Cool Tools: GeoGebra

Shayla K Heavner

Technology Leadership for School Improvement

Johns Hopkins University

Abstract

GeoGebra is a free downloadable software that both aids mathematics students of all ages in comprehending the material as well as offers the opportunity for instructors to integrate technology into the classroom to encourage both independent exploration and 21st century skills. The available tools GeoGebra offers and possible educational applications are vast. In the following paper, we seek to provide a brief overview of GeoGebra's functions as well as highlight the many uses of the software in an educational landscape.

Cool Tools: GeoGebra

Since the beginning of its development, mathematics has always relied on calculating devices. O'Connor and Robertson (1999) discus these many forms, from simple tables to the abacus and its Chinese counterpart the *suanpan* or ball-arithmetic that were used as early as the 3rd century. For 21st century learning, the ability to utilize technology for everything from simple to complex calculations and beautiful constructions including 3D graphs and geometric shapes has become easier than ever. The cool tool we will focus on is the mathematics software GeoGebra and its features that span from a traditional graphing calculator to the complex calculation and solving through use of a computer algebra system (CAS).

GeoGebra is unique as it possesses both a dynamic geometry system (DGS) and a computer algebra system (CAS). As its name implies, GeoGebra allows students to make connections between geometry and algebra. However, along with this comes additional powerful tools that are useful in higher areas of mathematics such as calculus. The DGS allows students to create and manipulate geometric shapes. While this may seem simple, the educational benefits are vast. In considering Bloom's revised taxonomy, GeoGebra allows students to experiment and make critical connections alongside aiding visualization, which is particularly useful for 3D shapes and transformations. Hohenwarter and Fuchs (2004) discuss one application in which a student can explore the equation of a circle. They state, "it is possible to investigate the parameters of a circle's equation by dragging the circle with the mouse. On the other hand, students may also manipulate the equation directly and see the changed circle in the geometry window" (p.2). This experimentation can mean the difference between a basic understanding and a deep comprehension of the material. In many courses, the equation of a circle is presented as a formula. In using GeoGebra they can witness how changes effect the graphic representation and in turn students become much more comfortable understanding these relationships.

While the above example may seem geometry-adjacent, it represents an algebraic perspective. However, GeoGebra offers many tools unique to students in a traditional high school geometry course.

For instance, Chapter 14 of Geometry by Jurgenson, Brown, and Jurgensen deals with transformations. I have found that many students struggle on this chapter. The first reason is because in order to understand transformations, learners are introduced to the concept of functions. While this topic is lightly discussed in the prerequisite algebra course, it is a complicated topic that requires higher order thinking. Further, students must visualize a geometric object changing, rotating around a point or a line and shrinking or growing. GeoGebra offers geometry students the ability to view these changes rather than attempt to imagine them, thus deepening their understanding. GeoGebra also has a 3D shape option which expands its use to elementary students learning about shapes to complex area and volume problems of calculus using integration.

Lastly, GeoGebra has all of the features of a traditional graphing calculator and goes further with its CAS. This means that students can utilize the program for simple arithmetic calculations, or they can rely on its powerful commands such as “slope” or “factor” to help translate equations and begin to understand their parts. Students can use tables to plot a function, or locate individual points, and GeoGebra displays beautiful graphs that can be saved, downloaded and shared. In addition, GeoGebra has a probability option which is useful in both high school and higher education settings. It is clear that GeoGebra has a plethora of tools and possible applications across all age and skill levels. While we cannot explore every tool in-depth, we would like to examine some of its possible applications in education.

The educational applications for GeoGebra are vast. Hohenwarter and Preiner (2007) provide the following outlook, “GeoGebra was created to help students gain a better understanding of mathematics. You can use it for active and problem-oriented teaching, it fosters mathematical experiments and discoveries in classroom and at home”. One great aspect of GeoGebra is that it is a free, downloadable application. This means an internet connection is not needed to utilize its many functions. This sets it apart from other programs with similar capabilities like Desmos or Symbolab, that require internet access. Students with access to a computer can download the software to use at home or administrators can

preinstall GeoGebra on school devices. While it works in many ways like a traditional calculator, students would need instruction or time to explore in order to utilize its more advanced features. Hohenwarter and Fuchs (2004) provide four great examples for integrating this technology into education. The first is "GeoGebra for demonstration and visualization" (p.3). As previously stated, visualization can be a difficult barrier to learning. Next, they suggest using GeoGebra for both "a construction tool" and "discovering mathematics" (p.3). This can be as simple as geometry students using the software to draw shapes and represent problems while more advanced applications include inserting an image and having students make mathematical connections to the real-world. "Discovering mathematics" refers to the exploratory nature of the software. By playing with shapes and equations students make vital connections to deepen their understanding. Lastly, the authors suggest using "GeoGebra for preparing teaching materials" (p.3). Educators have the ability to use GeoGebra to bring mathematics to life and create new problems using concepts of culturally responsive teaching and universal design for learning to help all students relate and comprehend the material.

In conclusion, GeoGebra is a dynamic software that is beneficial to students of all ages and all branches of mathematics. It is free and does not require internet access after the initial download making it available for use at any location. It functions as both a traditional graphing calculator, a CAS, and a DGS with an immense number of tools and applications. In 1-1 schools, GeoGebra can easily replace the graphing calculator however its powerful capabilities and platform would prevent it from being used on standardized tests. Its educational applications are extensive. Elementary students can explore shapes and basic plotting, middle school students can utilize its ability to factor, find the slope, and the GCD for introductory algebra courses, high school students can use its graphing capabilities, geometry constructions and translations and integration for geometry to calculus courses and higher education students can utilize its many features for courses such as statistics and linear algebra. Educators can transform lessons, improve student understanding, and create visual marvels. With GeoGebra the only limitation is really imagination.

References

Hohenwarter, M., & Fuchs, K. (2004). Combination of dynamic geometry and calculus in the software system GeoGebra. Retrieved from https://archive.geogebra.org/static/publications/pecs_2004.pdf

Hohenwarter, M., & Preiner, J. (2007). GeoGebra. *The Journal of Online Mathematics and Its Applications, 7*. Retrieved from https://www.maa.org/external_archive/joma/Volume7/Hohenwarter/About.html

O'Connor, J., & Robertson, E. (2018). MacTutor history of mathematics archive. Retrieved from http://www-history.mcs.st-and.ac.uk/