ENDLESS POSSIBILITIES WITH THE GEOMETER'S SKETCHPAD

How the World's Leading Mathematics Education Software Surpasses GeoGebra

Key Curriculum Press

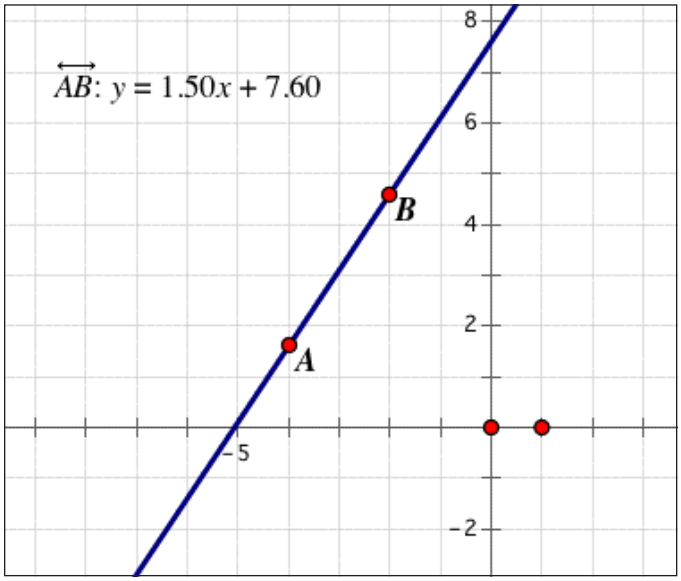
In a third-grade classroom in Philadelphia, students construct fractions along a number line. Down the hall, eighth graders build a visual proof of the Pythagorean Theorem. Down the street, twelfth graders investigate the Fundamental Theorem of Calculus. What do these Philadelphia students and their teachers have in common? Like students and teachers in classrooms all over the world, they are using The Geometer's Sketchpad®.

Sketchpad's logical, elegant, and simple design makes it a powerful learning technology. From the very first day that students use Sketchpad®, they can begin doing meaningful mathematics. Sketchpad's tools behave in expected—and often delightful—ways that enable students to explore and construct mathematical models, build connections among mathematical concepts, and communicate mathematically.

This document demonstrates a few of the ways in which Sketchpad offers a clear advantage over the open-source software GeoGebra in everything from **mathematical coherence** to **ease of mathematical communication** to **support for teachers and students.**

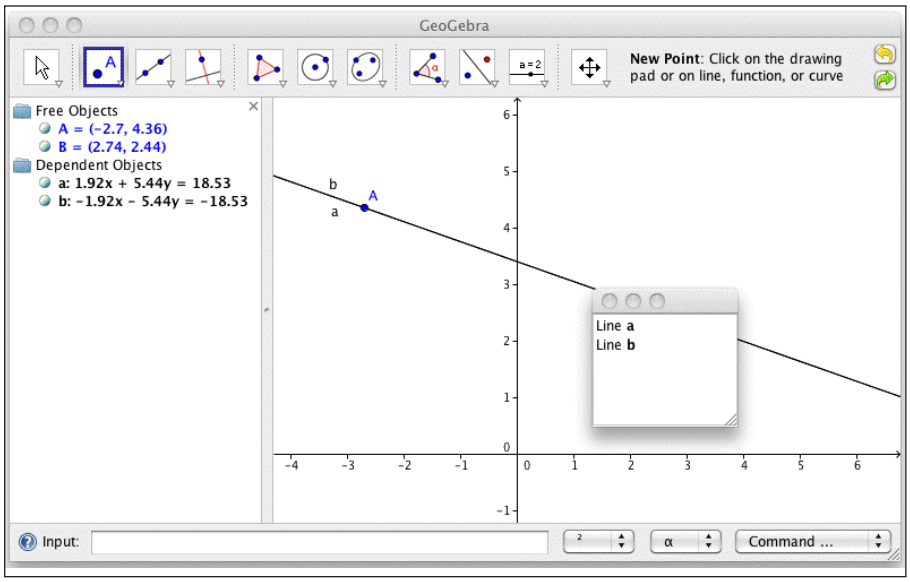
Mathematical Coherence

John Dewey observed in the early part of the 20th century that "how an idea is represented is part of the idea, not merely its conveyance." Dewey's insight is more relevant today than ever, as software and technology become the means by which we represent mathematics to our students. Sketchpad is the most widely used math software in American high schools not only because of its mathematical power, but also because its mathematical representations are consistent with all other classroom representations.



Take, for example, this fundamental postulate of high school geometry: *You can construct exactly one line through any two points.* This is certainly the case in Sketchpad, but what about in GeoGebra?

In Sketchpad, you construct a line by clicking first on point A and then point B. If you tried to use the same points to make another line and you clicked on point B first, then point A, Sketchpad would present a single line, with one equation, as shown at left.



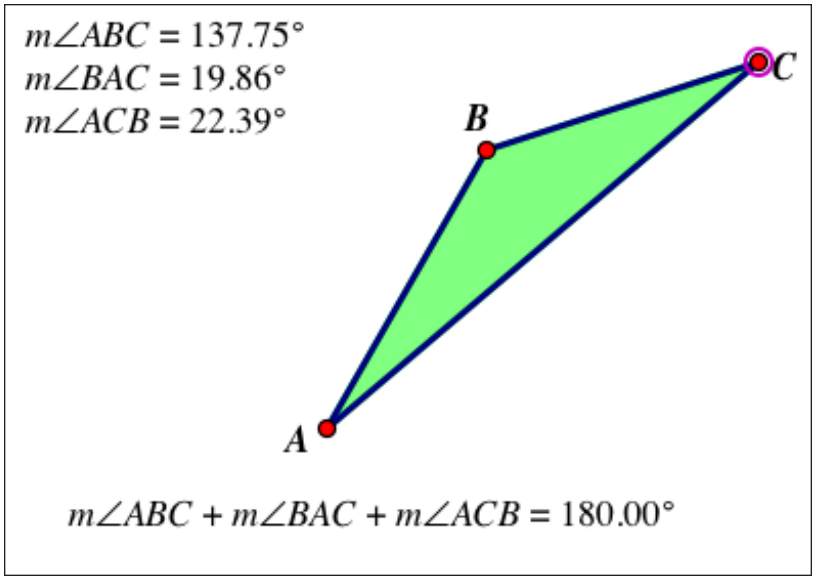
In GeoGebra, the line constructed through point A and then B is represented as a *different line* than the one constructed through point B and then A. Moreover, each of these lines is represented by a different equation. Imagine the confusion and incorrect suppositions that students will make from these representations.

This is just one example of how the open-source software's representation of mathematics can lead students to unsound conclusions. Sketchpad's representations make mathematical sense and are consistent with school curriculum and best practices.

Ease of Mathematical Communication

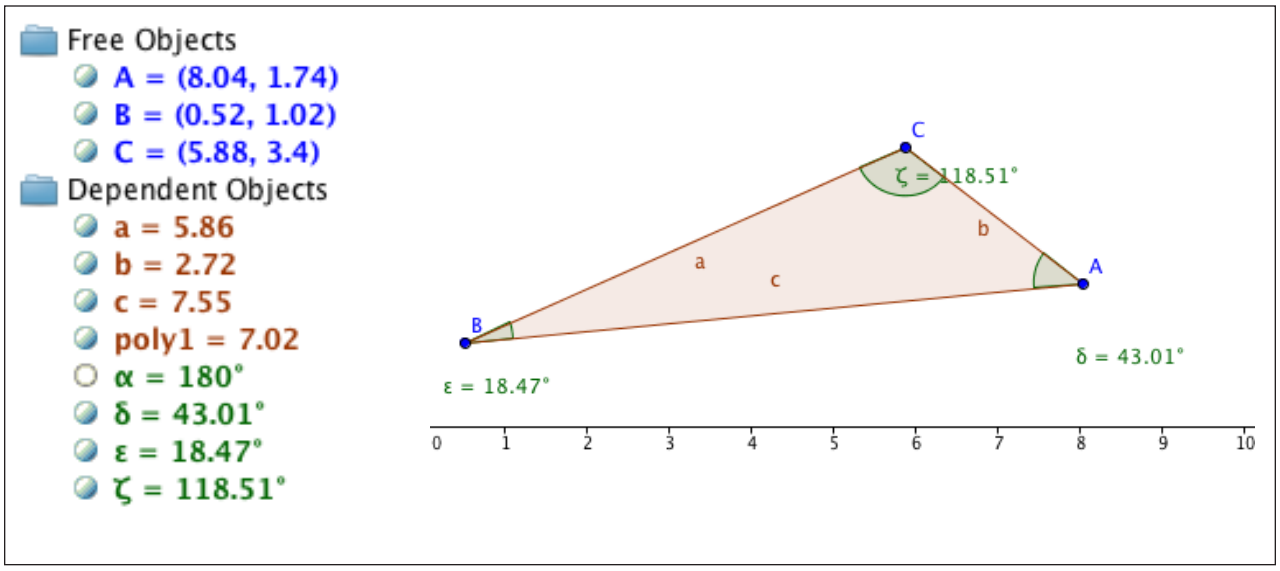
Sketchpad is a powerful tool for exploring mathematics, and it's grounded in pedagogy. Students not only see and interact with the mathematics represented by the software, they also make sense of the explorations by communicating their understanding. As they develop their ability to communicate what they have learned, their understanding is deepened and enhanced.

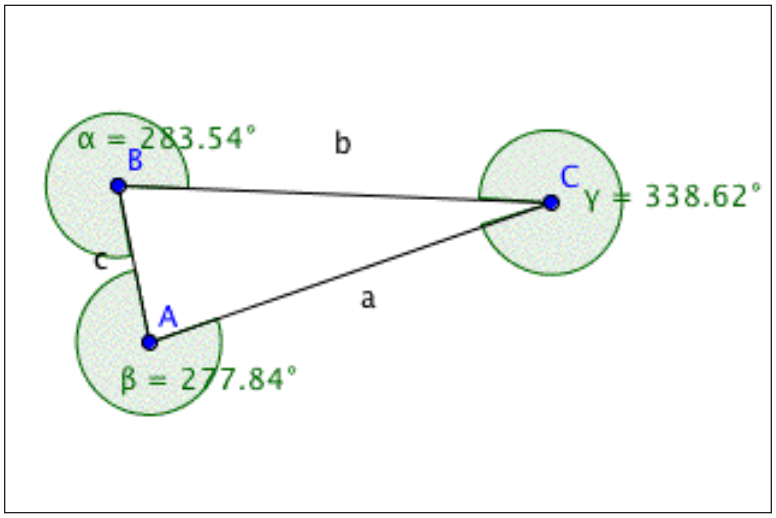
Through its ease of use, Sketchpad facilitates student exploration and discussion. Students immediately connect to the mathematics in Sketchpad because the mathematics on the screen is represented in the same nomenclature that is used in their classroom and textbook.



Consider the investigation of the sum of the measures of the interior angles of a triangle. Sketchpad allows students to calculate the sum of the angle measures by clicking directly on each measure in the sketch. The angle measures and the sum are displayed in standard classroom notation, clearly communicating the mathematical results. Students can easily manipulate the triangle to reinforce the concept that for every triangle, the sum of the interior angles is equal to 180 degrees.

To accomplish this same task in GeoGebra, students must enter instructions in a command-line form, which means that they must decipher the commands and syntax before they can engage with the mathematics. In the example below, GeoGebra assigned the Greek letters δ, ϵ, and ζ for the angle measures, and the student used the command-line menu to sum the measures. This example reveals additional barriers to learning: Not only is the result buried in the list of Dependent Objects in the left panel, but the calculation that produced the sum is hidden, making this document an ineffective tool for communicating the geometric property it is supposed to illuminate.



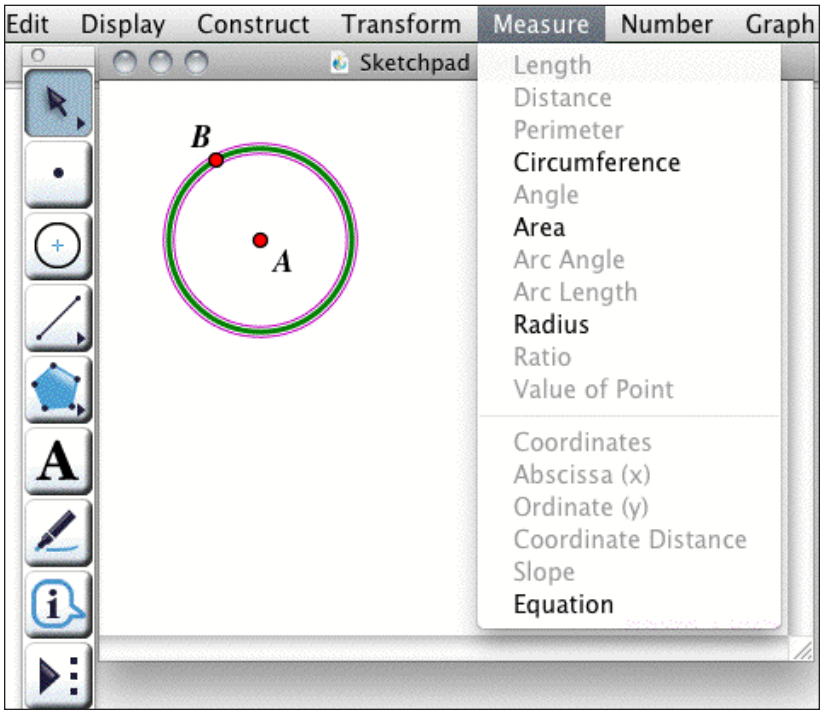


Furthermore, manipulating the triangle to reinforce a concept can lead to inconsistent and confusing results in the open-source software, such as "flipping" the measured angles from interior to reflex angles, as shown at left.

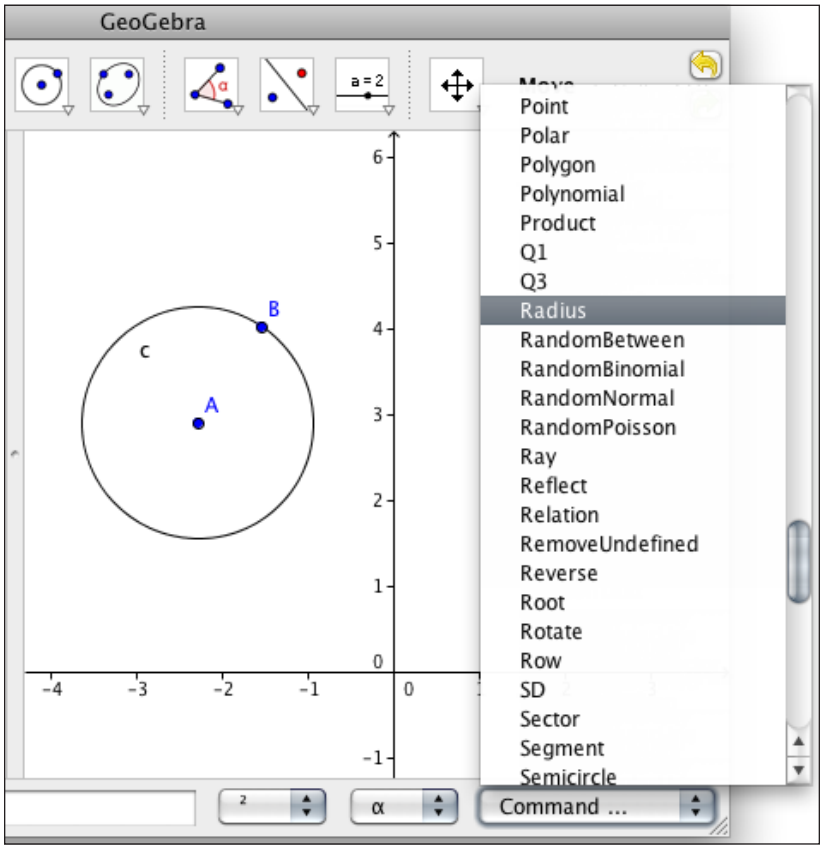
GeoGebra's use of Greek letters, reliance on a command-line interface, hidden calculations, and unexpected dynamic behavior distance students from the mathematics and could easily detract from their ability to synthesize and communicate their conclusions.

With Sketchpad, students are not so encumbered. Sketchpad users interact directly with the mathematics. Sketchpad's clear representations facilitate student exploration and enable students to communicate their observations.

The two screen captures below provide another example of how Sketchpad and the open-source software differ in their approaches to instruction and the development of a mathematical vocabulary.



When a student selects a circle in Sketchpad, only those commands applicable to a circle are available. This interface supports the student's exploration of mathematical objects and their properties.



In the open-source software, the student must search through the full list of commands from the pull-down menu, including commands that have no applicability to the circle.

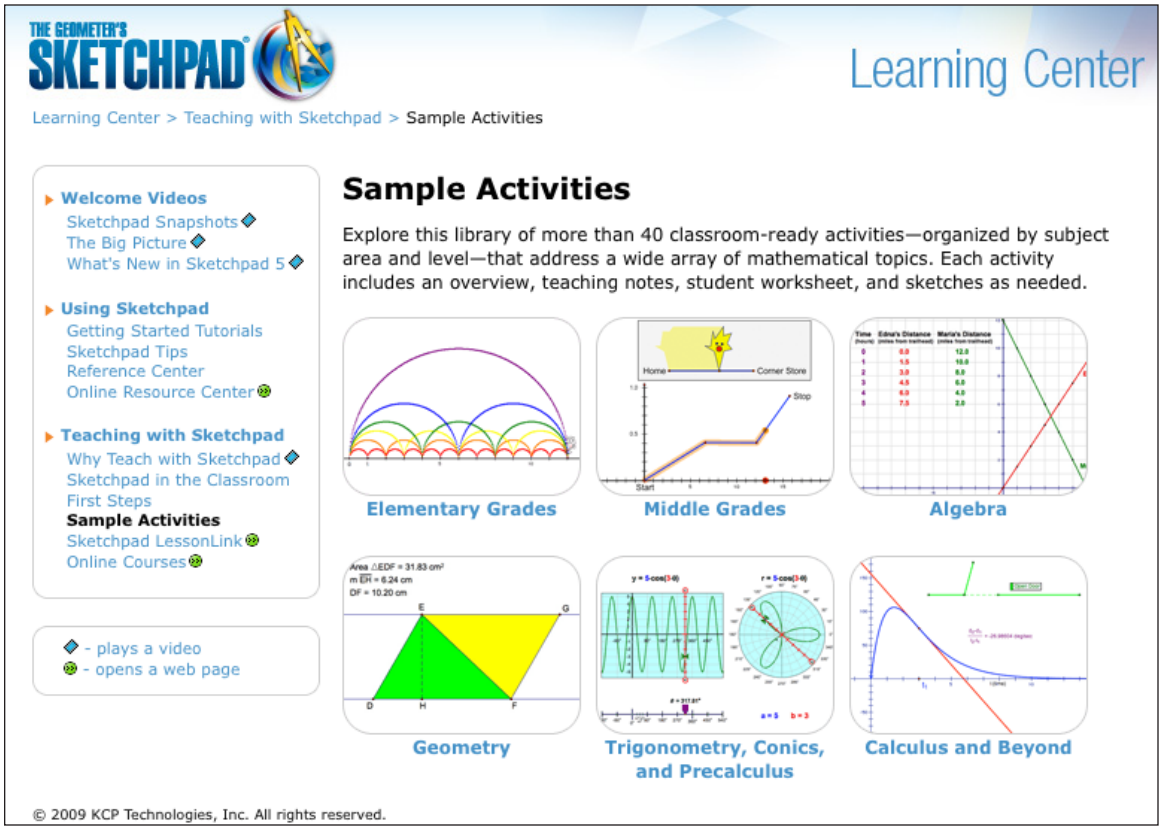
Students' exploration should be scaffolded in a way that leverages their curiosity yet focuses their effort on correct suppositions. Sketchpad structures student interaction so that it reinforces correct concept development and appropriate use of vocabulary.

Support for Teachers and Students

Educational curriculum and tools have value only when students are interacting with the materials. Support for Sketchpad users, both teachers and students, includes integrated curriculum, extensive professional development offerings, technical support, a dedicated website, and an active user base. This type of support assures regular use of Sketchpad by students and has helped to make Sketchpad the world's leading educational mathematics software.

To highlight just three of these support services:

- **The Sketchpad Learning Center**—embedded in the software—provides introductory tutorials with video, tool tips, sample activities, and information on how to use Sketchpad in a variety of grade levels and classroom settings.



- **Sketchpad Professional Development** includes face-to-face workshops, moderated online courses, and webinars, all of which consistently get outstanding reviews from Sketchpad users. This type of ongoing support is both mathematically and pedagogically rich and facilitates growth among teachers as well as their students.
- **Sketchpad LessonLink** is a searchable online library of more than 500 Sketchpad lessons and activities, aligned to textbooks and standards, for grades 3 to 12. Classroom-ready worksheets, pre-built sketches, and teaching notes streamline lesson planning. Sketchpad LessonLink facilitates student engagement without requiring teachers to create lessons from scratch.

GeoGebra's community maintains a wiki where teachers contribute activities and a forum where teachers can ask for technical support from other users. The activities on this site are not vetted and can vary widely in quality and usability. Furthermore, GeoGebra lacks curriculum, professional development, and authentic technical support. In contrast, Key Curriculum Press, the education company that publishes Sketchpad, is dedicated to the development of quality teaching materials and provides integrated curriculum, fully vetted activities, extensive professional development, and technical support for Sketchpad.

Endless Possibilities for Student Growth with Sketchpad

John Dewey believed that good teachers were those who could create "genuine intellectual curiosity." He argued that the methods of such activity were the product of human curiosity, inquiry, and the search for truth. Therefore, we think the tools our students use should facilitate and encourage this behavior.

Sketchpad grows with students in their mathematical journey because its foundation is built upon mathematical principles. GeoGebra, because it is an assemblage of representation tools, cannot allow for the depth of inquiry Dewey envisioned. Students can explore their curiosity only to the depth that a specific tool will represent.

In Sketchpad, students may begin their mathematical journey by constructing a triangle and measuring and summing its angles, move into more complex sketches, such as using the locus definition to construct a parabola, and continue their mathematical education by using Sketchpad to explore derivatives of functions. Through this growth, the consistent and predictable mathematical behavior and the clear mathematical notation of Sketchpad allow students to focus on mathematical concepts and develop their understanding as deeply as their curiosity takes them.