Using More Sophisticated Technology to Teach Mathematics

Maurice Young

Abstract: Over time, the debate about using technology in the classroom has evolved as much as the technology itself. Not only has the role of technology grown and shifted in the classroom, but also the level of technological sophistication has changed the way these tools are used. Employing these tools in the mathematics classroom allows students to no longer take a somewhat passive role, treating technology as either their master or servant. Rather, these tools allow the technology to become the students' partner or an extension of themselves. In addition, students can now engage in the role of active learners by producing and/or publishing content previously not possible. Even though the TI-83/84 has its place in the mathematics classroom, particularly considering the high-stakes testing relationship, mathematics educators must embrace the ever-growing tools of Web 2.0 to become even more efficient and effective.

The Debate about Technology in the Classroom

Technology's role in education has long been a source of debate, and the content area of mathematics is no different than others. From the beginning of my teaching career, controversies about several types of technological tools in mathematics have occurred. In the late 1990's, the use of graphing calculators in a mathematics classroom was the hot debate topic of concerning technology. As the rigor and requirements of our mathematics courses progressed through the next several years, the acceptance of the graphing calculator came to be commonplace, so much so that now, several years after that debate's beginning, our high-stakes graduation testing in Ohio allows for the use of the TI-83/84 series. With the advent and evolution of Web 2.0 tools, a new debate has begun about utilizing technology in the mathematics classroom.

One of the main obstacles to incorporating technology is navigating past the fear teachers may have that their students may lose proficiency in basic skills. As Goos (2010) wrote, "[f]ears are sometimes expressed that the use of technology, especially hand-held calculators, will have a negative effect on students' mathematics achievement" (p. 67). Studies on this impact, however, have contradicted this. Examining studies conducted by several researchers, Goos (2010) concluded that "meta-analyses of published research studies have consistently found that calculator use, compared with non-calculator use, has either positive or neutral effects on students' operational, computational, conceptual and problem-solving skills" (p. 67). In addition, implementing technology effectively in the classroom allows certain remedial but time-consuming tasks to be avoided, while allowing larger, more important relationships to appear more rapidly. For instance, comparing the effects of replacing "x" with "x – h" in a function can more efficiently be determined when learning about translations, because the time-consuming task of graphing many functions by hand to discover the pattern would not allow for the rich discussion of "what if's" that naturally follow with technology. Thus technology allows us to more quickly identify misconceptions. In addition, using this technology allows students to begin making connections to authentic problems. As Pierce and Stacey (2010) stated "[i] mproved speed and accuracy allows access to real world tasks, using real world data where pen-and-paper calculations may be too error prone or time consuming." In addition, accurate observations of these faster and correct results "may support their learning of pen-and-paper skills" (p. 7). Wolfram (2010) further disputes the idea that focusing less on "the basics" dumbs down mathematics by showing that mathematics problems in the real world are not solved as easily as the problems in mathematics textbooks, such as easily factored quadratics (Wolfram, 2010). As Wolfram put it, "the problem we've really got in math education is not that computers might dumb it down, but that we have dumbed-down problems right now."

The Roles of Technology in the Classroom

To begin the discussion about effectively using technology in the classroom, its fundamental roles must be examined. Technology can take on several distinct roles in the mathematics classroom. Goos, Galbraith, Renshaw and Geiger (2003) identified these as the role of master, servant, partner and extension.

Master

Technology assumes the role of master when students are dependent upon the technology to perform mathematic functions for them without consideration for the outcome. For instance, students allow technology to be their master when using calculators to perform basic functions without acknowledging potential errors in either input or output. Goos et al. (2003) described this role by stating that students may become subservient to technology if a "lack of mathematical understanding prevents them from evaluating the accuracy of the output generated by the calculator or computer" (p. 78).

Servant

Technology assumes the role of servant when students use technology only as a means of replacing basic functions. For example, students make technology their servant when using a calculator to perform the simple operations of addition, subtraction, multiplication, and division. Goos, Galbraith, Renshaw and Geiger (2003) defined this role by stating, that technology is a servant if used by students or teachers only as a fast, reliable replacement for mental or pen and paper calculations, but the tasks of the classroom remain unchanged" (p. 78).

Partner

Technology assumes the role of partner when students use it to provide opportunities for understanding that would have been either too time consuming in the past, or to explore relationships that may not have presented themselves through non-technological means. For instance, students graphing several parabolas (or using sliders) on Desmos or GeoGebra to explore the importance of the leading coefficient on the graph. Rather than taking the time to graph several of these parabolas, utilizing the technology allows for connections and relationships to be discovered in a much more accelerated and efficient manner. Goos et al. (2003) described this role by stating that technology is a partner "by providing access to new kinds of tasks or new ways of approaching existing tasks" (p. 79).

Extension

Technology assumes the role of an extension of self when students utilize it as a part of their normal routine, allowing them to engage complex mathematical processes. For example, students using technology as an extension of self would allow independent discovery of the relationship between the type of roots of a quadratic and their location on the Cartesian plane. Goos et al. (2003) described this role by stating that technology becomes an extension of self when students "integrate a variety of technological resources into the construction of a mathematical argument so that powerful use of computers and calculators forms an extension of the individual's mathematical prowess" (p. 80).

Analysis of Technology Metaphors

Progressing through the four metaphors of technology's roles in the classroom also increases the engagement level of the students. In the roles of master and servant, students are not using technology to its upmost benefit, but rather using it to replace insubstantial tasks. In the role of partner and extension, students begin to incorporate technology in ways to enhance their learning. Therefore, mathematics teachers must present the technology where students do not become dependent upon it, but rather use technology as a partner and an extension of themselves to scaffold learning. As Olive and Makar (2010) argued, "if we consider the technological tools as providing access to new understandings of relations, processes, and purposes, then the role of technology relates to a conceptual construction kit" (p. 138).

The Roles of Web 2.0 Tools in the Classroom

Web 2.0 tools offer teachers a way to bring 21st century tools into the classroom. Just as in the discussion of technology in the classroom, Web 2.0 tools also play roles in the classroom depending upon how they are used. Luckin et al. (2009) defined these roles as researcher, collaborator, producer, and publisher.

Researcher

Luckin et al. (2009) claim that "researchers" are different than the traditional notion of a researcher, in that a Web 2.0 researcher shows "little evidence of critical enquiry or analytical awareness" (p. 94). Such a researcher does not contribute to creating original content on the web, but instead is a "learner who commonly refers to online resources as a means of retrieving information and/or extending their knowledge base" (p. 94).

Collaborator

Collaborators are students who mostly utilizing their web resources for "file sharing, gaming and communicating, with only few examples of collaborative knowledge construction" (Luckin et al., 2009, p. 94). A collaborator also uses "on-line networks and technologies to work together with others, whether they be peers, teachers or other 'experts'" (Luckin et al., 2009, p. 96).

Producer and Publisher

Producers and publishers are characterized as "sharing experience through social networking sites" (Luckin et al., 2009, p. 94). Producers and publishers are viewed as the most original contributors, because they create and/or publish content such as "photos, artwork, music, podcasts, games, etc." as well as "blogs, wikis" and other material (Luckin et al., 2009, p. 97).

Analysis of Web 2.0 Roles

Analogous to the discussion of the technology metaphors, as students progress through the roles of Web 2.0 learners, their learning enhances. As a researcher and collaborator, students participate in their learning, but do not create content. On the other hand, producers and publishers are creating their own content, leading to heightened understanding of content.

The Evolution of Technology in My Classroom

Early on in my teaching career, I embraced the use of the TI-83 Plus calculator in my classroom. I attended several professional learning opportunities to further enhance my own understanding about these instruments and their worth. I embraced this technology and marveled at its ability to explore relationships in five minutes that otherwise by traditional, non-calculator methods would take an entire period. I used these amazing tools to facilitate my students to utilize technology as a partner or an extension of themselves. We could compare and contrast the graphs of several parabolas at once, while recognizing patterns, intercepts, vertices, and other fundamental concepts quickly and efficiently.

Yet in the past several years, my attitude towards the TI-83/84 has gradually changed due to the abundance of Web 2.0 tools. While the TI-83/84 price point has remained stable throughout my tenure as a mathematics educator, more free Web 2.0 tools have become available as this resource continued to grow. Imagine being told to pay the 1999 price for a first-generation Blackberry while others are getting the newest iPhone or Samsung Galaxy for free! The TI-84, released 5 years after the TI-83 Plus in 2004, offers only "480 kilobytes of ROM and 24 kilobytes of RAM," while having had an MSRP of $150 for over ten years (McFarland, 2014, para. 2).

Not only are the Web 2.0 tools much more accessible and affordable, but they also provide a sophistication that the TI-83/84 cannot match. In addition, with the introduction of these far superior tools, students who were once using the TI-83/84 as a partner or extension of themselves may have regressed to where the TI-83/84 is now in the servant or master role. For instance, when students compare the graphs of a function with roots nearby one another on a TI-83/84, sometimes they will not acknowledge more than one intercept because of the pixel size of the graph. In Figure 1 and Figure 2, the graphs of y = (x – 1)(x – 1.5)(x – 2) are shown, both with the domain restriction [-4,4] and the range restriction [-5,5]. The low-quality level in Figure 1 does not allow for students to observe the three intercepts that the more sophisticated graph in Figure 2 enables. This mistake in viewing one x-intercept instead of three demonstrates how the low quality of the TI-83/84 graph has become a hindrance to students' understanding.

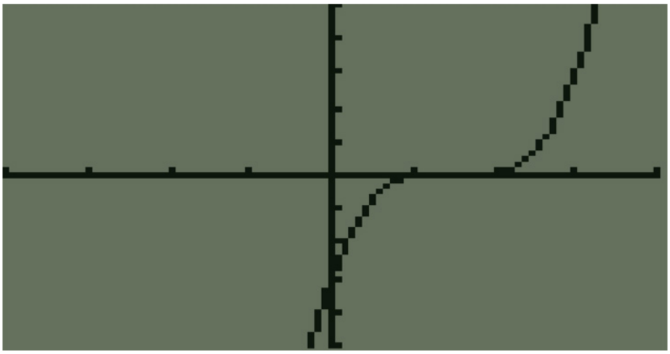

Figure 1: TI-83 screenshot of y=(x - 1)(x - 1.5)(x - 2)

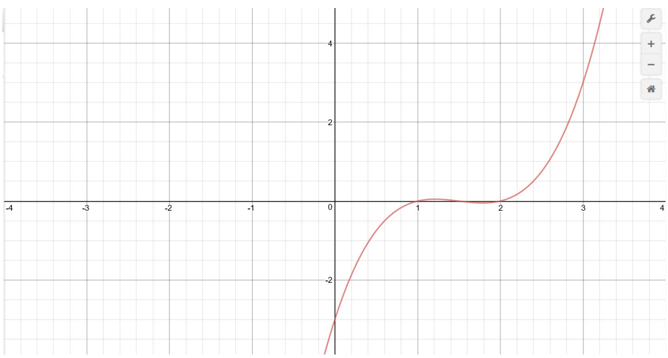

Figure 2: Desmos screenshot of y=(x - 1)(x - 1.5)(x - 2)

In addition, other Web 2.0 tools open up learning in ways that the TI-83/84 cannot,nnot, even with the use of their Calculator Based Ranger (CBR) or Calculator Based Laboratory (CBL). For instance, using Phet.edu, students can simulate repeatedly the path a certain projectile (such as a cannonball, car, piano, etc.) takes when launched at various angles and velocities. Multiple simulations allow for observations of various outcomes, while with the CBR/CBL, these activities are usually restricted to one or two trials, since the materials are often too expensive or it is impossible to perform experiments. Through these new possibilities, teachers begin to find themselves presented with a chance to explore real-world content by using these technologies as an opportunity to leap into a problem, rather than the traditional "teach to solve a problem" approach. "Instead of starting with detail, teachers may choose to approach topics through different entry points e.g. starting with an overview or real-world motivating application, using technology to generate results, and then going back to look at details" (Pierce & Stacey, 2010, p. 10).

Some have argued that because high-stakes testing now utilizes the TI-83/84 that mathematics teachers should continue utilizing these tools in their classroom, while using books that also integrate this technology into the content. Peter Balyta, president of education technology at Texas Instruments stated, "TI calculators continue to be trusted on 60 high-stakes exams around the world -- including the SAT, ACT, AP and IB exams" (as cited in McFarland, 2017, para. 6). However, ironically, school districts in Texas have already begun piloting efforts to incorporate Web 2.0 tools into their state testing (Locke, 2015, para. 2). By utilizing efforts throughout the school, teachers could block Wi-Fi and camera access, while ensuring students only had access to Desmos during the testing period (Locke, 2015, para. 5). In addition to the Texas pilot, "Smarter Balanced, which administers school proficiency tests in 15 states, is building a digital calculator into its tests this spring" based off the Desmos brand of graphing utility (McFarland, 2017, para. 1-3).

Conclusion

While there is definitely still a need for TI-83/84 calculators in mathematics classroom due in particular to high-stakes testing, we must increase our use of newer and more sophisticated technology. The TI-83/84 series were adequate when they were first utilized in the late 90's and 2000's, as they allowed students new abilities to build relationships, such as comparing graphs and scenarios quickly. However, with our ever-evolving resource of online tools, apps, etc., teachers can be even more efficient and sophisticated in their use of mathematics technology and prepare students to use technology that was truly developed in the 21st century.

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About the Author

Maurice Young received a Bachelor of Science in Education from Kent State University in 1998. Maurice recently completed his Master of Mathematics and Education at the University of Toledo. In the fall of 2017 Maurice returned to Woodward High School where he has taught for the past 18 years.