

Lines, Curves, and Graphs

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My project "Lines, Curves and Graphs" was based on the study of linear and nonlinear relationships. Students completed their study of the units *Moving Straight Ahead*, *Thinking with Mathematical Models*, and *Growing, Growing, Growing*. Throughout these three units, five classes of students used the SMART Board™ interactive whiteboard in conjunction with graphing calculators and computers to introduce, enforce and strengthen their understanding of graphing linear relationships, nonlinear relationships and exponential functions.

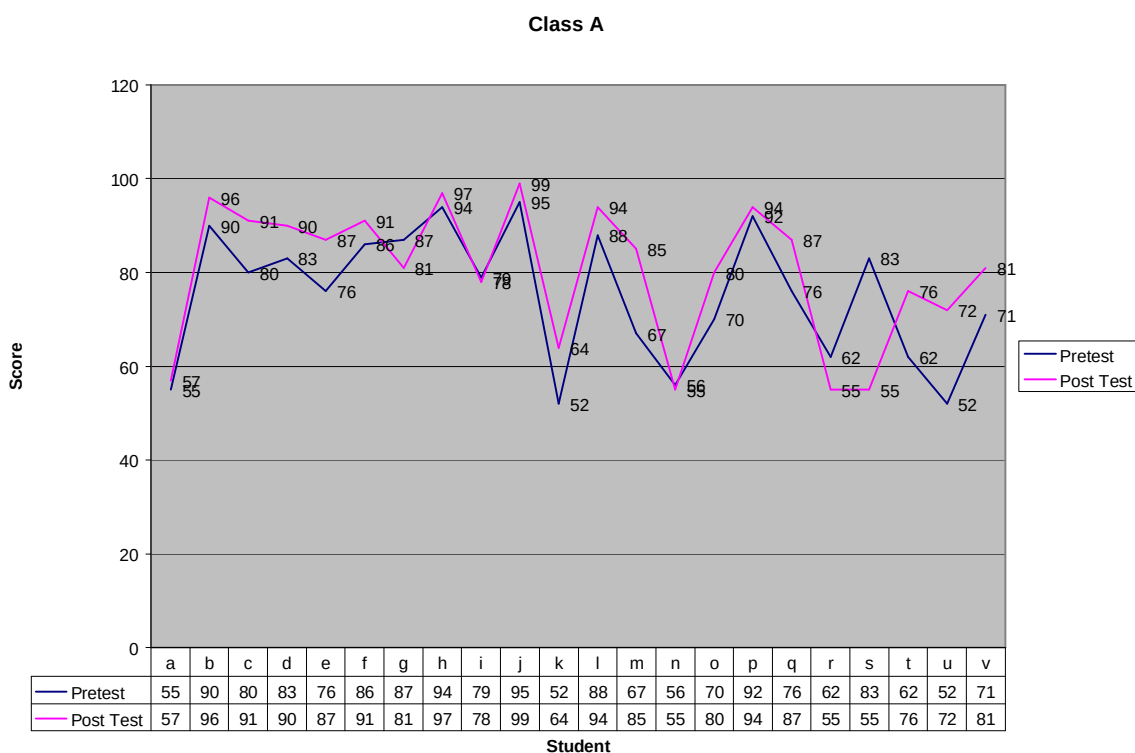
At our school, students are heterogeneously mixed into one of five math classes. Each class consisted of a wide range of abilities that included both special education students and basic skills students. The math program used for this study and for our curriculum is *Connected Mathematics* by Prentice Hall. Each class period was 43 minutes in length, and most classes had two teachers that co-taught lessons.

Our first unit, *Moving Straight Ahead*, focused on the study of linear relationships. Students compared two variables that had a constant rate of change. Through their discovery, students measured variables, such as time versus distance, time versus walking rates, and the distance of the rise of a step to the run of a step. Using these variables, students found the slopes and y intercepts by using graphs, tables, and equations. Students showed that using TI Interactive on both the SMART Board and the computers, helped to increase their visual understanding of linear relationships. Students were able to input information into excel, TI interactive and SMART Notebook to illustrate their data.

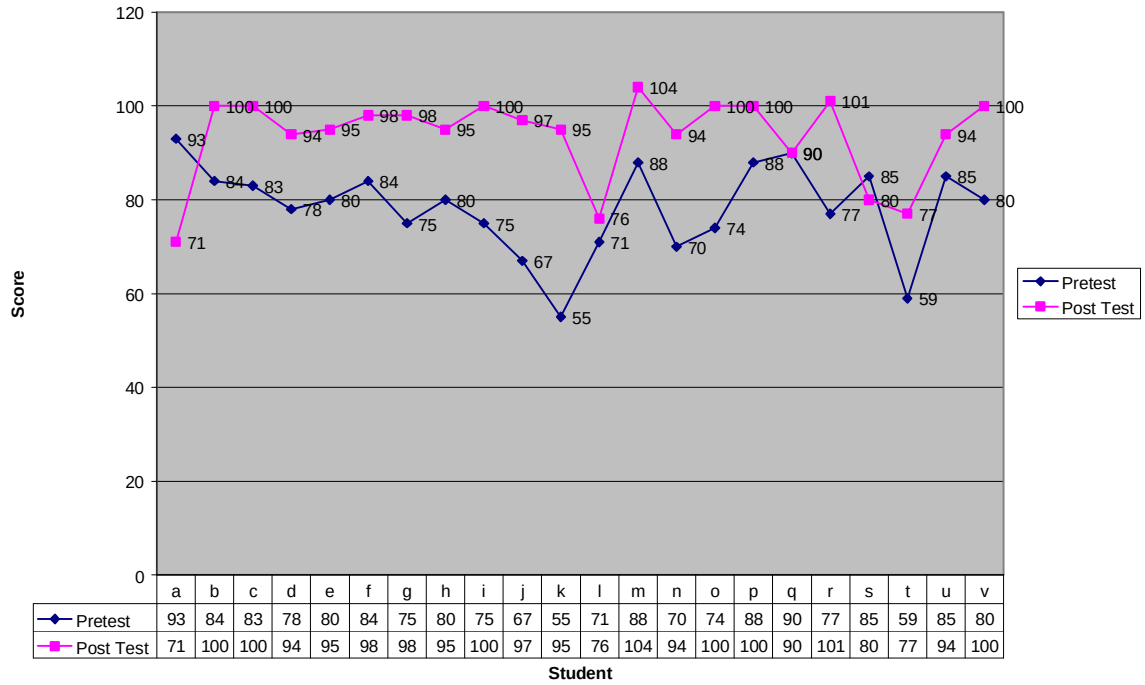
One experiment that students used to demonstrate linear relationships was "Climbing Monkeys." This experiment, which is found at the following link, http://www.phschool.com/atschool/cmp2/active_math/site/Grade7/monk/index.html, demonstrated the constant rate of change between the distance the monkeys climbed up or down a palm tree. The website was displayed on the SMART Board unit and students changed the variables being tested. Students saw how the linear relationships changed when one or more of the variables being tested changed. The original position of the green monkey was 0 and the blue monkey was 100. By looking at the graph, students saw that the green monkey started at the origin and the blue monkey started at the top of the graph. As students changed the original position, they saw on the SMART Board interactive whiteboard, that the original position moved on the Y axis.

Students then changed the reach of each monkey and noticed that it affected the steepness of the line, as well as the total amount of time it took to climb up or down the palm tree. Students determined that each monkey still moved at a constant rate but as the variables changed, so did the Y intercept and the steepness of each line.

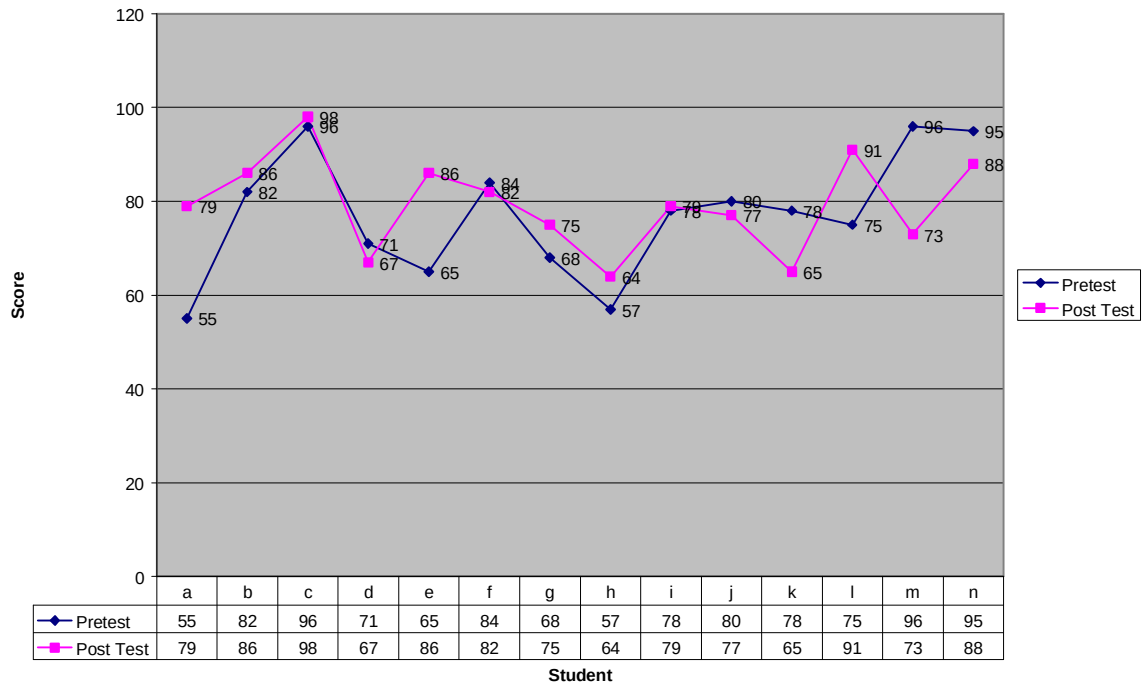
By using “Climbing Monkeys” on the SMART Board interactive whiteboard, students could visually identify the properties of a linear relationship. Although “Climbing Monkeys” was only one of the experiments conducted in *Moving Straight Ahead*, it was the most visual activity to introduce and reinforce linear relationships to the eighth-graders. The posttest was given at the end of the unit and you can see in the tables and graphs on pages 3 through 6 for *Moving Straight Ahead*, all classes increased their average score from the pretest to the posttest. When comparing the data from each class separately, I found that most students increased their scores from the pretest to the posttest. The results of their pretest versus the posttest showed an average increase of 6.462049 points, which in most cases increased the students’ scores by at least one grade level, over five class periods. The graphs and tables on the next two pages illustrate the average increase per class, as well as the progress each student made for their class period.



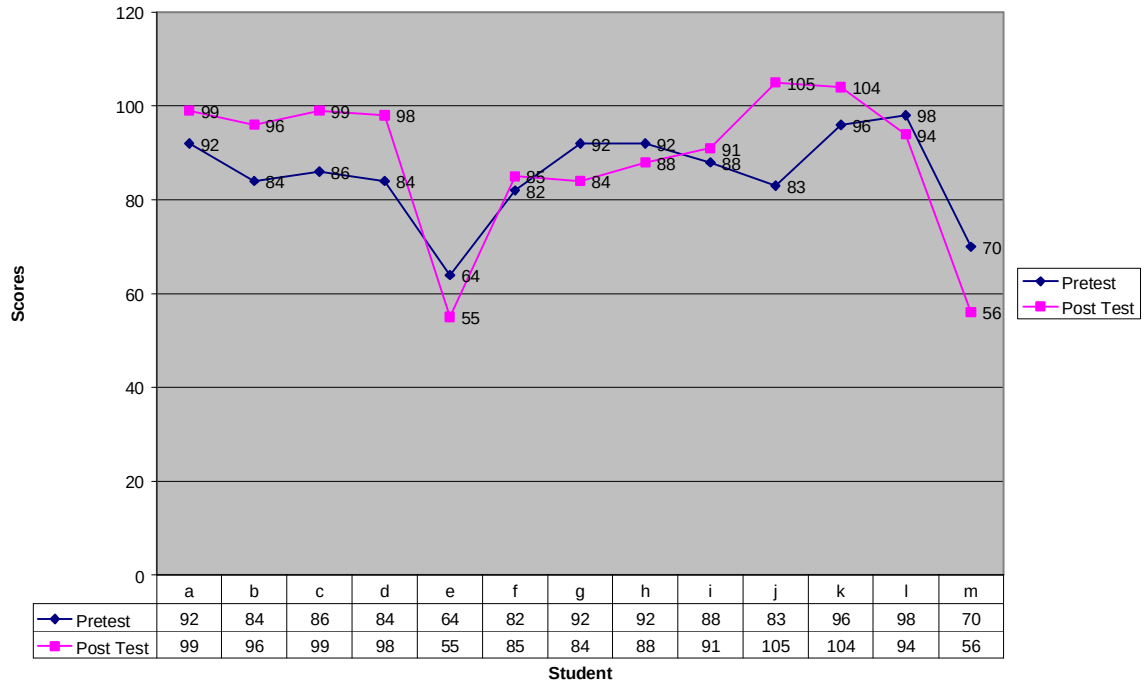
Class B



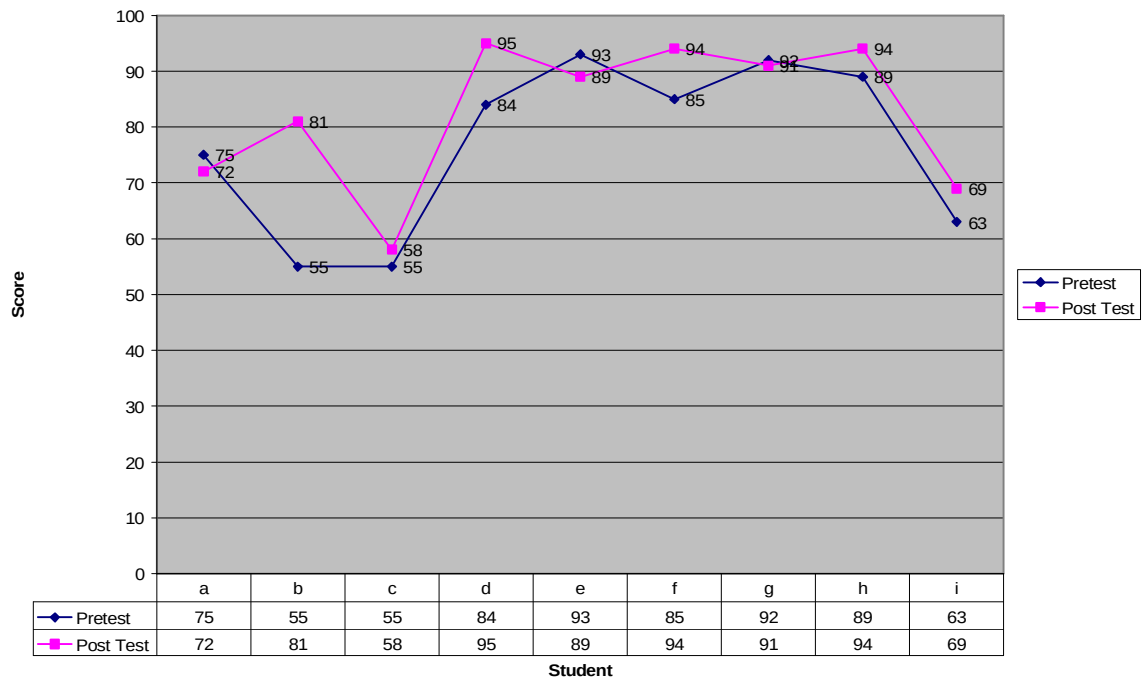
Class C

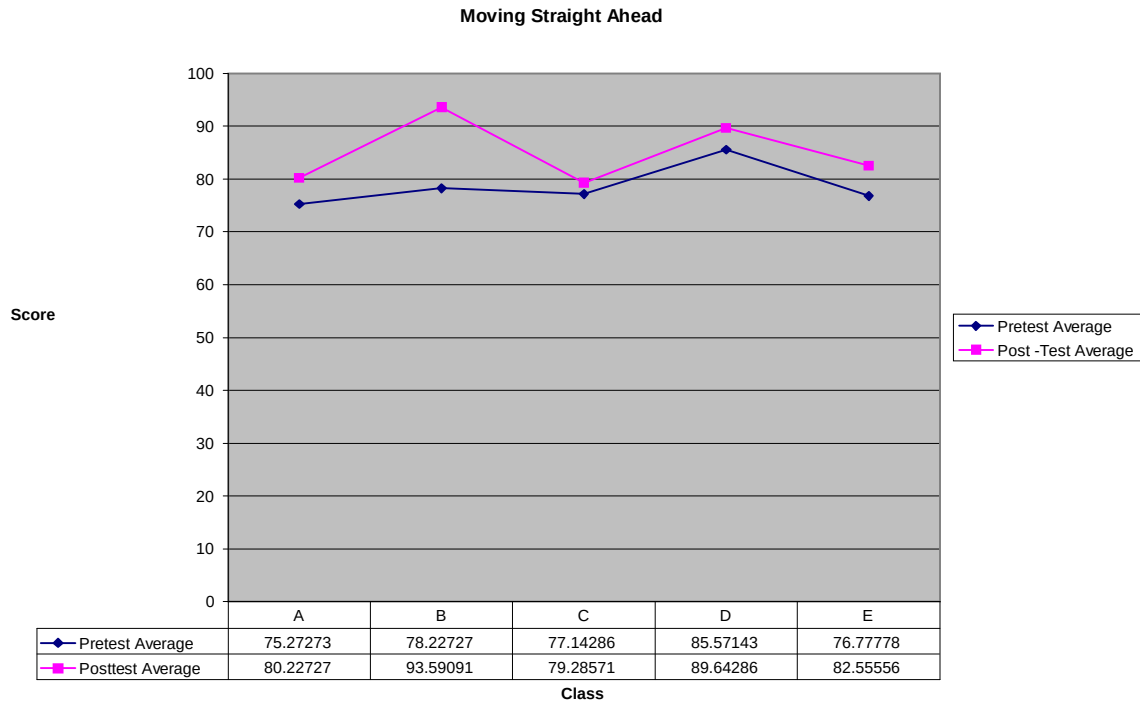


Class D



Class E





The second unit of study for “Lines, Curves, and Graphs” was *Thinking with Mathematical Models*. This unit focused on both linear and nonlinear relationships. Students were able to describe characteristics of linear relationships by creating graphs on the SMART Board interactive whiteboard that showed a constant rate of change that were increasing, decreasing, or staying the same. By using TI Interactive™ computer software, students created what they believed were linear relationships. Once students created the graphs, they were able to check tables for each graph to see if the rate of change was constant between all of the points and determine if the line was linear.

To reinforce linear relationships, students used the activity “Virtual Bridge Experiment” at http://www.phschool.com/atschool/cmp2/active_math/site/Grade8/Bridge/index.html to compare the bridge’s thickness versus its breaking weight. To begin, students set the length of the bridge at five and changed the thickness of the bridge. They noticed that as the thickness of the bridge increased by one, the weight increased by an average of four pennies. Students recorded the data in a table in Excel® spreadsheet software and graphed their table to determine if there was a linear relationship between the thickness of the bridge and the number of pennies used to break the

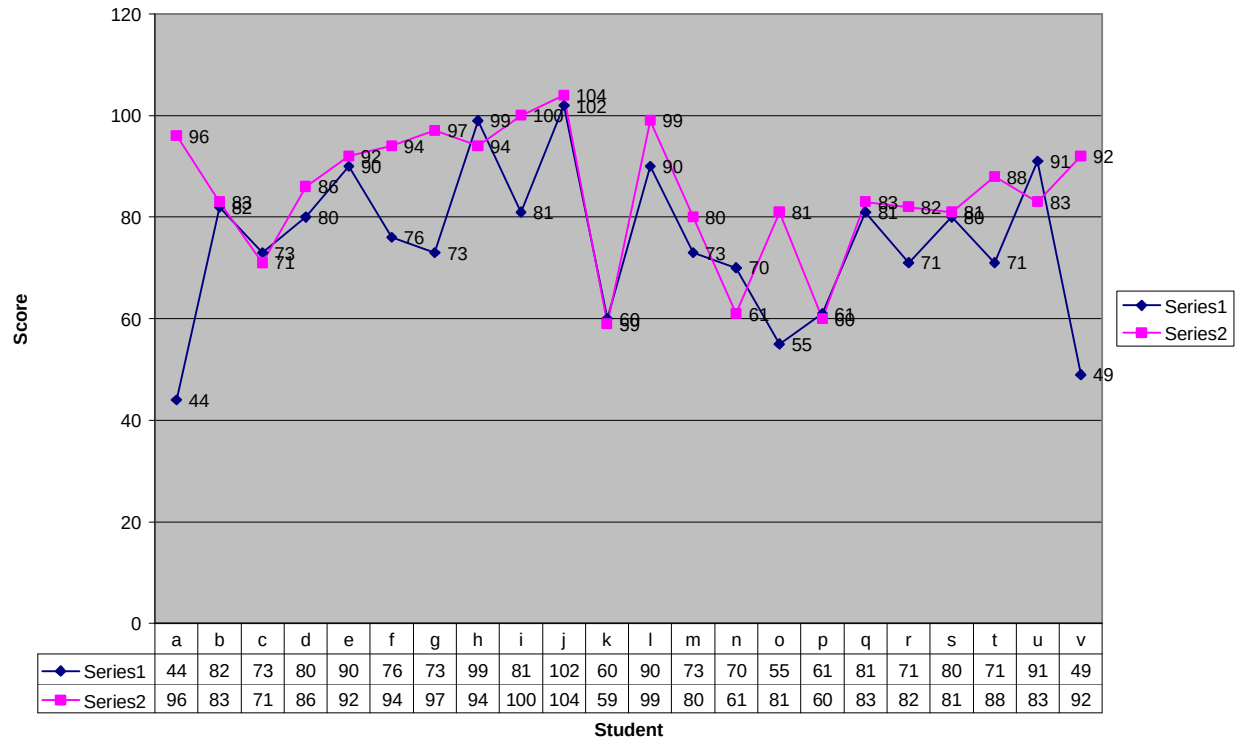
bridge. From their graph, students concluded that there was, indeed, a constant rate of change between the two variables being tested.

Students also explored nonlinear relationships in this unit. Students, again, used the “Virtual Bridge Experiment” to compare the bridge length versus the breaking weight. This time, students set the bridge thickness at one and changed the length. Students noticed the shorter the bridge, the more pennies the bridge could hold but decrease in the number of pennies was no longer constant. Students, again, recorded their data into an excel spreadsheet and graphed their table. This time, they found that the line was no longer linear but created something like a curve, or in their terms, a slide. By looking at this graph and table, students determined properties of two variables that do not have a constant rate of change and do not create a linear relationship. In order to strengthen the idea of nonlinear relationships, students also explored the concept of interest.

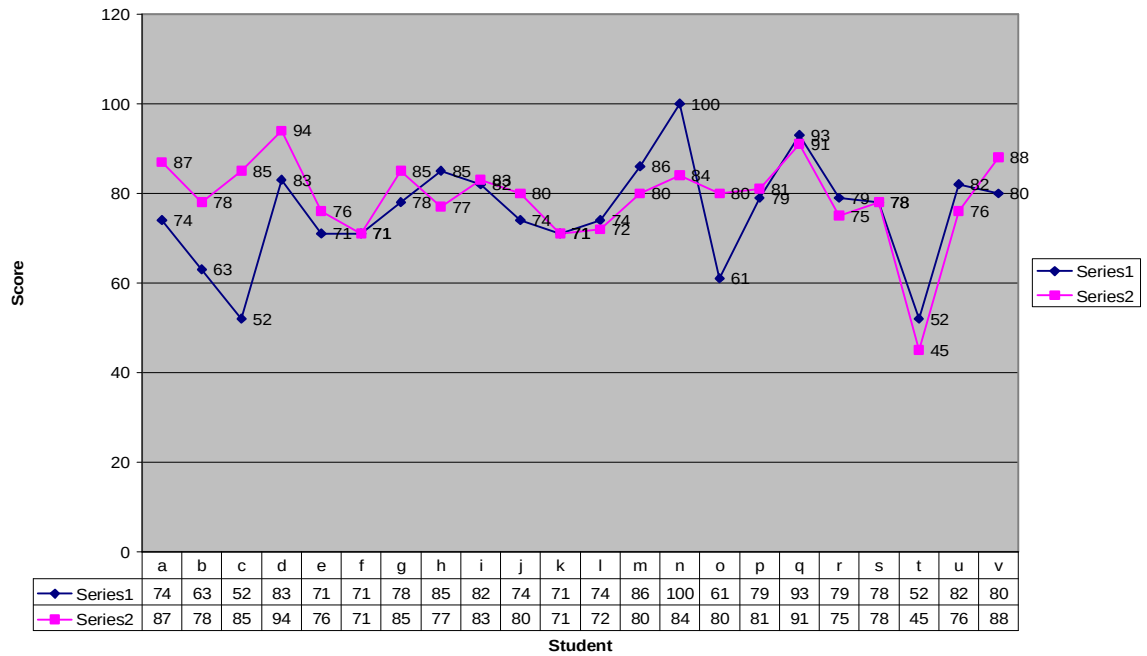
To thoroughly understand the concept of interest, each student was given \$100 of play money. Students had the right to deposit the money into a play account at a daily interest rate of 1.5%. Students could withdraw the money at any time. Students could use the money to buy extra credit points, homework passes, computer time, or other classroom activities. Each activity had a price. During the first five minutes of class time, students determined the amount of play money in their account and plotted it on the SMART Board interactive whiteboard. Some of the students watched their money increase rapidly, while others watched their money decrease rapidly. This process showed students that their increase and decrease changed over time but the increase or decrease was not a steady rate of change.

In both the pretest and posttest for *Thinking with Mathematical Models*, students were given 25 multiple-choice questions and two open-ended questions. Students used graph paper and graphing calculators to complete the pretest but were given the opportunity to use their data from the “Virtual Bridge Experiment” and the interest project to help them with the posttest. Below are the results from both the pretest and the posttest for each of the five classes, as well as the class averages. Students inputted their data into Excel spreadsheet software in order to compare class data. Students were able to view the class averages, not student averages, to determine their increased abilities in *Thinking with Mathematical Models*.

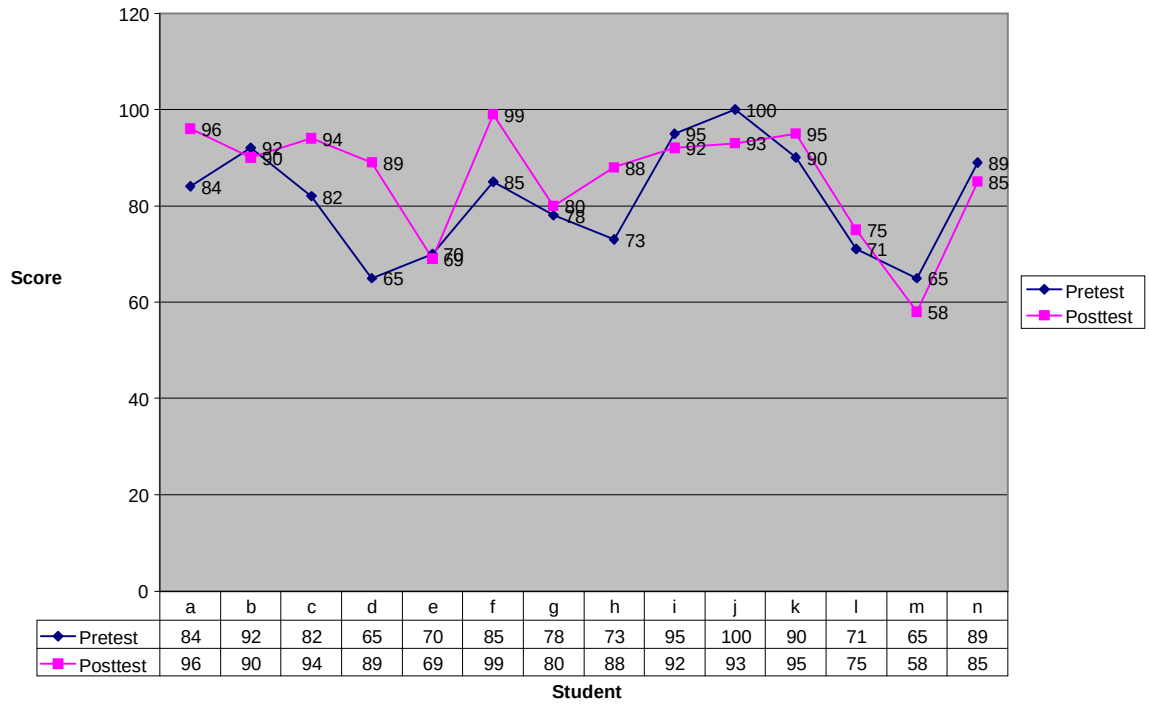
Period 2 - Thinking with Mathematical Models



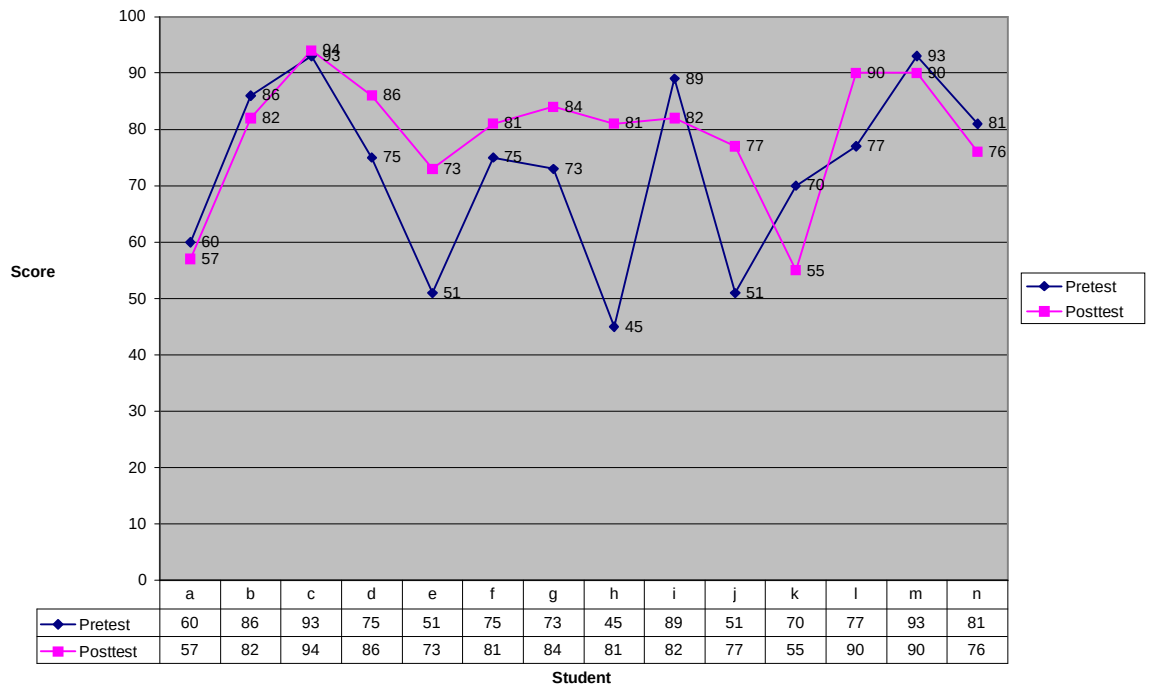
Period 4 - Thinking with Mathematical Models



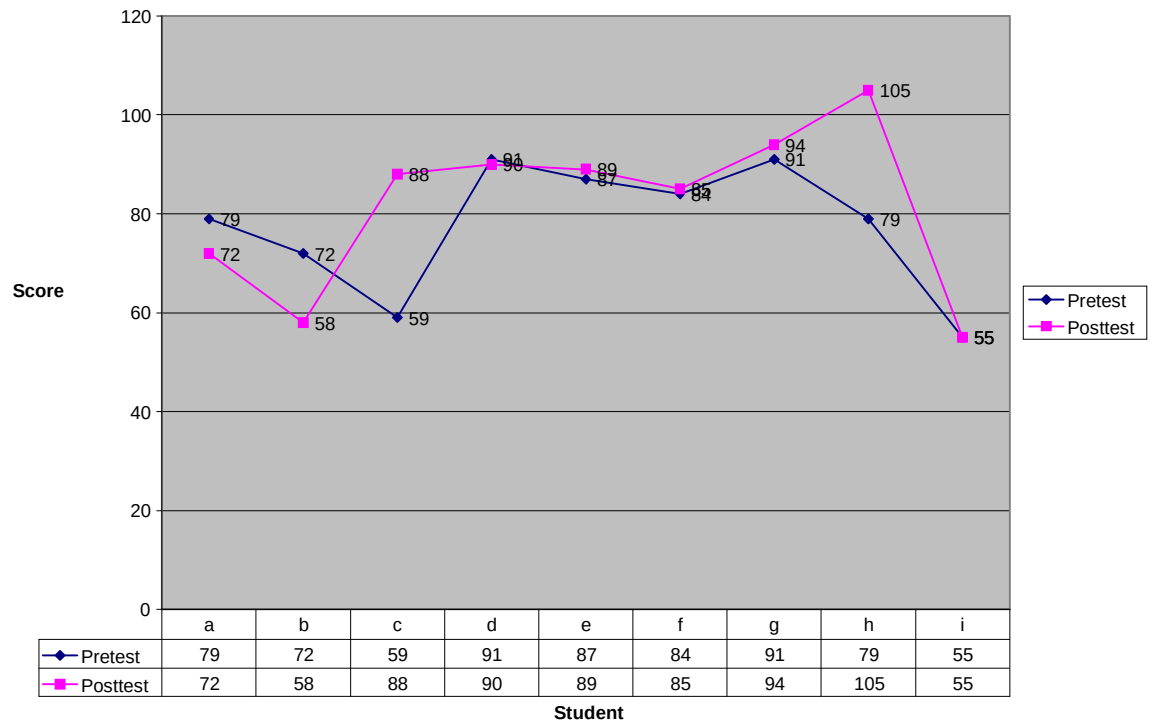
Period 6 - Thinking with Mathematical Models



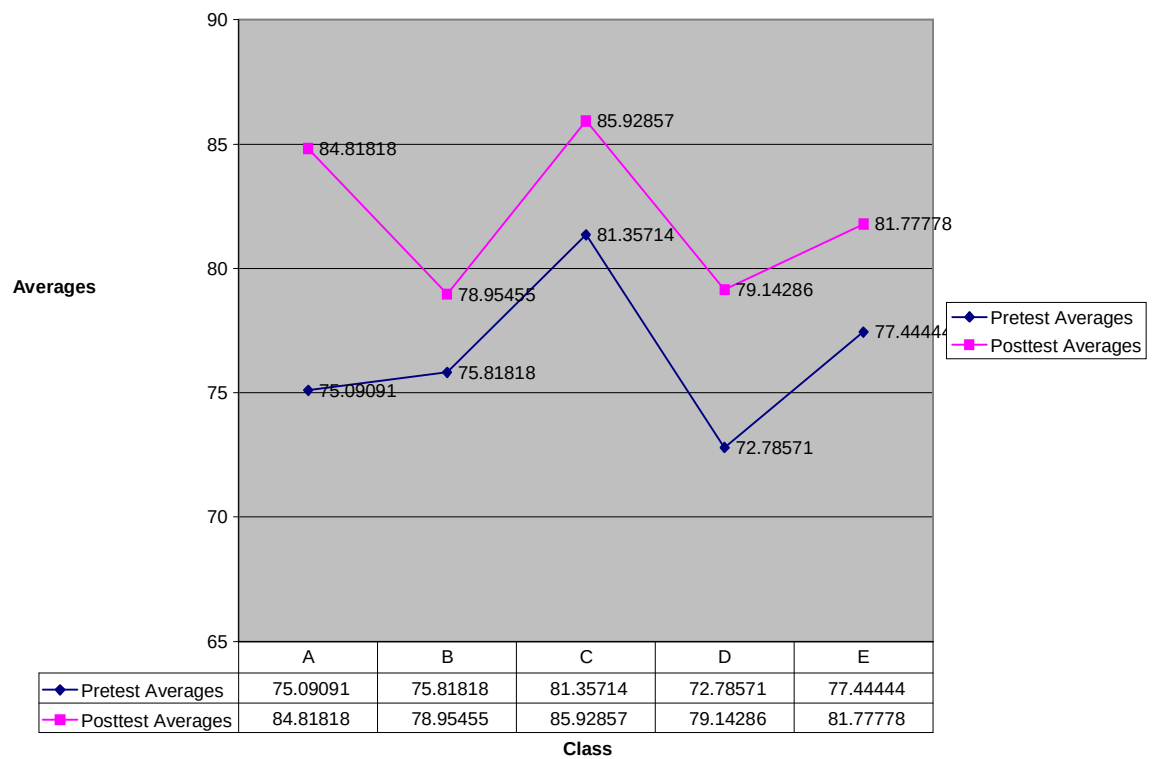
Period 8 - Thinking with Mathematical Models



Period 9 - Thinking with Mathematical Models



Thinking with Mathematical Models



To conclude our study of graphing, students worked on the third unit, called *Growing, Growing, Growing*. This unit was based on exponential relationships and students reinforced their understanding of nonlinear relationships. To begin, students cut ballots for a school election. Each student was given only one sheet of paper and created as many ballots as possible that were the same size. Students recorded the number of cuts they made and the number of ballots that resulted. When students made only one cut, they created 2 ballots, but when they made five cuts, they created 32 ballots. Students compared their results with one another and found that the number of ballots doubled from the previous cut. Later, they discovered that this “doubling” was an exponential growth with a base of 2 and a changing exponent that depended on the number of cuts. Students were able to plot their points from their table in TI Interactive computer software to create a nonlinear relationship.

After cutting ballots, students moved on to an activity in which they were to repay a peasant for saving the princess of the kingdom of Montarek. Using a chessboard, the peasant was given several choices for rewards. The peasant was then to choose the reward that he felt adequately repaid him for saving the princess. Students were split into groups and each group was given one reward. The groups tried to convince the peasant that their reward was the best. Students presented their rewards using PowerPoint® presentation graphics program, Excel spreadsheet software, and TI interactive computer software to the class.

Group one's reward was to place one coin on the first square of the chessboard, two on the second square, four on the third square, eight on the fourth and so on, doubling the number of coins from the previous square until they reached the sixty-fourth square on the chessboard. Group two's reward was to make a chessboard with only sixteen squares but place one coin on the first square, three on the second square, nine on the third square, and so on, tripling the number of coins from the previous square until they reached the sixteenth square. Group three's reward was to make a chessboard with only twelve squares but place one coin on the first square, four on the second square, sixteen on the third square, and so on, increasing by four times the previous amount until they reached the twelfth square. Group four's reward was to create a chessboard with sixteen squares but place 500 coins on the first square, 1000 on the second square, 2000 on the third square, and so on, doubling previous amount until they reached the sixteenth square. Group

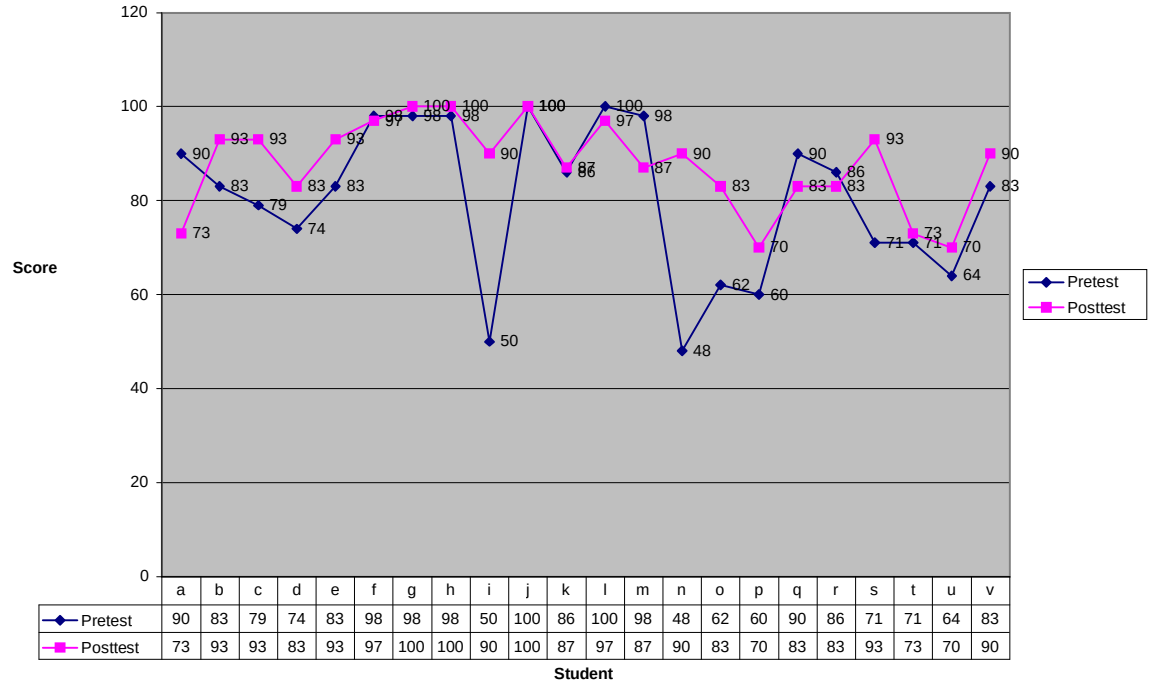
five's reward was to create a chessboard with sixteen squares but place 5 million coins on the first square, 6 million coins on the second square, 7 million coins on the third square, and so on, adding one million coins until they reached the sixteenth square.

Students did their best to convince their classmates to choose their rewards though no one was sure until the last presentation which reward was the best. Each class did conclude that Group one's reward was the best reward by far. All groups displayed tables and graphs of values for the number of coins that were on each square of their chessboard. Then, we created equations to illustrate the situation. From the graphs, tables, and equations, students found the properties that created linear relationships, nonlinear relationships, and exponential relationships.

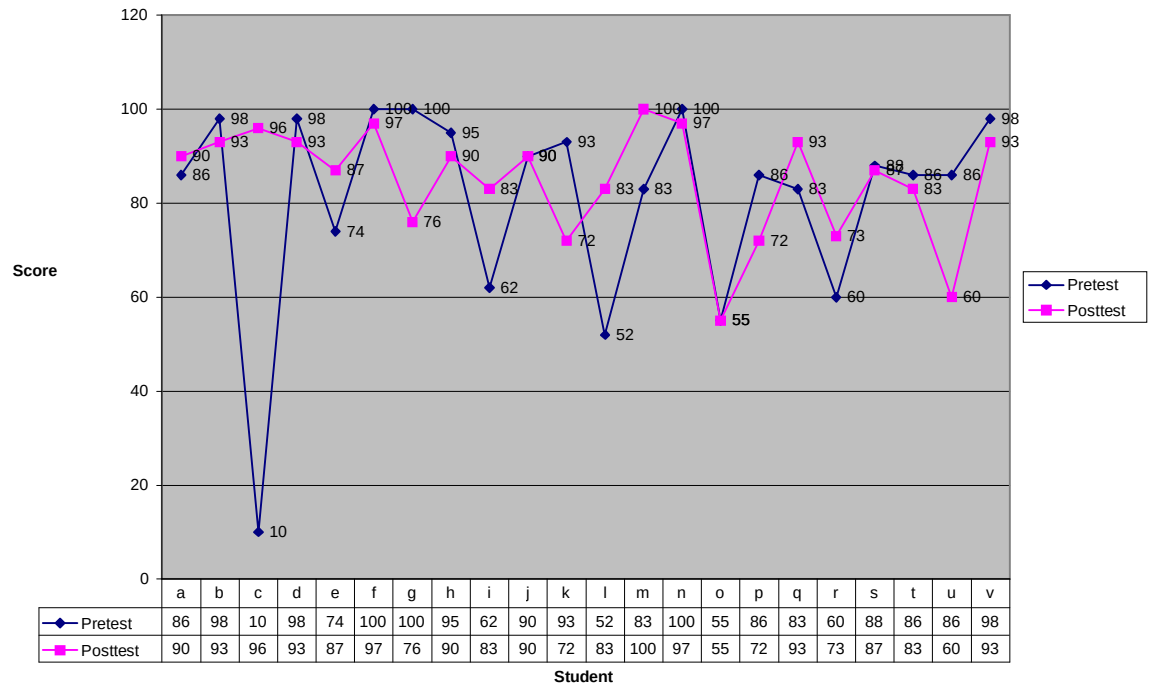
We concluded the unit of exponential relationships by studying the rabbit growth in Australia in 1859. Students researched the experiment using the Internet and found that twenty-four rabbits were introduced in 1859 and that there were more than 600 million rabbits within a century. We estimated the number of rabbits that the twenty-four rabbits may have reproduced in one year if twelve of those rabbits were male and twelve were females. Students found on the Internet that the gestational period for rabbits is only thirty-one days and that they could have anywhere from two to twelve rabbits. We averaged that a female could have about six litters a year and an average of seven rabbits per litter. So, by the end of the first year, we determined that there may have been about 22,665 rabbits in Australia. We then used that information to determine the number of rabbits for the second, third and fourth years. Students plotted the data on a graph to see that the number of rabbits increased exponentially.

When comparing the results for the pretest and the posttest for *Growing, Growing, Growing*, the task was more difficult. The pretest consisted of both multiple-choice and open-ended questions but the posttest was based on a project. Students used their understanding of exponents and exponential relationships to determine the amount of bacteria that forms in your mouth between brushings. Students demonstrated a more consistent understanding of exponents in the posttest than in the pretest. By looking at the results, you can see that the range of scores on the posttest is smaller than the pretest in most classes. The average increase of scores, using the SMART Board interactive whiteboard for *Growing, Growing, Growing*, was 4.864502.

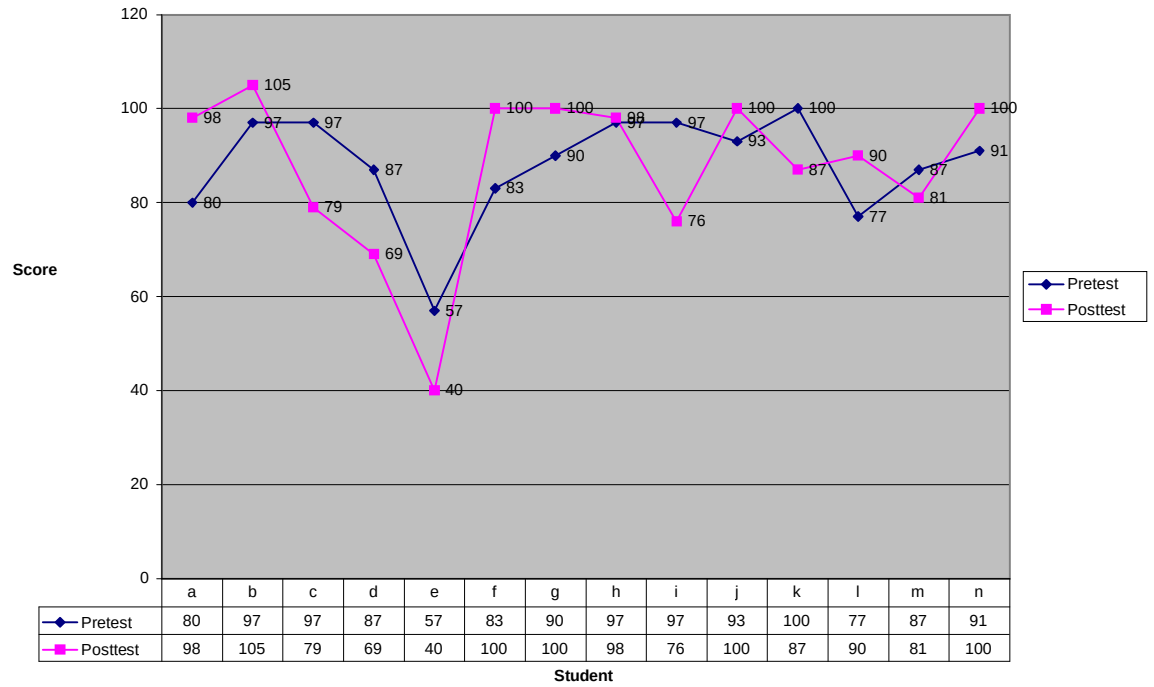
Period 2 - Growing, Growing, Growing



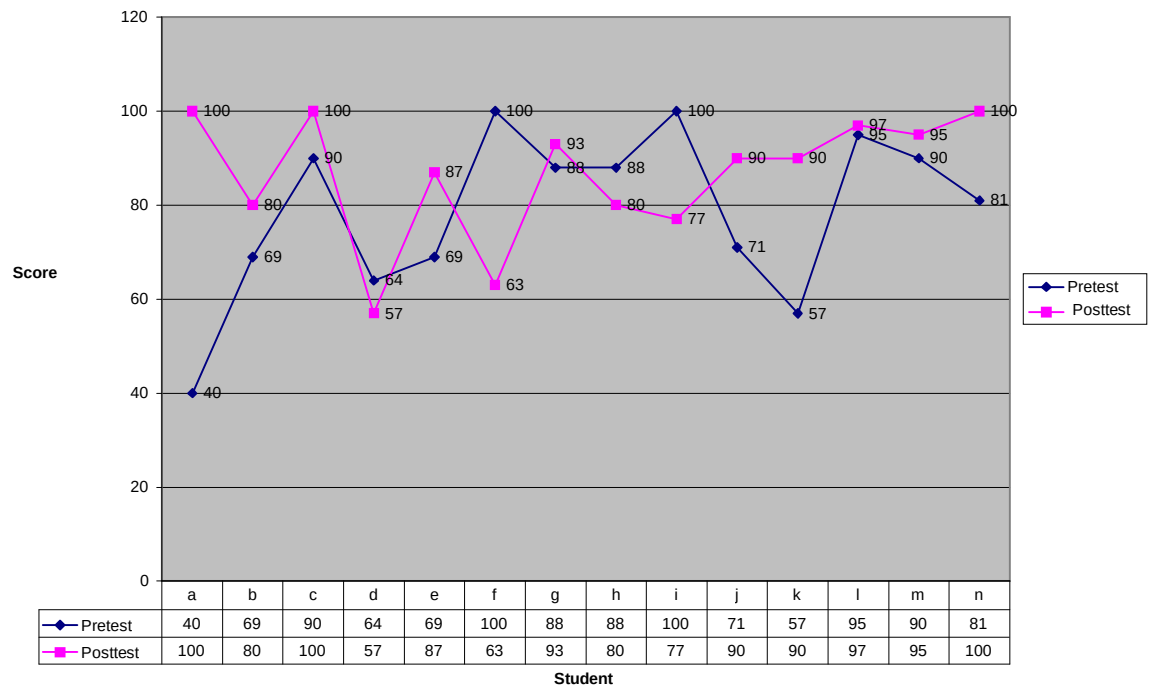
Period 4 - Growing, Growing, Growing



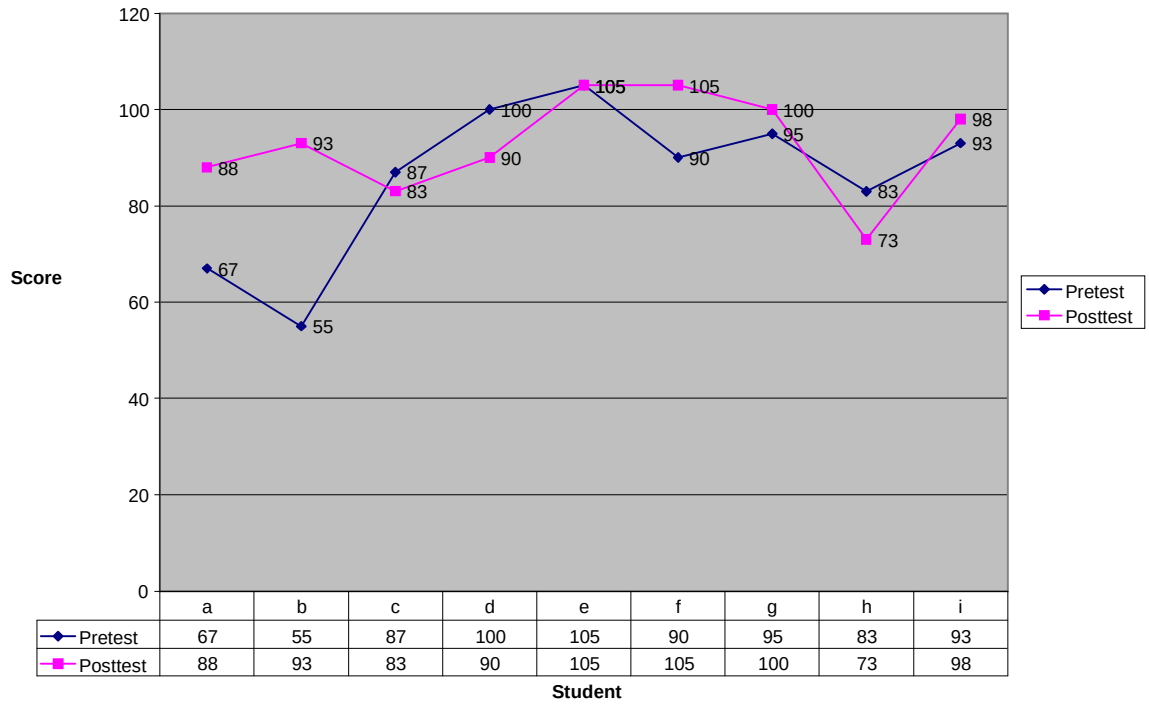
Period 6 - Growing, Growing, Growing



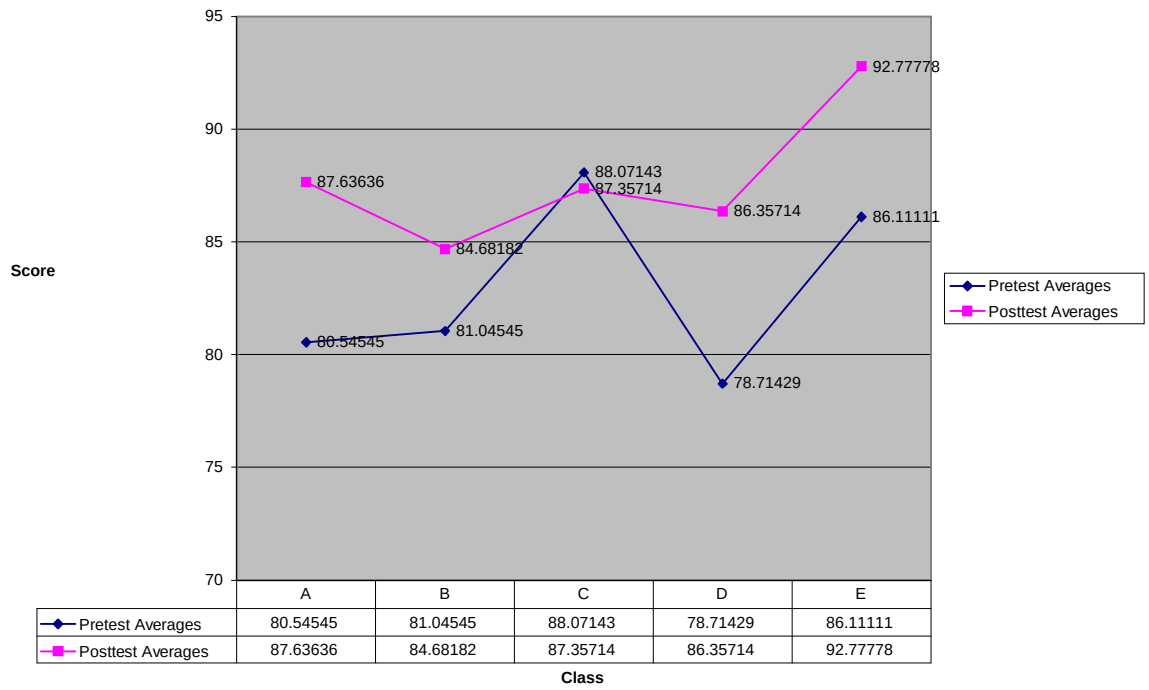
Period 8 - Growing, Growing, Growing



Period 9 - Growing, Growing, Growing



Growing, Growing, Growing



When conducting experiments, taking notes, creating graphs and composing tables, the SMART Board interactive whiteboard allowed the eighth-graders at Woodstown Middle School to use a hands-on approach to understanding linear, nonlinear and exponential relationships. This opportunity to use the SMART Board interactive whiteboards increased the creativity and alertness of the students in my class. Each day, we took time to explore the functions and abilities that the SMART Board interactive whiteboard gave to us. I also found that the students are more involved when they have the opportunity to visually show their work and compare it to the work of other students in their class, as well as the work of students in other classes. Although neither I, nor the students, were experts at using the SMART Board interactive whiteboard, we worked together to learn the capabilities that it allowed us to have in the classroom and more specifically with graphing. The SMART Board interactive whiteboard opened many doors for both myself, as an educator, and for my students, as learners.

References:

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http://www.phschool.com/atschool/cmp2/active_math/index.html