GEOGEBRA 4 AND ITS COMMUNITY

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Abstract: The open source software GeoGebra is rapidly gaining popularity in the teaching and learning of mathematics around the world. Currently, GeoGebra is translated to 60 languages, used in 190 countries, and downloaded by approximately 500,000 users in each month. In this paper, we offer a brief introduction to the history of the software, introduce its worldwide community, outline new features of the latest version GeoGebra 4, and share future software development plans.

Key words: dynamic mathematics software, GeoGebra, mathematics education

Introduction

The software GeoGebra originated in the master's thesis project of Markus Hohenwarter at the University of Salzburg in 2002. It was designed to combine features of interactive geometry software (e.g. Cabri Geometry, Geometer's Sketchpad) and computer algebra systems (e.g., Derive, Maple) in a single, integrated, and easy-to-use system for teaching and learning mathematics (Hohenwarter & Preiner, 2007). During the past years, GeoGebra has developed into an open-source project with a group of more than 30 developers and over 200 translators all over the world. Since 2004, the number of visitors to GeoGebra's website has increased from 7,000 per month to currently over 1 million visitors per month coming from 190 countries.

International GeoGebra Institute

To be able to better assist the GeoGebra community through its rapid growth we established the International GeoGebra Institute (IGI) at the end of 2007. The four principal aims of IGI are to
- offer teacher training and support;
- develop teaching materials and the software;
- conduct research;
- outreach to less well-off communities.

IGI is essentially an umbrella organisation for local GeoGebra Institutes (GI) established by teachers and researchers at universities and teacher education institutions (Hohenwarter & Lavicza, 2007). Local GeoGebra Institutes agree to follow the aims of IGI, but the emphasis of their work depends on their local needs, interests, and priorities. Currently, there are more than 60 local GeoGebra Institutes in over 30 countries (Figure 2) and all of them are doing valuable and diverse work for the GeoGebra community.

Figure 1: Map of local GeoGebra Institutes, http://www.geogebra.org/igi

The development of the international community has also been catalysed by the new GeoGebra website (http://www.geogebra.org) where local Institutes and community members can post their meetings and workshops. There are numerous GeoGebra talks offered at various conferences and there were 15 specialised GeoGebra conferences in 2011 in Europe, North and South America, as well as Asia. Furthermore, owing to the good work of local GIs there are hundreds of well-trained (certified in most cases) GeoGebra trainers who support teachers in their communities. Local GeoGebra Institutes are also actively involved in projects, which are not only locally important, but contribute to the entire community.

GeoGebra 4

Work on the new version GeoGebra 4.0 started in November 2008, even before GeoGebra 3.2 was released in June 2009. For the 4.0 release, we have had a much bigger developer team - with 10 people making major contributions, compared to 3 for GeoGebra 3.2 - and much more time which has resulted in many improvements across the board.

One of the interesting consequences of GeoGebra's Open Source model is that almost all developers and translators contribute to GeoGebra because they are already interested in it as a user. Generally, they also add something that they personally want, be it a missing feature, fixing a bug or translating the software into their language. Sometimes people will work on just one feature but we now have several long-term developers who brought new ideas on board that have significantly affected the new version. In addition, we have a group of about 100 semi-official beta-testers who enjoy trying out the latest development builds even at an early stage.

Ease of use

This has always been the most important design consideration for the GeoGebra developers. One major improvement in GeoGebra 4 is in the way that dynamic texts can be created. The Text Tool has been completely redesigned so that object names can be selected from a drop-down menu. Alternatively, one can simply drag an object from the Algebra View to the

Graphics View to create dynamic text.

Many other things that were possible in GeoGebra 3.2 are now easier. For example: creating random numbers, buttons to trigger events, export multiple linked files to HTML, export as animated GIF, select objects before or after choosing a tool like Reflection, and visual bracket matching in the Input Bar.

Layout Manager & Perspectives
In GeoGebra 3.2, the Views could be arranged either vertically or horizontally. In GeoGebra 4.0 a much more flexible arrangement is now possible using the new drag & drop layout manager. Also, as a result of this, it is now possible to have two Graphics Views open simultaneously showing the same objects or different objects, at the same scale or at a different scale.
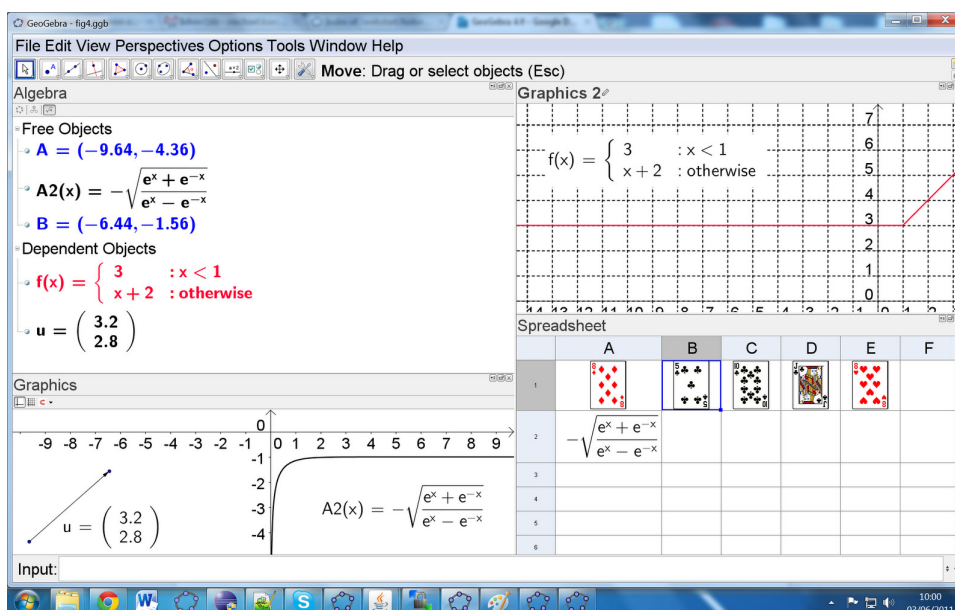

Figure 2: Flexible arrangement of Views in GeoGebra 4

There is a new Perspectives menu option which allows switching quickly to a pre-defined set of views and tools including the Primary perspective which is used in our new version for younger students, GeoGebraPrim.

Filling old Gaps
There have been some obvious gaps in what GeoGebra can do which have now been remedied in version 4. For example: hatching as a fill option, compound paths, animation of a point on a path, inequalities (e.g., $y < \sin(x)$), missing transformations (shear, stretch), implicit curves (e.g., $x^3 + y^3 = 1$), functions of more than one variable (e.g., $f(a, b, c) = a + b^2 + c^3$), functions and parametric curves can now be transformed, a variable can now be entered for the minimum and maximum of both sliders and axes, lists are now draggable, loci can be now created from a slider, and text can have a background colour.
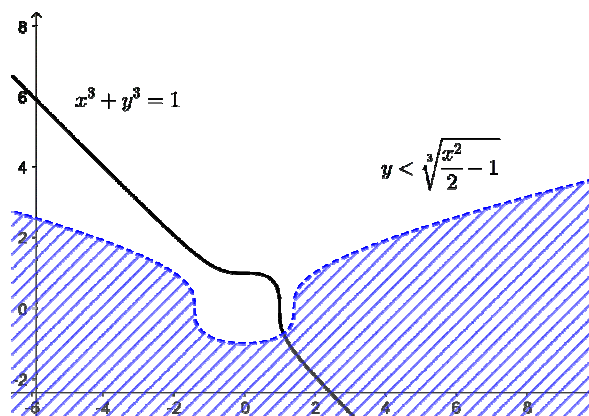
Figure 3: Implicit Curve, hatch filling,
"Stick to Edge" option for axes, and improved equation rendering.

The equation rendering, used in for example FormulaText[sqrt(x/2+1)], now uses the
JLaTeXMath renderer. This means that virtually all LaTeX commands are now supported and
the rendering is now of professional quality.

The spreadsheet now has its own Toolbar with One and Two Variable analysis and chart
Tools. It also provides a Probability calculator which allows you to plot and calculate with
more than a dozen common distributions.

We have made some improvements for interactive whiteboards and Tablet PC including a Pen
Tool and an on-screen keyboard. With the addition of the on-screen keyboard, GeoGebra 4.0
is also completely controllable using just a mouse. For accessibility, we now allow GeoGebra
to be controlled completely from the keyboard (and not only by using a "mouse emulator").
We believe that this is a feature unique to GeoGebra amongst similar software, and this is
possible due to its original command-based design.

New Commands
GeoGebra's command-based design allows us to add many powerful commands without
making the program too complex (e.g. we don't have to keep adding more and more buttons
into the Toolbar). Some examples for new commands in GeoGebra 4:

- SolveODE: numerical solution of first- and second-order differential equations
- SlowPlot: actually a macro, which just creates a function whose drawing is controlled
  by a slider
- Voronoi: Draws a Voronoi Diagram for the given points
- Sample: takes a simple random sample from a list (with or without replacement)
- Shuffle: shuffles a list
- StemPlot: Plots a Stem Plot in the Graphics View
- ComplexRoot: plots the complex roots of a polynomial (as points, on an Argand
  diagram)
- PrimeFactors: eg returns {2, 2, 2, 3} for 24

In addition, GeoGebra 4 now offers scripts (in JavaScript, or just comprising GeoGebra
commands) which can be attached to objects including the new Buttons and Textfields.

GeoGebraTube

In parallel with the GeoGebra 4.0, we have launched our new material sharing platform GeoGebraTube (http://www.geogebratube.org) to replace the old GeoGebraWiki. It supports direct uploading of constructions from GeoGebra and offers easy searching as well as user ratings, tagging, and commenting of materials.
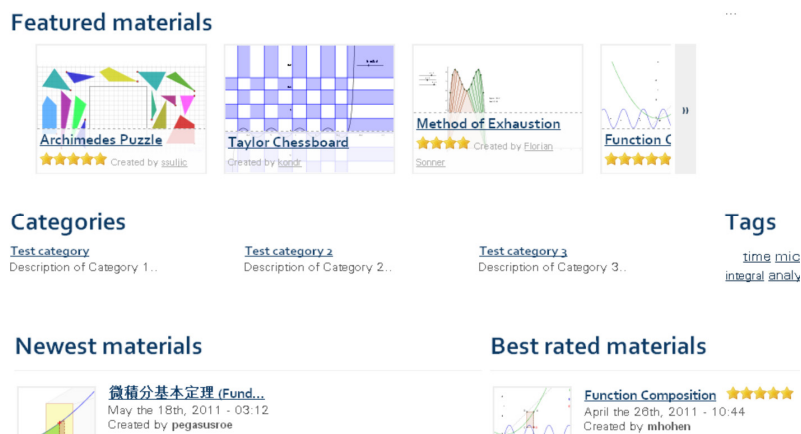

Figure 4: GeoGebraTube material sharing platform

GeoGebra's Future: Web, CAS, and 3D

The GeoGebraWeb project (Hohenwarter, Ancsin, et al 2011) will allow using GeoGebra applets, so called *dynamic worksheets*, on a wide range of devices including smart-phones like the iPhone or the Google Android platform. To achieve this, we are currently porting parts of GeoGebra to the web programming language JavaScript. This will allow the use of GeoGebra online materials in modern web browsers without the need for a Java plugin, both on mobile devices with touch support as well as on desktop and laptop computers.

We have chosen to use the Google Web Toolkit (GWT) for this as it will allow us to maintain the one code base for the desktop and web versions of GeoGebra fairly easily. For the moment we only support the Graphics View. In the future, GeoGebraWeb should support other views as well and allow you not only view but to also create GeoGebra worksheets on an iPad or Google Chromebook.

CAS View

GeoGebra has been using a built-in a computer algebra system (CAS) for symbolic computation of derivatives and integrals for several years. Until now this powerful component was merely used under the hood and not directly accessible to the user for symbolic manipulations of expressions. We have now opened this up and are currently adding a CAS view to extend the symbolic features of GeoGebra allowing students to work with fractions, equations, and formulas that include undefined variables.

This new symbolic algebra view should be easy to use by students starting at age 12 and fully integrated in the dynamic GeoGebra environment. Thus, basic features like expand and factor will be available by using toolbar buttons with the mouse from a specific CAS toolbar which is shown automatically when the CAS view is clicked. An important feature is the possibility to manipulate only part of an expression by selecting it with the mouse and then clicking on a

tool like "factor". First teaching materials for the CAS View have already been tested in Austrian classrooms.

GeoGebra3D

GeoGebra3D aims to create a three dimensional Geometry and Graphics View in GeoGebra that is easy to use with the mouse. This view will allow the creation and interactive manipulation of 3D objects like points, lines, polygons, spheres, and polyhedrons as well as function plots of the form f(x,y). The 3D view should both be usable in the GeoGebra standalone application as well as offer the possibility to be embedded into interactive web pages. A key feature is that you will be able to take a (dynamic) slice through the 3D construction to create a new 2D view which will be displayed alongside using the layout manager from GeoGebra 4.
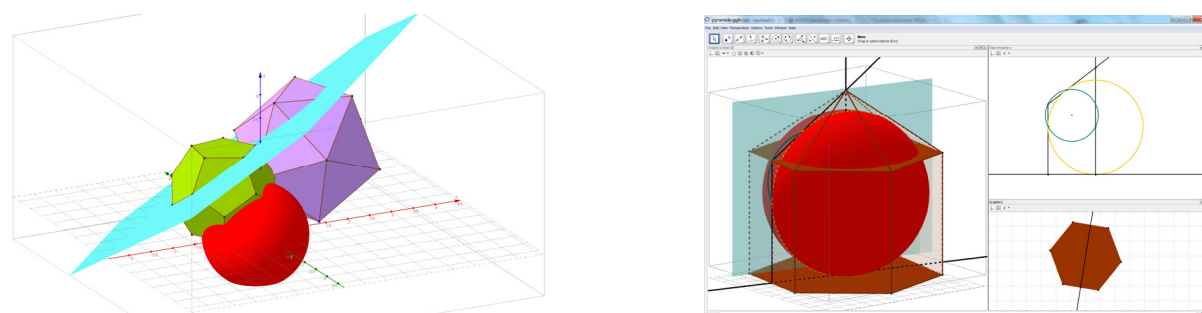

Figure 5: GeoGebra3D as part of GeoGebra 5 Beta

Conclusion

GeoGebra has grown from a small student project to an international community. Due to the involvement of hundreds of volunteers we hope that it will offer a new way to teach mathematics around the world and contribute to the education of students. The latest version of GeoGebra 4 can be found at http://www.geogebra.org. Beta versions of the CAS and 3D views and be found on our website under "Roadmap".

We invite everyone to join our efforts, help to develop new ideas and share experiences with the community. If you are interested in getting involved, please join our mailing lists, Facebook page, YouTube channel, get involved in a local GeoGebra Institute, or come to one of the local conferences in the upcoming years.

References

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