AN INTRODUCTION TO GEOGEBRA 3.2

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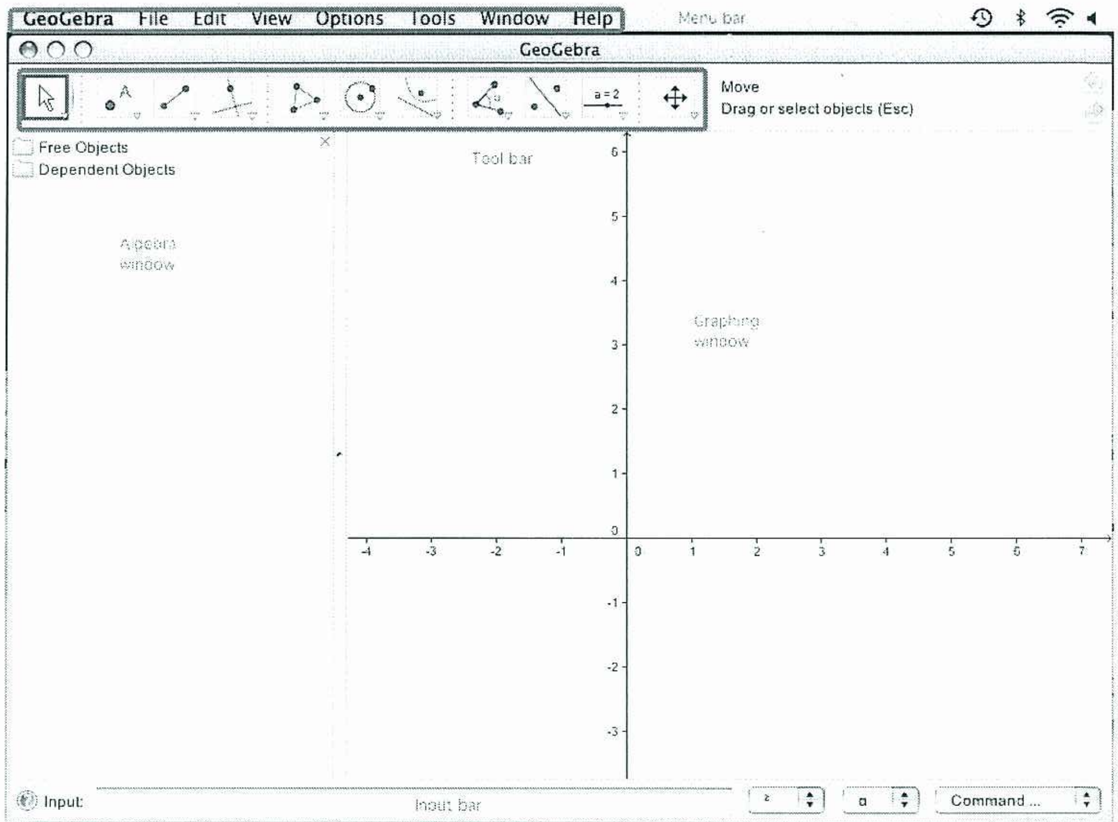
Overview - GeoGebra is a free, open source, cross platform program that can easily be used to construct demonstrations, visualizations, and exploration tools for courses in mathematics from algebra through calculus. The program allows the user to easily mix graphical and algebraic representations of objects. GeoGebra also allows the user to easily export demonstrations as applets embedded in a dynamic web page, to be used either over the web or through a java enabled browser locally. At ICTCM XX, we described how to use GeoGebra to create active web pages with embedded dynamic applets. ([2] Using GeoGebra to Create Applets for Visualization and Exploration.) GeoGebra is under active development. The previous paper used version 3.0 for its baseline. Throughout that paper we referred to handouts ([2]) used at the ICTCM workshop. This paper highlights a few of the new features that have been added to GeoGebra with release 3.2. We will refer to handouts that are available on a wiki developed for an online PREP workshop over GeoGebra ([4]).

Section 1 – fast overview

It will be useful if the reader has a copy of GeoGebra available while reading this paper. This can be obtained from <http://www.geogebra.org/cms/en/download>, the main GeoGebra site. On that site the "Applet Start" button will launch a copy of the GeoGebra applet in the browser window. The image below shows the GeoGebra application with labels on regions we will refer to in the paper. Starting at the top, there is a bar of drop down menus. Below the menu bar is a row of icons that are actually menus of tools. (The small triangle in the lower left corner of each tool icon activates the prop down list of tools.) The main region has an algebra window to the left and a graphing window with axes to the right. At the bottom of the screen is an input bat for typed commands. The right hand side of the input bar has three drop down menus for special symbols and functions, Greek letters, and commands.

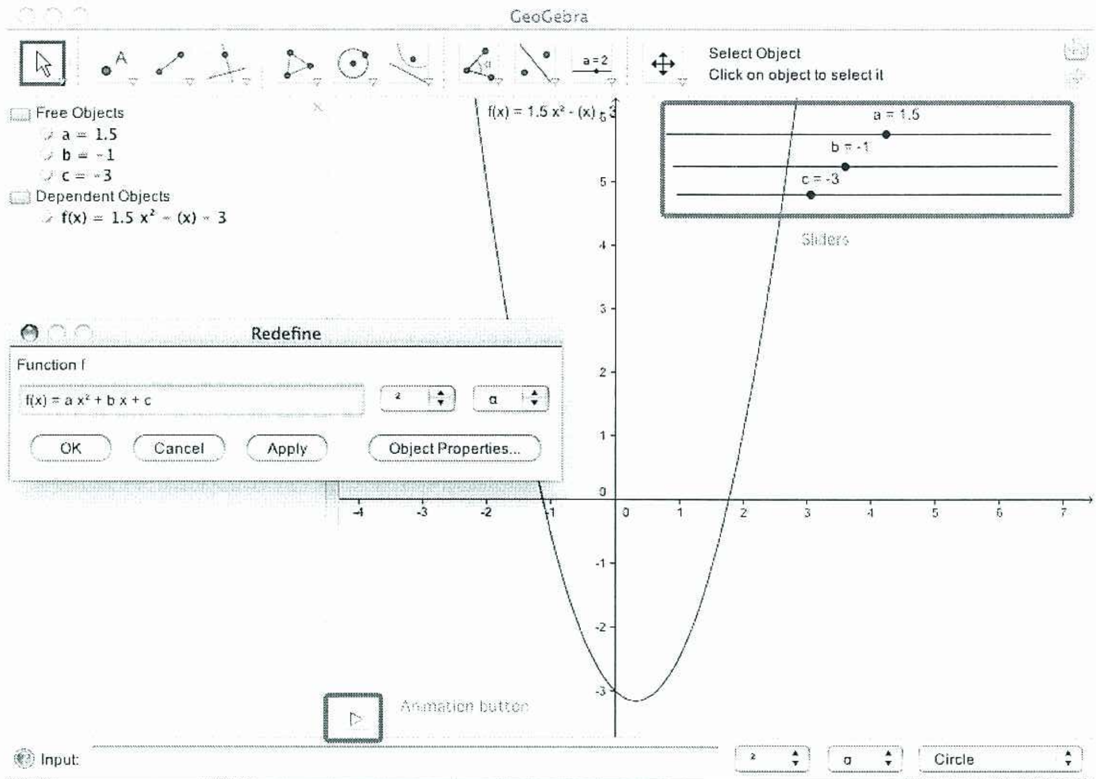


The applets referred to in this paper are available as part of a larger collection of applets at [5] <http://www.slu.edu/classes/maymk/GeoGebra/>. A huge collection of applets and activities is available at the main GeoGebra wiki, [6].

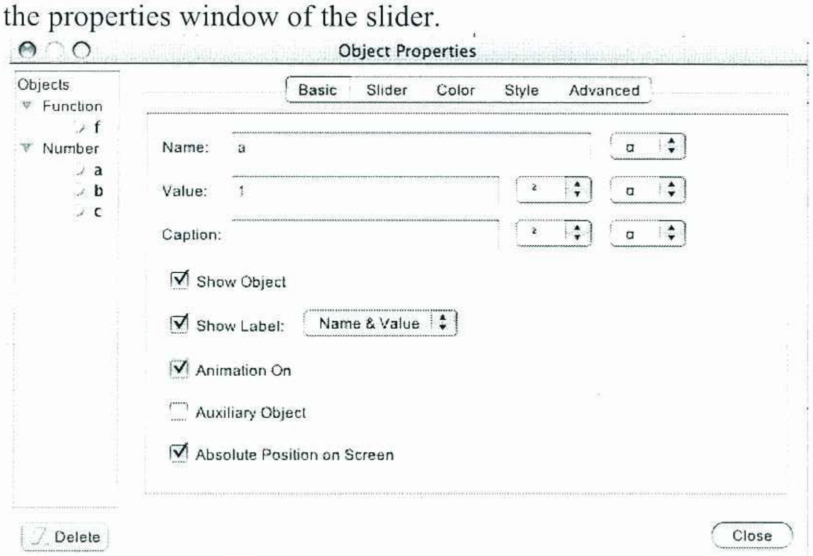
Section 2 – Animation

One of the nice new features of release 3.2 is the ability to animate constructions. This is done with a modification of how sliders work. To illustrate animation of sliders, we start with a construction we did in the previous workshop, the graphing of functions with parameters. (Go to
< http://www.slu.edu/classes/maymk/GeoGebra/FamilyOfFunctions.html > to see the old applet.) In several math courses the teacher wants to tell the class that they will be studying the graphs of some favorite type of function and be able to relate values of the parameters to features of the graph. Depending on the course, the favorite graph might be a parabola, or a sin curve, or an exponential curve.

Thus we start be adding three sliders (a, b, and c) to our GeoGebra window. We define a function in terms of the parameters by typing f(x) = a*x^2+b*x+c in the input bar. In the image below the redefine window shows that the function is defined with parameters. In the lower left corner of the graphing window there is an arrow button that can be used to turn on the animation.



To allow animation of a slider, you need to first turn animation on under the basic tab of the properties window of the slider.



(This puts the aniamtion button the graphing window.) The speed and direction of the animation of the slider is controlled under the slifer tab.

In a construction with several sliders, the values of the different sliders can be given different speeds. Even with multiple sliders, there will only be one animation button. To give independent control of multiple sliders without opening the properties box, one would have to construct a javascript control for turning the sliders on and off. An example of this can be found at <http://www.slu.edu/classes/maymk/GeoGebra/Conics2.html>.

Section 3 – Best Fitting Curves and Statistics

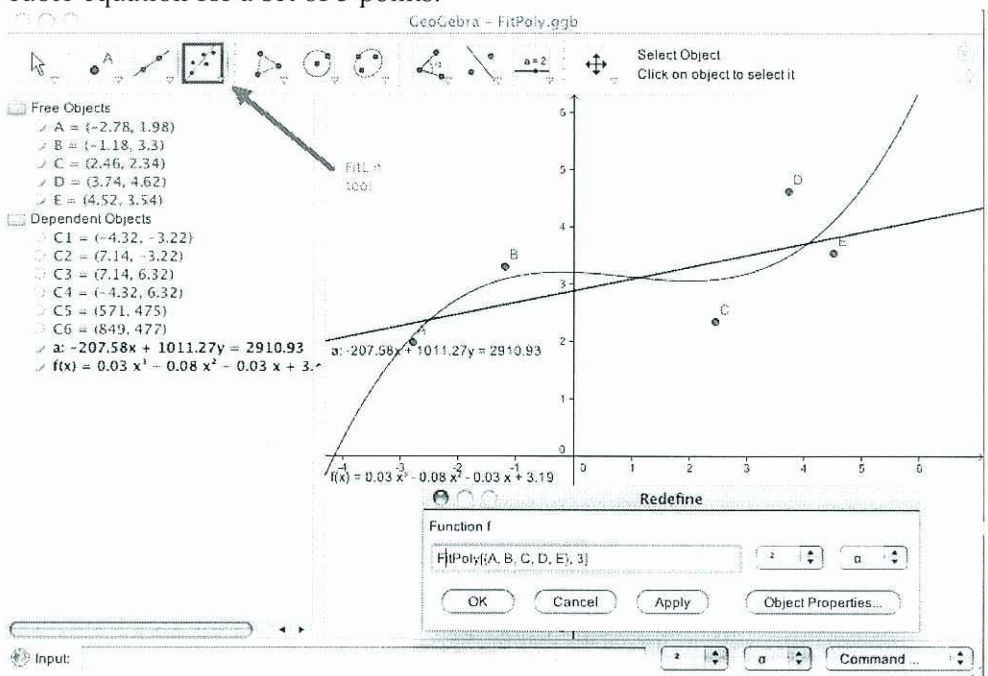
The upgraded statistical commands and tools probably constitutes the area where version 3.2 has made the most significant improvements GeoGebra 3.0. Enough functionality has been added to make it useful to address the additions in the blocks of random numbers, descriptive statistics, best fitting curves, and graphical representations of data.

In the area of random variables, GeoGebra 3.2 has the ability to generate a random number from a distribution that is uniform (and integer with RandomBetween), binomial, normal, or Poisson. The menu option to "Recompute all objects" takes a new random sample. There are function commands for the normal and inverse normal distributions.

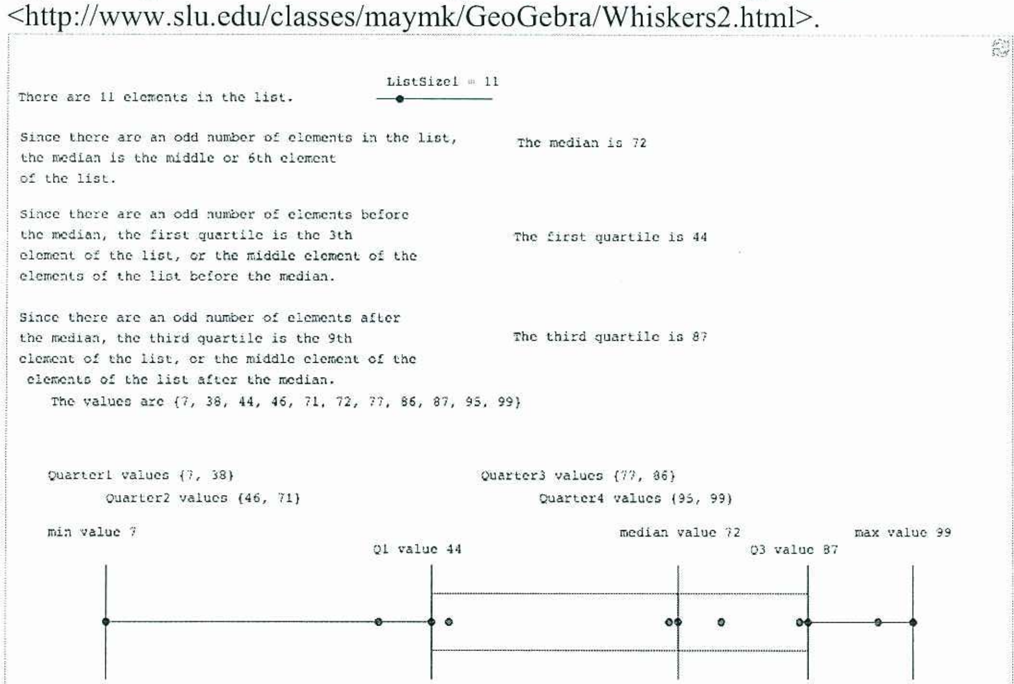
A second block of statistics has to do with computing descriptive statistics of samples. GeoGebra 3.2 will compute the mean, mode, and median of a set of numbers along with the quartiles. For a set of points there are commands for finding the mean of the X and Y coordinates. It will compute the sum of squares and variance of a set of numbers or the X or Y coordinates of a set of points. For a set of points it will compute the covariance.

Another place where student see "statistics" is with the use of best fitting curves. The simplest case of this is the regressions line. This can now be addressed in GeoGebra by either using the FitLine tool from the fourth tool menus, or by using the same command in the input bar with a list of points. The standard setup calculates the best fit line assuming x is the independent variable. To make y the independent variable we use the

FitLineX command. There are also commands to find best fitting curves where the function is specified as being polynomials, logarithmic, exponential, power function, logistic or sinusoidal. The diagram below illustrates a best fitting line and best fitting cubic equation for a set of 5 points.



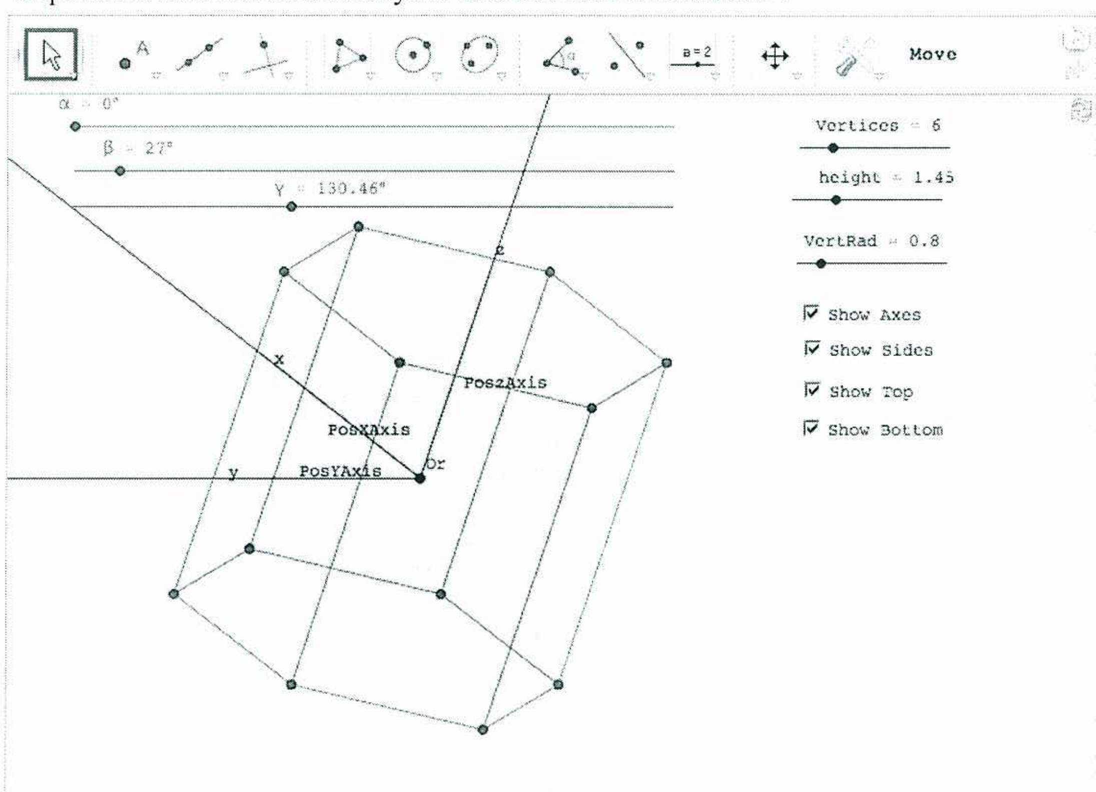
GeoGebra 3.2 can represent data in box plots, histograms, and bar charts. An example applet using a box and whiskers diagram of a random list is given at <http://www.slu.edu/classes/maymk/GeoGebra/Whiskers2.html>.



Section 4 – Lists and Matrices

Another area where functionality is significantly increases with GeoGebra 3.2 is the ability to work with lists and matrices. Version 3.2 allows the ability to work with lists in several useful ways. Computationally, lists can be used with most standard functions. If the functions take several arguments, you can mix lists and numbers as long as all the lists have the same length. In such a case, the numbers are treated as constant lists, and all operations are done component wise. There are commands for taking the sum and product of the elements of a list. Version 3.2 has all the expected commands for manipulating lists. You can take the intersection, join, and union (eliminate repetitions) of two lists. You can insert a list at a specified spot on a second list. You can sort or reverse the elements of a list, and take either an element, or a beginning or ending sequence of a list.

Version 3.2 also allows you to define a matrix as a list of lists, and then do all the usual matrix operations. An interesting application of this functionality is the ability to present objects that appear to be three dimensional, with motion in three dimensions. To illustrate this, see the prism applet at
<http://www.slu.edu/classes/maymk/GeoGebra/3DPrism.html>.



An examination of the construction protocol shows that the appearance of 3 D graphics is obtained by working with a list of points, using matrix multiplications for the rotations, and projections of the points into a plane.

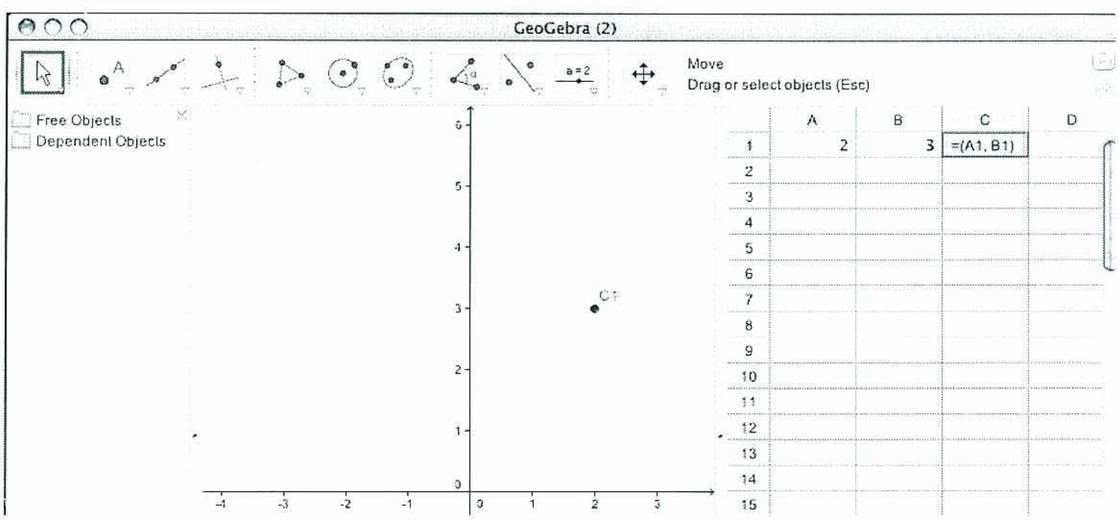
Construction Protocol

File View Help

No.	Name	Definition
1	List ProjMat	
2	Angle γ	
3	List RotGamma	{{cos(γ), -sin(γ), 0}, {sin(γ), cos(γ), 0}, {0, 0, 1}}
4	Angle β	
5	List RotBeta	{{cos(β), 0, -sin(β)}, {0, 1, 0}, {sin(β), 0, cos(β)}}
6	Angle α	
7	List RotAlpha	{{cos(α), -sin(α), 0}, {sin(α), cos(α), 0}, {0, 0, 1}}
8	List RotMat	RotGamma RotBeta RotAlpha
9	List BPts	
10	List BPtsRot	Transpose[ProjMat RotMat Transpose[BPts]]
11	List BPtsProj	Sequence[(Element[Element[BPtsRot, i], 1], Element[Element[BPtsRot, i], 2]), i, 1, 4]
12	Point Or	Element[BPtsProj, 1]
13	Text xLabel	
14	Text yLabel	
15	Text zLabel	
16	Ray PosXAxis	Ray through Element[BPtsProj, 1], Element[BPtsProj, 2]
17	Ray PosYAxis	Ray through Element[BPtsProj, 1], Element[BPtsProj, 3]
18	Ray PosZAxis	Ray through Element[BPtsProj, 1], Element[BPtsProj, 4]
19	Boolean Value ShowAxes	
20	List A0	
21	Number height	
22	Number Vertices	
23	Number VertRad	
24	List TopVerts	Sequence[(VertRad cos(i 360 ° / Vertices), VertRad sin(i 360 ° / Vertices), height / 2), i
25	List TopVertsRot	Transpose[ProjMat RotMat Transpose[TopVerts]]
26	List TopVertsProj	Sequence[(Element[Element[TopVertsRot, i], 1], Element[Element[TopVertsRot, i], 2]), i, 1
27	List TopEdges	Sequence[Segment[Element[TopVertsProj, i], Element[TopVertsProj, i + 1]], i, 1, Vertices]
28	List BotVerts	Sequence[(VertRad cos(i 360 ° / Vertices), VertRad sin(i 360 ° / Vertices), -(height) / 2)

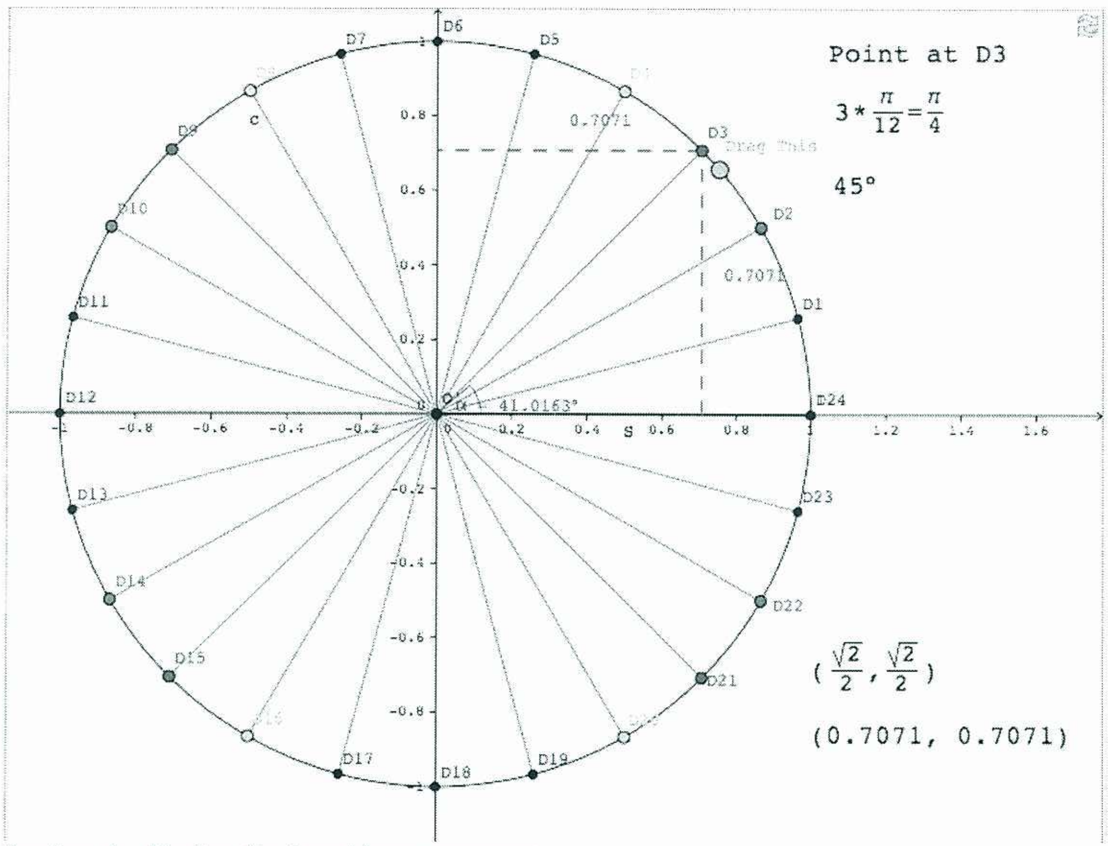
Section 5 – Spreadsheets

One of the big innovations with release 3.2 is the addition of a spreadsheet view to GeoGebra. This is accessible through the view menu.



Entries in the spreadsheet can be different kinds of objects. One interesting use of a spreadsheet is to use it with a collection of objects, and then let a parameter be used to select the appropriate object from the list. (This allows the objects to be edited outside of the main list in the algebra view and with copy paste and fill.) An example of this use was the creation of the applet for reviewing standard points on a unit circle at <http://www.slu.edu/classes/maymk/GeoGebra/UnitCircle.html>. In this case the objects in the spreadsheet included numbers, points, blank cells, and LaTex strings.

A simple applet to review the trig functions of the standard angles.



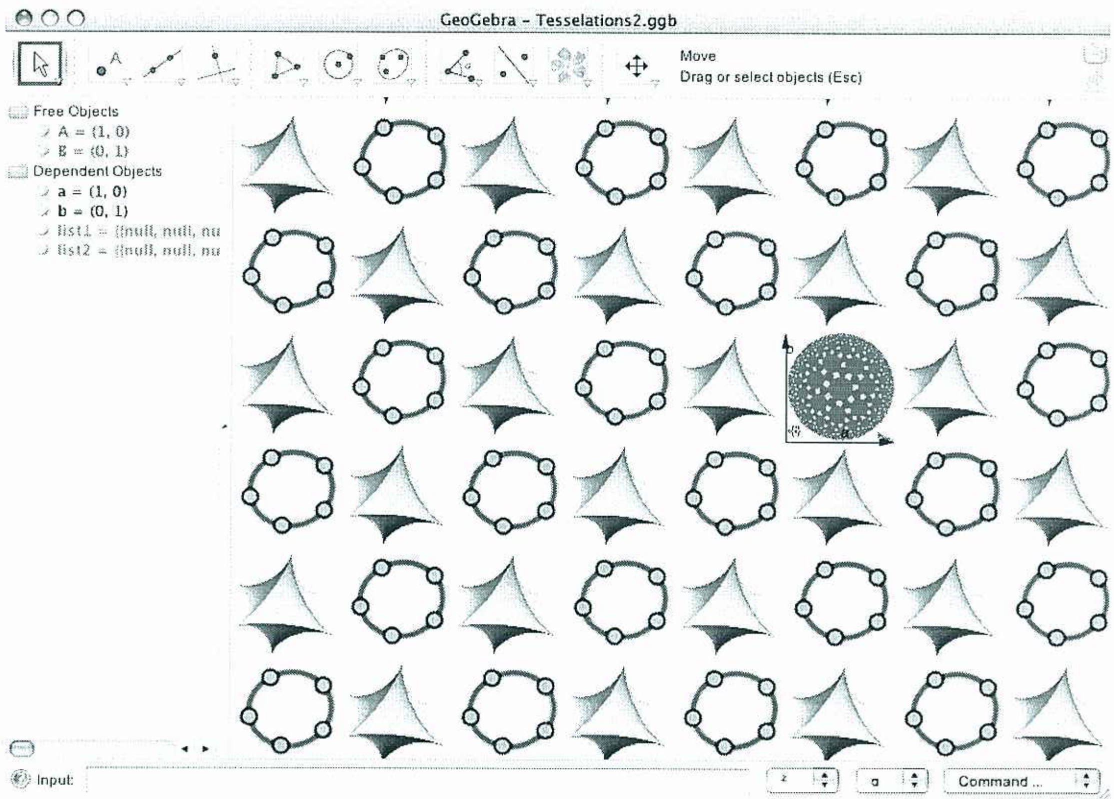
Section 6 – Under the hood improvements

The features that have been described or alluded to in this paper are generally things that are accessible for a beginning user. It is easy to imagine how they will be used for pretty straightforward demonstrations. It is worthwhile to note that there are also a number of "under the hood" improvements in release 3.2. These improvements make the program easier to use or more broadly applicable, but they can be ignored by many users.

Of particular interest to people managing collections of applets is ability to export using ggbBase64 encoding. With this option chosen when exporting to dynamic web page, the ggb file is encoded as an ASCII string and made part of the html page. This makes it possible to reduce an apple to a single html page, making it much easier to manage collections of applets.

Complex numbers are supported for the four basic operations and for taking powers.

Items in the graphical view can now be given layer designations. Higher layers appear in front of lower layers. In the picture below, the graphing window was tessellated with images. This was done with the sequence and translate commands. The layers feature was used to insure that the single image at the origin appeared in front of the tessellations.



The Corner command creates points that let you refer to the 4 corners of the graphing window. This lets you position objects at a particular position of the screen, in terms of percentage from top to bottom and left to right.

It should be noted that this paper only gives the highlights of the new features of GeoGebra 3.2, focusing on the features that are easiest to understand.

References:

[1] http://www.slu.edu/classes/maymk/GeoGebra/pdfs/ICTCMHandouts.pdf - Handouts for the minicourse on GeoGebra at ICTCM XX

[2] < http://archives.math.utk.edu/ICTCM/i/20/M013.html> - Using GeoGebra to Create Applets for Visualization and Exploration – from ICTCM XX
[3] <http://prep09geogebra.pbworks.com/> GeoGebra PREP workshop home page. Location of current training handouts.
[4] < http://prep09geogebra.pbworks.com/Sorted+New+Commands+in+3-2>
[5] http://www.slu.edu/classes/maymk/GeoGebra - Web location of the collection of applets discussed in this paper.
[6] http://www.geogebra.org/en/wiki/index.php/Main_Page - The largest repository of other GeoGebra material.