

CREATING STATISTICS APPLETS WITH GEOGEBRA

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1. Introduction

I spent most of the last 20 years teaching elementary statistics classes using the TI-83 and TI-84 graphing calculators as the only source of technology. While teaching these classes, I have constructed hundreds of graphs on the board, worked through thousands of example problems, and answered numerous student questions. All of this led me to imagine ways of improving the process. When I discovered the statistics applets on the Rossman-Chance website, I knew there was a way to implement my ideas.

After spending a few years trying to learn what I could about web-page creation, I discovered GeoGebra in the summer of 2010. I enrolled in Mike May and Russell Blyth's PREP Online Course, *Web-Enhanced Instruction with GeoGebra*, and also completed the tutorial that was available on the GeoGebra website. After that, my main source of information was *A List of the Commands in Release 3.2* by Mike May and S. J.

Most of my applets were created using GeoGebra 3.2. I am not yet very familiar with GeoGebra 4.0, but I have started updating some of my applets using GeoGebra 4.0 and have not run into any big problems so far. Also, I do not use Apple computers.

2. Why GeoGebra?

GeoGebra is a mathematical software package that melds geometry, algebra and calculus in a dynamic fashion. You can create geometric objects using points, lines, vectors, segments or conic sections; and then change the objects by dragging the component parts around on the computer screen. You can also input mathematical equations and change the resulting graphs by moving sliders on the screen. You can work with geometrical figures or evaluate integrals and derivatives all within this one program.

Why use GeoGebra for statistics? GeoGebra can create the graphs and do the calculations used in statistics. It can also include the wordy problem statements and conclusions that are characteristic of statistics. Best of all, there is a built-in procedure for creating web-based applets. Doing all of these things is fairly easy with GeoGebra. You can do the examples you want, and make the changes you want. You are the author, the editor and the publisher. The only cost is your time.

3. Sequences

Sequences provide the basic framework for most of the applets I have created. The command for creating a sequence is shown below.

General Format

Seq1 = Sequence[Function(Index), Index, StartNo, EndNo, Increment]

Example

INPUT: SquareSeq = Sequence[k ^ 2, k, 1, 10]

OUTPUT: SquareSeq = {1, 4, 9, 16, 25, 36, 49, 64, 81, 100}

Warning: Do not use “i” as index. I used “i” as an index for a dot plot applet, and the applet is now frozen: the applet has no interactivity. I think the problem was caused by the fact that GeoGebra uses “i” to denote the square root of negative one.

Another way to create sequences is by just by putting a list between set brackets. I use this option much more than the formula option, but I had to discover it for myself. The lists can be of anything: numbers, letters, words, sentences, paragraphs, etc.

Examples

DataSeq = {16, 35, 16, 28, 34, 41, 30}

ColorSeq = {"Red", "Yellow", "Blue", "Green", "Orange", "Purple"}

Empty sets or empty sequences are not a problem. To create my dot plots, I just plot the set of data values occurring at each number in a regular sequence from the minimum of the data to the maximum. If one set is empty, the program just moves to the next set.

4. Generating Random Numbers and Sampling without Replacement

GeoGebra has various routines for generating random numbers. You can generate random numbers with a binomial, normal, Poisson or uniform distribution, or you can generate random integers that are between two given integers. I find the random Poisson is best if you want to generate data sets with outliers.

I started out using random number generators a lot, but I later decided to sample data from the real world data sets in our statistics textbook. The samples still contain real world data, but they are small enough that our students can work with them on their calculators during in-class tests.

I wanted to sample without replacement but, unfortunately, GeoGebra does not have a built-in routine for sampling without replacement. After working on this problem for quite a while, I decided the best option was to use modulo arithmetic with numbers that are relatively prime to the size of the data set. Different start values and different relatively prime numbers produce different samples of the given size.

General Format

OptSeq = Element[List, Mod[StartValue+k * RelPrime, ListSize]+1,

k, 1, SampleSize]

Example

INPUT: List = Sequence[k,k,1,9]
 OptSeq1 = Sequence[Element[List,Mod[2+5 * k,9]+1],k,1,6]

OUTPUT: List = {1,2,3,4,5,6,7,8,9}
 OptSeq1 = {8,4,9,5,1,6}

I tried to create a GeoGebra routine to generate all numbers that are relatively prime to a given sample size; but failing that, I now choose the relatively prime numbers to use for the set generation algorithms beforehand.

The data values generated by this procedure do not repeat, but the results may sometimes not seem random. They may appear to have an identifiable pattern or they may be bunched together from some section of the original data set. To avoid this problem, test various start values and relative primes to see if the results are to your liking.

5. Constructing Numeric Scales for Graphs

Constructing scales for graphs is something I spent some time working on because I am a little particular about how graphs look. Since I received an e-mail from a statistics instructor who was impressed with the results, I thought I should share them. Here are the assignments I use to create a basic uniform numeric scale.

DataMin = Min[DataValues]
 DataMax = Max[DataValues]
 DataRange = DataMax – DataMin
 AxisScale = floor(DataRange/3)
 AxisMax = ceil(DataMax/AxisScale) * AxisScale
 AxisMin = floor(DataMin/AxisScale) * AxisScale

The assignments for a uniform frequency scale are shown below. Since frequency scales start at zero, there are fewer assignments to make.

FreqMax = Max[FrequencyValues]
 FreqScale = Max[1, floor(FreqMax/3)]
 FreqAxisMax = ceil(FreqMax/FreqScale) * FreqScale

6. Labeling Objects in GeoGebra

There are many types of objects in GeoGebra: boolean values, complex numbers, ellipses, functions, lists, numbers, points, polygons, segments, text, vectors, etc.; and the

alphabet does not last very long. While constructing one of my first GeoGebra applets, I went through the entire alphabet before I had finished creating the items I needed.

If you create an object in the input bar and give it the same name as existing object, the existing object will disappear. If you rename an existing object with the name of another existing object, GeoGebra will automatically provide a subscript to the name of the other object. To avoid these problems, use descriptive label names. This helps keep you from repeating labels and it also makes finding an object later that much easier.

When you use labels over and over again in different formulas, it helps to keep them short. Labels that are not used very often can be as long as you like.

7. Making Changes

If you decide you want to improve an applet, save it as a new version first. If you make a few different changes to an applet and all of a sudden, it no longer works, it is nice to have that working copy as a starting point instead of beginning from nothing.

There are Free Objects and Dependent Objects in the algebra view. Dependent Objects are defined using objects that have been defined elsewhere and Free Objects are not. If you double click on a Dependent Object, a little window pops up with the object's formula in it. You can make any changes you want to the formula in the window, and then by pressing either the "Apply" or "OK" button, the changes will take effect.

Making changes to Free Objects is a little different. Double clicking on the item name makes the object editable. After making any changes you want, you must press "Enter" for the changes to take effect. It took me a while to figure this out. The other option for changing Free Objects is to enter an entirely new definition for the item in the input bar.

Changing item labels is very easy. Right click on the item label and then choose "Rename". Other instances of the label will be automatically updated. Just make sure you have not used the new label for something else in the applet.

There are no copying and pasting options available in the edit menu when you are working with formulas in GeoGebra. In these situations, you can press the buttons "Ctrl" and "C" simultaneously for copying formulas and press the buttons "Ctrl" and "V" simultaneously for pasting formulas from one place to another in GeoGebra. I usually avoid using meaningless button combinations, but I noticed my wife using these while doing something on her computer, so I tried them in GeoGebra and they worked.

After making numerous changes to my applets like moving around problem statements or increasing font size, I have decided it is best to set text locations and table locations as labeled points. Then, if you want to move the items around, you just change the coordinates of the labeled point. If you assign labeled values for row heights and column widths in a table, then you can resize the table to fit a larger font just by changing the values assigned to row height and/or the column width.

8. Working with Text

Text items in GeoGebra are very easy to use. Variable values may be inserted at any point in a text item. I use text items for graph titles, axis labels, problem statements, questions, calculations, answers, etc.

Text items are not listed in the algebra view with everything else. To find them, choose “Edit” and “Object Properties”, and click on the “plus” sign next to “Text”. This is a situation where descriptive labels help. If your text items are labeled Text1, Text2, Text3, etc., you have to pull them up, one at a time, until you find what you want. Changing variable values in text items is not straightforward. Creating an entirely new text item to replace the one you want to change is sometimes the easiest option.

I have a procedure for creating problem statements, questions, and answers for sample test items. Suppose you are creating the problem statement. First, create a text item for each different version of your problem statement. You should locate each text item at a given point when you create it. I would name this point something like StmLoc. Also, label each statement version with names like Stm1, Stm2, Stm3, etc. Once you have created the labels, put them together in a sequence. For example: StmSeq = {Stm1, Stm2, Stm3, ... } To select the problem statement that will appear on screen, just choose an element from the statement sequence. For example: Stm = Element[StmSeq, OptNo].

If you have answers or calculations that are specific to each option, put them in sequences as well. Just make sure they are in the same order as the corresponding options. Font size and color can be determined for the visible problem statement just by choosing it and selecting “Edit” and then “Object Properties”. The positions of each possible problem statement, on the other hand, must be changed individually.

9. Display Size and Scale

Try to use the same size working area whenever you are building applets in GeoGebra. This provides a standard for how things will appear on your website. Use the default scale and origin location whenever possible.

Changing the scale or location of the working area can put items out of alignment in other files you open during the same session. Returning misaligned items to their correct position can take time, and if you log out of GeoGebra and log back in, the file you just fixed will be out of alignment again.

If you change the scale or origin of the working area for an applet and you decide to open another file with a different scale, log out of GeoGebra and then log back in so that the default scale is selected.

I use my applets during classes in different rooms on different computers. Most of the time, the applets appear fine. If they are out of alignment, however, it may just be that the magnification on the computer screen is set to something other than 100%.

10. Conclusion

I have learned a few things in the process of creating my applets. First, schedule a given amount of time to work on an applet, and when the time is up, stop. I could spend hours and hours working on these applets, but I am sure my other obligations would suffer as a result. Logging out of GeoGebra and working on something else for a while can be helpful. Many ideas for improving my applets occur to me while I am doing other tasks.

Second, do not try to update applets on your website the day before they are needed. Once, I tried updating an applet the day before a test and the webpage just went totally white. I thought maybe the links from other pages needed to be updated as well; but when I updated the links, the other pages also went totally white. I had to postpone a test that was dependent on these pages as a result. I later found out that a glitch in the university server had caused the problem. If I had not tried to make those changes in the first place, I would not have had to postpone the test.

Finally, to create complicated applets, making a flow chart helps. As an undergraduate, for programming assignments, I would usually write the program first and then create the required flow chart for it. Now that I am older, laying out the possible options on paper beforehand seems to reduce the number of trials needed before an applet starts working.

In the future, I intend to write more step-through applets to demonstrate some of the more complicated procedures in elementary statistics. I also plan to become more familiar with the changes in GeoGebra 4.0. In particular, I would like to find out what I can do with the new input option.

If you have any questions, send me an e-mail.

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