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An Introduction to Using Spreadsheets to Increase the Sophistication of Student Projects

When gifted students are asked what they like best about being in a special program for the gifted and talented, their first response usually deals with the greater freedom allowed for selecting topics of study. Conversely, when they are asked about their greatest objection to the regular curriculum, students' comments frequently refer to the limited opportunities to pursue topics of their own choosing. Independent projects are a popular option for talented youth. These projects not only capitalize on students' interests, they also afford students an opportunity to study something that interests them in much greater depth. Many independent projects go beyond merely copying information from library resources and the Internet. Rather than regurgitating existing knowledge, students of any age can begin to develop interesting questions and collect data to answer them. This process of conducting original research transforms students from lesson learners to creative producers (Renzulli, 1982).

At an early age children are fascinated with the world around them. They can spend hours observing a ladybug traverse a blade of grass or be mesmerized by the colors and patterns on a simple rock. One way to capitalize on this fascination to observe is to encourage students to ask questions that can be investigated through hands-on data collection. By systematically defining and recording what they observe, young people begin to acquire sophisticated research skills (Renzulli, Siegle, & Hoffmann, in press).

Very young students can begin to use technology to organize and analyze their data in sophisticated ways. The National Center for Education Statistics (2005) reported that 67% of nursery school students and 80% of kindergarten students were using computers in 2003. By the early elementary grades, some of these students are ready to begin using spreadsheet programs. Although most computers are equipped with some type of spreadsheet program, spreadsheets are probably one of the most underutilized pieces of software on school and home computers. While spreadsheets were once the purview of bookkeepers and accountants, the functions built into spreadsheets are useful with a wider audience for various purposes. Spreadsheet programs will produce impressive graphs, and most include a myriad of statistical functions that range from simple calculations of averages to more complex tests of statistical significance. The purpose of this column is to introduce readers to two simple procedures available in Microsoft Excel that can be used with gifted and talented elementary students. The first can be used with primary students to create simple column (bar) graphs. The second can be used beginning with middle elementary students to plot and calculate simple relationships (correlations).

All research begins with a question (see Figure 1). The key is to refine the question into something that can be investigated through data collection. Upper elementary students can begin the research process by reading about the topic they are investigating. Researchers call this conducting a review of literature. This process serves three purposes. First, students develop background on what they are interested in studying. Second, it helps students focus their interest and helps them to refine research questions that they will answer by collecting data. Finally, the review of literature often describes other studies. Students can develop ideas for how they wish to conduct their study based on the methods that others have used.

Part of formulating a plan is to clearly define what data needs to be collected and how it will be collected. Imagine a group of first graders was interested in whether ants preferred apples or oranges. They might plan to place an apple and an orange equal distance from an anthill and observe which fruit drew more ants (Starko & Schack, 1992). Data analysis for first graders might include creating bar graphs of how many ants visited each fruit over a one-hour period. Initially, students should create their graphs by hand to ensure they conceptually understand how graphs depict data. Once they understand the concept, they can quickly move to graphing programs. Microsoft Excel has an excellent graphing program built into it. Enter the results into the spreadsheet, highlight the data, and click on the *Chart Wizard* icon (see Figure 2). A dialog box will appear. Select *Column* under *Chart type:* and click *Finish* (see Figure 3). An attractive chart will appear on the spreadsheet (see Figure 4).

Charts created in spreadsheets can be copied and pasted into other programs, such as word processing or presentation programs, where students are documenting their projects. To do this, click on the chart and select *Edit* ➔ *Copy* from the toolbar. Open the program where the chart is to be displayed and select *Edit* ➔

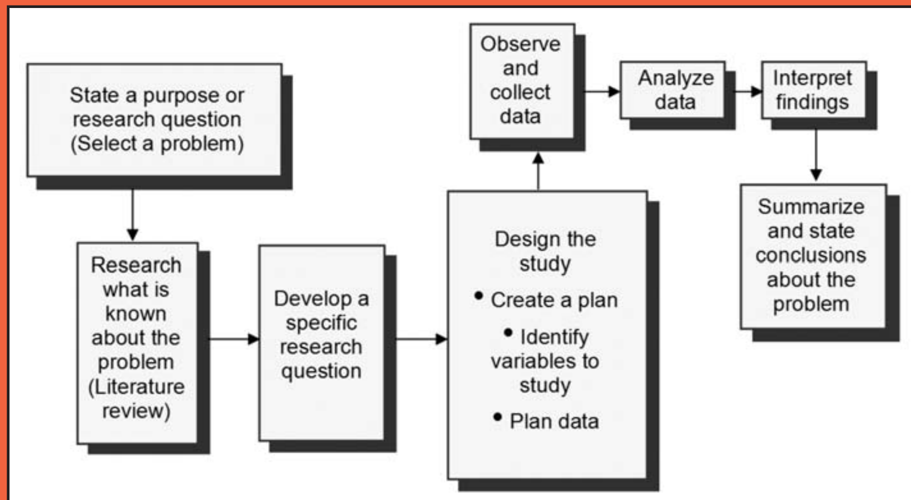


Figure 1. Flow chart of the research process

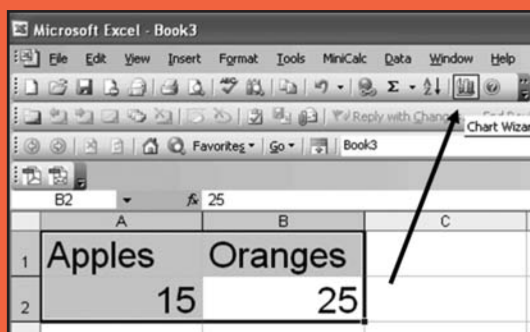


Figure 2. Spreadsheet data highlighted and Chart Wizard indicated

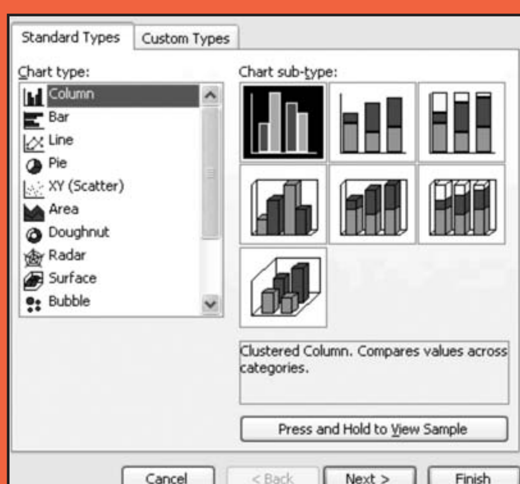


Figure 3. Chart Wizard dialog box with *Column* chart selected

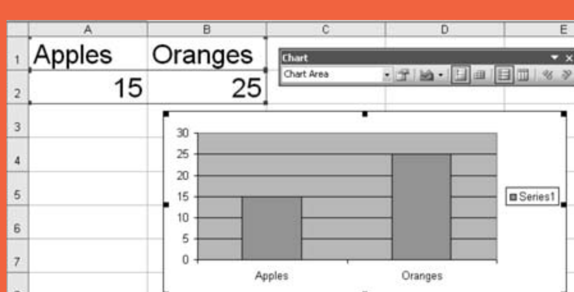


Figure 4. Sample column graph created in Microsoft Excel

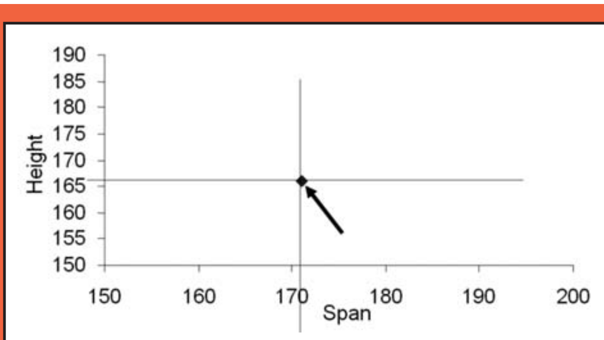


Figure 5. Plotting data for a subject with an arm span of 172 cm and a height of 166 cm

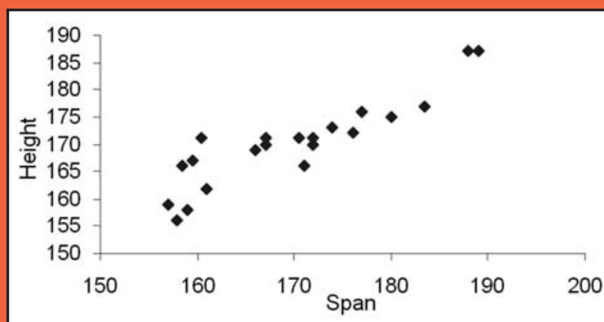


Figure 6. Scatterplot of the arm spans and heights of 21 subjects

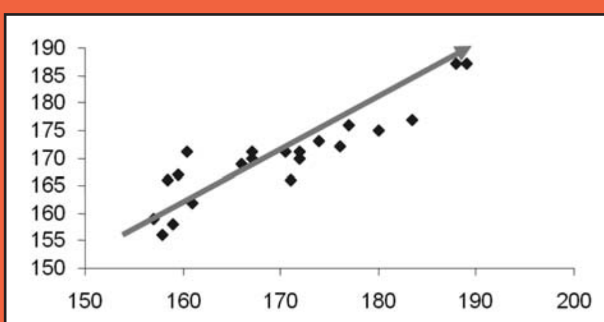


Figure 7. A positive correlation has high values on one variable associated with high values on the other variable

Paste. The chart will appear in the new document.

Gifted and talented students in third or fourth grade are ready to understand simple statistical operations. The elementary curriculum traditionally limits this exposure to calculating the mean, mode, and median of a set of numbers. I have found that students at this age can progress beyond calculating simple averages and grasp the concept of correlation. Correlational research investigates relationships between two variables, such as height and weight and answers the question, "What is the relationship between —— and ——?" If two variables have a strong relationship, one of them can be used to predict the other.

Suppose students were interested in investigating the relationship between height and arm span. First they would need to define the two variables they are comparing and develop a plan for measuring them. The definitions in this example might be as follows:

> Variable 1: Height—Distance in centimeters from the bottom of the heel to the top of the head of someone standing barefoot.
> Variable 2: Span—Distance in centimeters between the tips of the middle fingers as measured across the back of a standing person with outreached arms that are parallel to the floor.

Once the variables are defined and the students have a plan to select subjects, they can begin collecting data. Data for correlational research are collected in pairs. In other words, two pieces of data (e.g., height and span) are collected from each subject. Once the data are collected, students should first graph the results. A scatterplot is used to graph relationships. Scatterplots are two-dimensional graphs with one variable plotted on the x-axis and one variable plotted on the y-axis. Assume that a subject had a span of 172 cm and a height of 166 cm. Students would locate 172 on the x-axis and 166 on the y-axis and place a point at their intersections (see Figure 5). Data points would be plotted for each of the subjects (see Figure 6).

A correlation expresses the direction and strength of a relationship. If the pattern of data points leads upward (see Figure 7), the relationship is positive. Positive relationships indicate that subjects with high values on one variable tend to have high values on the other variable and subjects with low values on one variable tend to have low values on the other variable. Age and height tend to have a positive relationship. As children grow older, they are likely to be taller. If two variables are negatively correlated, as one variable goes up, the other variable goes down. The scatterplot of a negative correlation falls (see Figure 8). Time spent practicing for something and the errors made performing it later tends to have a negative correlation. The more time people spend practicing, the fewer errors they are apt to make in their performance (Starko & Schack (1992).

In addition to having direction, correlations have strength or magnitude. The stronger the magnitude, the better one can predict change in one variable from change in the other variable. A common measure of the magnitude of the relationship between two variables is a statistic called Pearson's r. A magnitude of r = 0.00 indicates no relationship and no predictions can be made. The data points in such a relationship form no pattern. Data points that fall near a straight line represent a very strong relationship and accurate predictions of one variable can be made from the other. Relationships that fall on r = 1.00 or r = -1.00 indicate a perfect relationship. This is highly unusual. The strength of relationships can be anywhere between 0 and ± 1.00. Figure 9 shows the strength of various relationships.

Elementary students enjoy making scatterplots and guessing the strength of the correlation. Once students master the concept of a scatterplot by creating one by hand, they can use a spreadsheet program to create them. The first step is to enter the data on a spreadsheet. Once the data are entered (see background of Figure 10), highlight the data and click on the Chart Wizard or click on *Insert* ➔ *Chart*. In the dialog box select *XY (Scatter)* from the chart type. Click on

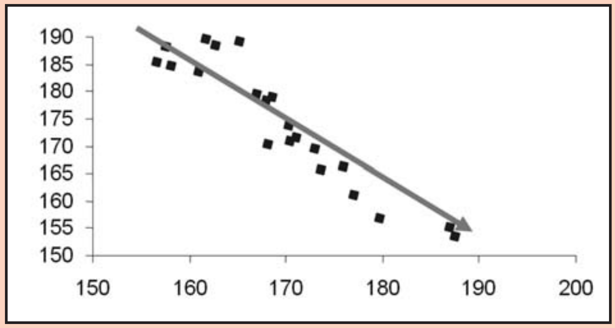


Figure 8. A negative correlation has high values on one variable associated with low values on the other variable

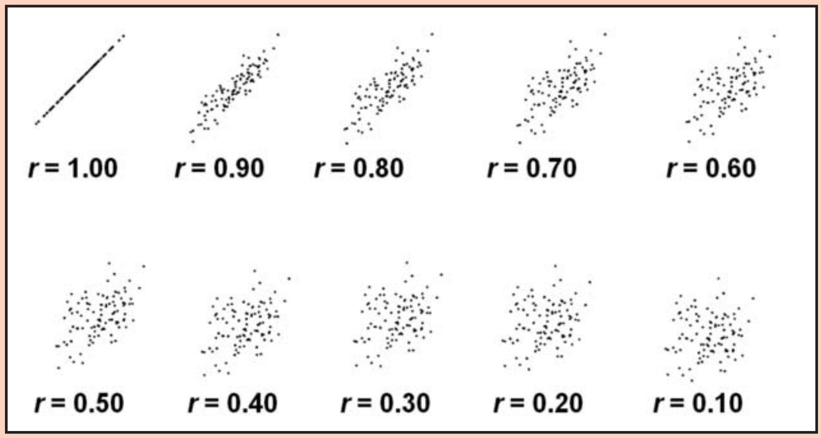


Figure 9. Scatterplots representing different correlation magnitudes

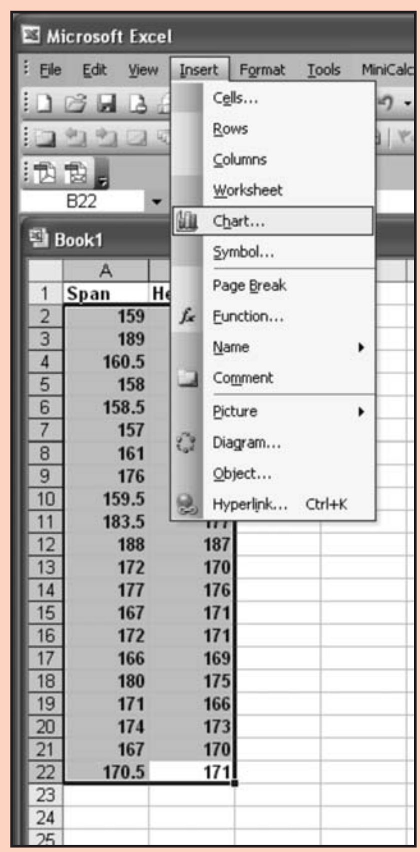
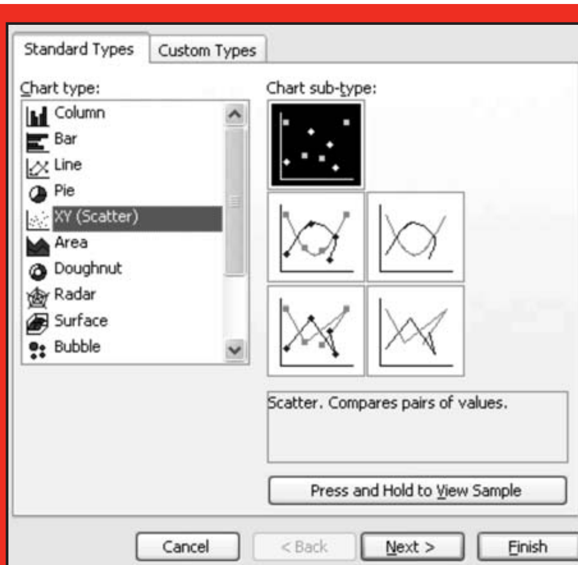


Figure 10. Highlight the data and select Insert ➔ Chart from the dropdown menu to begin creating a scatterplot

Figure 11. Select XY (*Scatter*) as the chart type



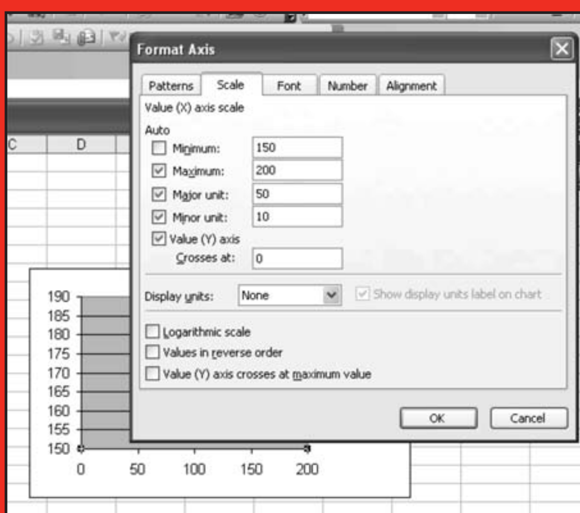
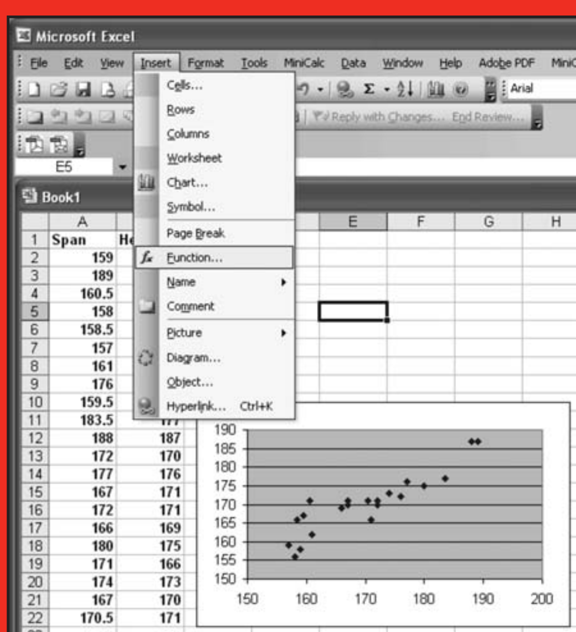


Figure 12. Adjusting the minimum and maximum value of the axis

Figure 13. Select Insert➔Function to begin calculating the correlation coefficient



the traditional scatterplot *Chart-sub-type* and click *Finish* (see Figure 11). The scatterplot will appear on the spreadsheet. The minimum and maximum values of the x- and y-axis can be changed by double clicking on the appropriate axis and changing the values in the dialog box (see Figure 12).

As stated earlier, students enjoy examining scatterplots and guessing the strength of the relationship. The Excel spreadsheet can be used to calculate the actual strength of the relationship (Pearson's correlation coefficient). Students will be motivated to learn how to use a spreadsheet to determine the strength of the correlation to check the accuracy of their guess. Once the data have been entered on an Excel spreadsheet, place the cursor in a blank cell where you wish to have the correlation coefficient (Pearson's *r*) appear and click the mouse button. Move the cursor to the *Function Wizard* (*fx*) button on the toolbar and click on it or select *Insert* ➔ *Function* from the pull down menu (see Figure 13). A dialog box will appear. Select *Statistical* from the top section of the box and *CORREL* from the middle section. After you have made those two selections, select *OK* at the bottom of the dialog box (see Figure 14). Enter the cell range for the first variable in the Array 1 box. For example, if the data for your first variable were in column A from row 2 to 22, you would enter A2:A22. Instead of typing the range, you can also move the cursor to the beginning of the set of scores you wish to use and click and drag the cursor down them. Do the same for Array 2. Once you have entered the range for both variables, click *OK* at the bottom of the dialog box (see Figure 15). The correlation for the two variables will appear in the cell you selected.

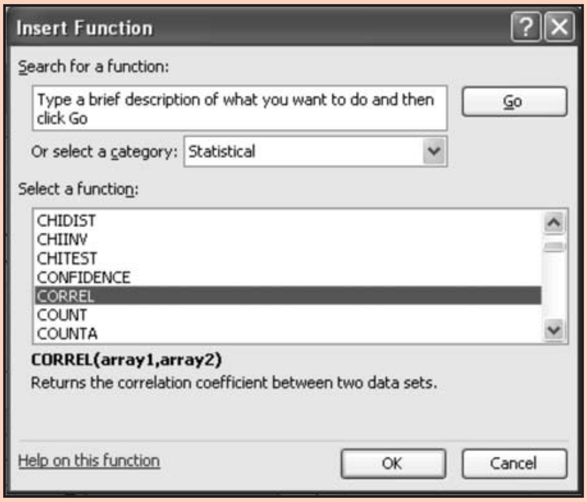


Figure 14. Select the appropriate statistic (*CORREL*) from the dialogue box

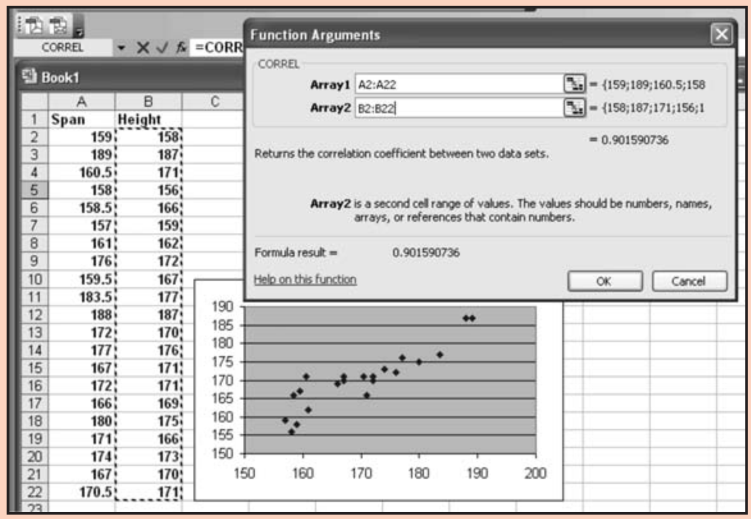


Figure 15. Enter the location of the data for which you wish to calculate the correlation

Educators should caution students that just because two variables have a strong correlation, that does not indicate that one caused the other. No matter how strongly the two variables are related, one can only state that the data reveal a strong relationship. More advanced research designs are necessary in order to state that one variable caused another.

Students may wish to participate in collaborative data gathering exercises. The Math Forum (http://mathforum.org/workshops/sum96/data.collections/datalibrary/index.html) provides a list of collaborative projects where students gather and share data with each other. The site also includes data sets in Excel that students may be interested in using. Readers who wish to learn more about correlations or other statistical procedures can visit the author's Web site at http://www.gifted.uconn.edu/siegle/Conferences/CTComputer/Start.html.

Correlations are one of the easiest statistics for elementary children to master. A third grade student who includes correlation calculations in a science fair project is sure to impress the judges and will gain confidence to continue collecting and analyzing data. While data collection techniques become more complex for older children, spreadsheet programs are powerful and versatile enough to aid the most sophisticated student researchers. Many advanced statistical procedures can be calculated with Excel, whose powerful functions have often been ignored. GCT

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