# On the Shoulders of the Technology Giant

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Technology has become the persuasive buzzword in hard-selling educational institutions and educational packages. Yet how much thought has gone into the creation of a 'techno-classroom'? When does technology enable the class? How do we select tech-enabled teaching learning materials and teaching aids? Are they self-sufficient and if not, how do we supplement them in order to push the student's learning to the next level? How do teachers ensure that real learning has occurred in the tech-enabled classroom?

NCF 2005 speaks of the importance of inclusion. If teaching focuses more and more on the brilliance of technology to deliver good teaching, then spaces for discrimination will naturally arise along economic divides. If, however, the focus is on the pedagogical brilliance of the tech-enabled lesson, then even the simplest and most available technology can align with the vision of NCF. The clarities sought in teaching with technology should be illuminating rather than blinding. Though this article is about teaching aids which rely on technology, I aim to show that it is time to enable the teacher rather than the technology.

A teacher, who is a first time user of technology in the mathematics classroom, seeks to exploit the potential of the technology. But there is a danger of shifting the focus to the technology rather than letting the mathematics speak through the technology. Instead of seeing technology as an attention seeking device, I propose that technology is the giant on whose shoulders students can see further in mathematics. I will illustrate this with examples using GeoGebra which is an interactive geometry, algebra, and calculus application, intended for teachers and students. GeoGebra is written in Java and thus available for multiple platforms (including, now, the smartphone). Its creator, Markus Hohenwarter, started the project in 2001 together with the help of open-source developers and translators all over the world. Currently, the lead developer of GeoGebra is Michael Borcherds, a secondary maths teacher. Most parts of the GeoGebra programme are licensed under GPL and CC-BY-SA, making them free software. One of the sites from which it can be downloaded is http://www.geogebra.org/cms/. An excellent manual for new users of Geogebra is available for download at http://www.geogebra.org/book/intro-en.zip.

GeoGebra's user interface consists of a graphics view, an algebra view and a spreadsheet view. On the one hand you can operate the provided geometry tools with the mouse in order to create geometric constructions in the graphics view. Or you can directly enter algebraic input, commands, and functions into the input bar by using the keyboard. While the graphical representation of all objects is displayed in the graphics view, their algebraic numeric representation is shown in the algebra view. The user interface of GeoGebra is flexible and can be adapted to the needs of your students. If you want to use GeoGebra in early middle school, you might want to hide the algebra view, input bar, and coordinate axes and just work with the graphics view and geometry tools. Later on, you might want to introduce the coordinate system using a grid to facilitate working with integer coordinates. In high school, you might want to use algebraic input in order to guide your students through algebra into calculus. Though many sketches and activity sheets are available on the internet, GeoGebra works best when it is used as an investigative activity which is skilfully facilitated by the teacher. A GeoGebra sketch can be saved as a .ggb file and interactive worksheets with questions inserted at crucial points can even be created and saved at the user-friendly site https://ggbm.at/e9Z6UDu4

In this article, I propose to take a brief look at some ways in which technology is currently being used in the classroom, point out some of the inherent pitfalls therein and then suggest ways in which this can be overcome.

Why is technology used in the classroom? Some persuasive reasons are:

**Appeal:** Technology is often used to grab eyeballs and footfall measure is used as a criterion of success as often in the computer lab as it is in the shopping mall. Slick productions might appeal to those who are ambivalent about math but when they return to the classroom and the textbook, will this impression be reinforced? (Meyer, 2013)

**Availability and convenience:** Replacing the text-book with the screen and the integration of audio-visual teaching with the conventional teaching limits human errors but often this is the boundary to which technology is integrated into the lesson. (Graulich, 2009) Teachers find it very difficult to abandon the idea of the blackboard even if the blackboard itself has disappeared from the classroom. Very often a PowerPoint presentation is simply an animated version of the textbook and this passes as integration of technology into teaching. 'Functional fixedness' (the ideas we hold about an object) can inhibit our ability to use the object for a different function (Birch, 1945) can seriously limit the use of technology in the classroom.

Example 1:

Take a look at this GeoGebra activity Direct_common_tangent.ggb (Math Science Subject Teacher Forum, 2012). The construction steps for the GeoGebra sketch are given in the box.

| No. | Name | Description | Tool |
|---|---|---|---|
| 1 | Number d | | Slider from 0 to 20 |
| 2 | Number $R_1$ | | Slider from 0 to 10 |
| 3 | Number r | | Slider from 0 to 10 |
| 4 | Point O | | Anywhere on the graphics screen |
| 5 | Point A | Point on Circle(O, d) | Choose the option Circle with centre and radius and click on O as centre, when prompted for radius, key in d |
| 6 | Segment a | Segment OA | Choose the Segment option from the Line tool and click on O and A. |
| 7 | Circle c | Circle with center O and radius $R_1$ | Choose the Circle with centre and radius option |
| 8 | Circle e | Circle with center A and radius r | |
| 9 | Circle f | Circle with center O and radius $R_1 - r$ | |
| 10 | Point M | Midpoint of O and A | Choose the midpoint option from the Point tool |
| 11 | Circle g | Circle through A with center M | Choose the Circle with centre through point option |
| 12 | Point B | Intersection of f and g | Choose the Intersection option from the Point tool |
| 13 | Point C | Intersection of f and g | |
| 14 | Segment h | Segment B, A | |
| 15 | Segment i | Segment C, A | |
| 16 | Ray j | Ray through O, B | Choose the Ray option from the Line tool |
| 17 | Ray k | Ray through O, C | |
| 18 | Point P | Intersection of c and j | |
| 19 | Point R | Intersection of c and k | |
| 20 | Segment l | Segment O, P | |
| 21 | Segment m | Segment O, R | |
| 22 | Line n | Line through A perpendicular to h | Choose the Perpendicular Line option |
| 23 | Point Q | Intersection of e and n | |
| 24 | Segment p | Segment A, Q | |
| 25 | Line q | Line through A perpendicular to i | |
| 26 | Point S | Intersection of e and q | |
| 27 | Segment s | Segment A, S | |
| 28 | Segment t | Segment P, Q | This is one of the direct common tangents |
| 29 | Segment $a_1$ | Segment R, S | This is the other direct common tangent |

Created with GeoGebra

Using a series of animated steps, it merely gives the recipe for the construction of a direct common tangent. Though the sliders used seem to bring a dynamic dimension to the activity, it merely changes the size of the circles and in no way leads to the understanding of why this construction works or how it can be tweaked to devise similar constructions. What is detailed is the algorithm for the construction of a direct common tangent.

In what way will this promote mathematical thinking? On the other hand if this activity is planned by the teacher with an accompanying worksheet, it becomes interactive and lays the ground for the student to do the next construction (of the transverse common tangent) on her own. Here are some questions which can prompt inquiry on the part of the student.

1. Why was the radius of circle f the difference of the radii of circles c and e?
2. Why did circle f have to pass through O and A? (Hint: What is angle OBA?)
3. Why is the point of contact of the tangents determined by circle f?
4. When does this construction fail and why?
5. How would you construct transverse common tangents?

Example 2:

Consider the well-known theorem, 'The angle in a semi-circle is a right angle'.

In the classroom, students are often taught the proof using a figure which the teacher draws on the blackboard. However, when this theorem was given to students who knew how to use GeoGebra, interesting interpretations emerged.

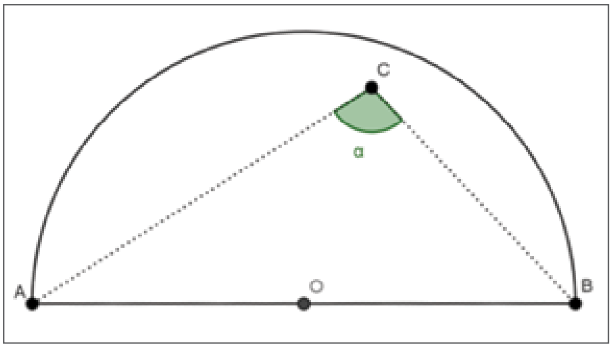


*Figure 1.*

These sketches are easily created using the Semi-circle option from the Circle tool. Angles can be

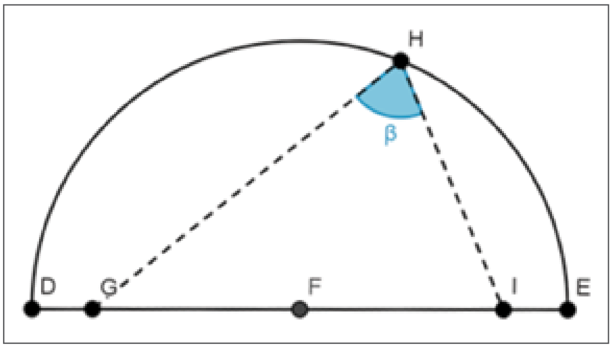


*Figure 2.*

measured using the Angle tool. But note how students interpreted the word 'in'. Though the angles look like right angles, the measure tool reveals that it is not. Student A immediately began to drag the point C and found that when it hits the circumference, the angle is indeed a right angle, wherever the point C is on the circumference. In the second case, the student tried moving the point H and found that the angle did not change significantly. He then tried moving G and found a significant increase as G moved towards D. This gave him a clue and leaving G at D, he proceeded to move I towards E. Immediately, he saw that whatever the position of H, angle DHE was a right angle. Allowing the student to interpret the theorem with a sketch surfaced their understanding. The dynamic nature of GeoGebra allowed them to understand the meaning of the theorem. Further, it helped them to understand the key mathematical concept of 'generalization'. Once they did this, the proof became ridiculously simple and obvious as they used the concept of isosceles triangles (which reinforced their understanding of the role played by the radii in the proof) and supplementary angles.

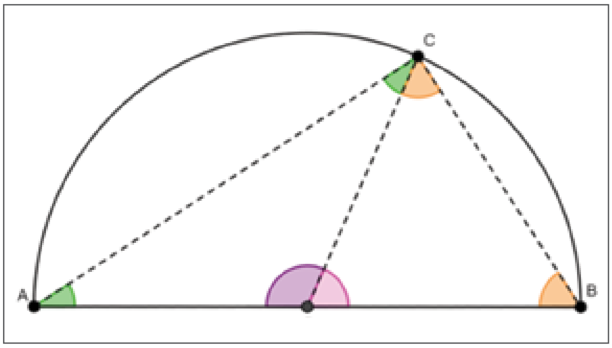


*Figure 3.*

Does the activity *challenge* them to *think* or to *guide* them to *accept*?

This is an important guideline for teachers to keep in mind while designing GeoGebra activities.

GeoGebra works brilliantly with paper folding activities and pushes students to understand the inherent geometrical relationships which facilitate such activities. For example, folding paper to get one point to fall on another can be replicated in GeoGebra by reflecting the point in the perpendicular bisector of the line joining the two points. When the crease is replaced by the perpendicular bisector, the laws of reflection come into play! Even intimidating topics like the locus of a point became child's play when we used paper folding to create conic sections and then replicated this on GeoGebra.

In conclusion, technology should be used in the math classroom for the following reasons:-

1. Students are digital natives and an intimidating subject such as mathematics now takes on a different complexion as the teacher is perceived as a fellow learner and not a giver of knowledge.
2. Technology enables students to experiment and move at their own pace and makes differentiated instruction easier to plan and administer.
3. Technology allows for dynamic investigation, leading to mathematically valuable strategies such as conjecture and proof.

Though the advantages of saving both time and effort is ostensibly used for teachers to plan the development of skills such as  problem solving, team-work  and collaboration, the focus is on how to use the software and very little effort is spent on training the teacher to work with it more meaningfully.

What should a school do to ensure good use of technology? Through this paper, I show that it is time to enable the teacher rather than the technology.

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