engage in a few minutes of aerobic type exercise. Again they take their pulses, calculate their bpm, and record the data. Each student forms an ordered pair with the data (bpm after aerobic exercise, bpm before aerobic exercise). The ordered pair from each student is listed and the points plotted using a dot sticker on a large poster graph. Each group is responsible for graphing the data and applying its knowledge of scatter plots to find the line of best fit. Equations are written for these lines and results are shared. The lesson concludes with students discussing how the information obtained could be used to make predictions.

Materials

Each Group

❶ Sheet of graph paper

❷ Colored pencil

❸ Colored dot sticker (one per student)

❹ Piece of uncooked vermicelli spaghetti

❺ One Ruler

Per Class

❻ Guest Speaker (Aerobic Instructor)

❼ Poster Graph

❽ Stopwatch

❾ Music

Procedure

Begin the lesson by asking students to recall some facts about scatter plots. Students should share, in small groups and then in full class discussion, such things as correlation, outliers, and line of best fit. *(See Mathematically Speaking...)*

Inform students that they are going to put their knowledge of scatter plots to practical use. Schedule an aerobic instructor to be a guest speaker. This person should be prepared to share specific information about the heart and how it operates.

In the video, the speaker informs the students that the heart is the most important muscle in the body. It is a pump and is responsible for delivering oxygen upon demand, through the blood, to the tissues. At rest, about 5 liters of blood flow through the heart per minute. When exercising, there is an apparent increase in demand for oxygen, at which time approximately 20 liters of blood per minute flow through the heart. There are two easily accessible strong pulse points. They are the carotid artery and the radial artery. To find the carotid artery, place you index and middle finger just below the angle of the jaw. The pulsation felt will be that of the carotid artery. To find the radial artery, place your finger on your thumb and slide it up, just above the wrist and gently press. The pulsation felt here is that of the radial artery.

Ask students how they could obtain the most accurate number of times that the heart beats per minute. Students should understand, that by actually taking the pulse for the full sixty seconds will result in the most accurate count. However, the pulse can be taken for time intervals which are factors of sixty, such as 30, 15, 12, 10, 6 seconds, etc. Once the time interval has been selected, the number of beats counted is then multiplied by the corresponding factor to obtain the approximate number of times the heart beats in a minute.

The aerobic instructor should have students find their pulse at either pulse point. However, before the data is collected, allow time for students to become comfortable taking their pulses. When students are ready, use the stopwatch, instruct them when to start and stop using a stop watch students begin and end counting their heartbeats when so instructed.

Note: In an exercise program, a person's pulse should be taken before, during and immediately after the exercises have been completed. (It may prove to be interesting for students to discuss why it is important to take your pulse frequently when exercising).

Allow the aerobic instructor to have the responsibility for conducting the aerobic activity. This includes having the students take their pulses before and after exercising, as well as orchestrating the actual exercise routine. This might also include having students identify activities which are cardiovascular in nature, such as dancing, jogging, swimming, walking, etc. and discussing why these types of activities are so important.

Once the number of beats have been counted, have the students multiply it by the appropriate factor to determine the approximate number of beats per minute. The data from each student is place in an ordered pair — (bpm after aerobic exercise, bpm before aerobic exercise).

Each student's ordered pair is listed on the board. Students should then take a critical look at the data and share any observations. They may notice, that in every case, the bpm after exercise is a larger number than the bpm before exercise and that all of the numbers are divisible by the factor used. A list of unorganized data is virtually impossible to analyze. Channel them to realization that constructing a scatter plot would be one way of displaying this data for analysis.

Discuss that the x-axis represents the bpm after exercising and the y-axis represents the bpm before exercising. Each student should receive a dot sticker on which their ordered pair is recorded and plotted on the large poster graph for the class to see.

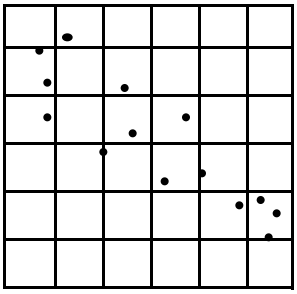
In order for students to analyze the data, each group should replicate the scatter plot. In this process, each group should pay attention to the clusters and outliers to assist in estimating where the line of best fit should be. Use a piece of vermicelli to estimate the position of this line. Encourage students to write the equation for the line of best fit. Students may also want to use computational means to find the line of best fit and compare this line with the vermicelli line. (See ***Mathematically Speaking***...)

Finally, students should discuss correlation, and any other information that the line of best fit indicates. For example, if the pre-exercise heart rate is known, it would be quick and easy to predict the corresponding heart rate after exercising.

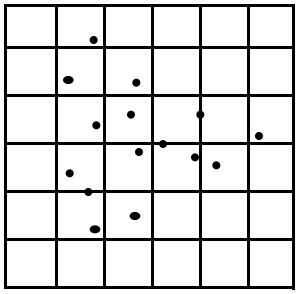
Mathematically Speaking...

A scatter plot is a graphical display that shows the relation between two data sets. It is constructed by placing points on a coordinate plane. When the two data sets increase together, they have a positive correlation. When one data set decreases as the other increases, the two data sets have a negative correlation. It is also possible for data sets to show no correlation.

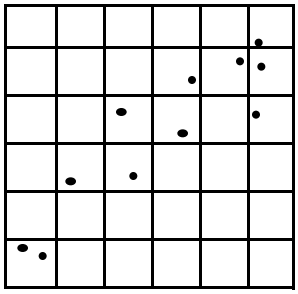
Negative Correlation



No Correlation



Positive Correlation



Often times scatter plots are used to assist in making predictions. This can be done in several ways. One way is to draw a line which passes close to most of the data points. This line is called a **line of best fit**. This line shows if the correlation between the two data sets is strong or weak. If the data points come very close to the fitted line, the correlation is strong. If not, the correlation is weak. The stronger the correlation, the better the prediction. The equation of this line can be found by applying the point slope formula.

The line of best fit can be also be found by dividing the data points into two equal groups. (One group may have one more point than the other if there is an odd number of data points.) This can be done by drawing a vertical line which separates the data points into the two groups. The mean is computed for the x-values and y-values in both groups, resulting in two new ordered pairs. These coordinates are plotted and the corresponding line is drawn. Again the equation for this line can be found by using the point-slope form.

Extensions & Connections

How would the graph look if the bpm before exercising were plotted on the x-axis, and the bpm after exercising were plotted on the y-axis.?

Have students predict the correlation between two related sets of data. Then have them collect a reasonable sample, plot the points and analyze to ascertain the relationship. For example, What is the correlation between a person's shoe size and his ring size?

Provide a variety of examples from which students have to explain what the data tells them. This may mean providing ordered pairs which have to be plotted, or it could include graphs of "best fit lines" with various arrangements of clusters.

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 The application of mathematics as incorporated in *In A Heartbeat* addresses the question: "*When are we ever gonna use this stuff, or when is anybody ever gonna use this stuff?"* How will this activity be received in your class. Did or do you predict that it will be one of those activities that will "turn the kids on?"

❷ Identify some data collecting ideas which you used to teach mathematical concepts and which were particularly appealing to your students.

Standard 4: Tools for Enhancing Discourse

❸ Often, teachers have professionals come to the classroom to share career experiences and to show how mathematics plays a role in their professional lives. Who are some of the visitors who have shared stories and experiences with you and your students. Describe what they offered and if applicable, how these persons can be contacted. If you are unable to share the names of these persons, identify the careers and share something about the nature of their presentations.

Standard 5: Learning Environment

❹ It is very important to "provide a context that encourages the development of mathematical skill and proficiency" (p. 57) Does the level of success increase when the data used in a lesson is, in some way, directly related to the students?

Standard 6: Analysis of Teaching and Learning

❺ The underlying concepts in this lesson approach some theoretical and abstract concepts in mathematics. How can you assess that all students are in command of these mathematical concepts, when the entire synthesis and analysis of the lesson is completed in either large or small groups?