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INTERACTIVE MATH DEMOS FOR MOBILE PLATFORMS

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Interactive Math Demos for Mobile Platforms

Introduction

Adoption of mobile devices such as tablets, smartphones, and iPads by universities and schools is increasingly common. One of the most exciting opportunities in using mobile devices in classrooms is the ability to create interactive objects that can increase student engagement with the content. Interactivity can be achieved using native and web apps, and within digital books.

This paper will present several demonstrations for teaching mathematics, adapted for mobile devices, from the National Science Foundation funded project, *Demos with Positive Impact* (<http://www.mathdemos.org>). The *Demos with Positive Impact* project, which the author undertook in 1999, developed a substantial collection of web-based interactive demos designed for instructors in mathematics classrooms. The content in the collection ranges from basic algebra to post-calculus topics to statistics.

Because the elements that make up the *Demos* collection were developed more than 10 years ago, the presentation of the web-based materials is not advantageous for today's technologies. Availability of mobile technology provides the opportunity to redesign the demos for delivery by web app and within digital texts.

To date, the most prevalent mobile device to be widely adopted is the iPad so initial development has focused on web apps formatted for iPad and electronic books created for iPad using iBooks Author. This paper will discuss the motivation for adapting the collection for mobile platforms and illustrative samples of demos that have been adapted.

Demos with Positive Impact

Visualization can be a powerful tool to help students explore mathematical concepts¹ and instructors have long made use of visual images to convey mathematical concepts. Over the past two decades, availability of sophisticated computer software has made it possible to replace the hand-drawn diagrams we have routinely used in mathematics teaching with images of very high quality. Visualization has been a primary objective of the *Demos with Positive Impact* project, but the project goes beyond presenting a collection of images.

Demos with Positive Impact developed a web-based collection of instructional demonstrations for mathematics that are short vignettes that usually involve some sort of technology and visualization. Individual demos include visualizations in the form of static images, movies and animated gifs. In addition, interactivity is achieved using Java applets, *Mathematica* notebooks, Mathcad worksheets, Maple workbooks, Excel worksheets and MATLAB m-files. The demos are presented in an instructional context,

¹ Bettina Rosken and Katrin Rolka. (2006) *A Picture is worth 1000 words—the role of visualization in mathematics learning*, ***Proceedings of the 30th Conference of the International Group for the Psychology of Mathematics Education***, Volume 4, pp 457-464.

including objectives of the demo, the level at which the demo is appropriate including prerequisite knowledge, platform requirements (including hardware and software), instructor’s notes that provide background as to how to include the demo in class, and credits that acknowledge the efforts of those who contributed to the development of the demo. Figure 1 provides a sample of one of the demos in the collection².

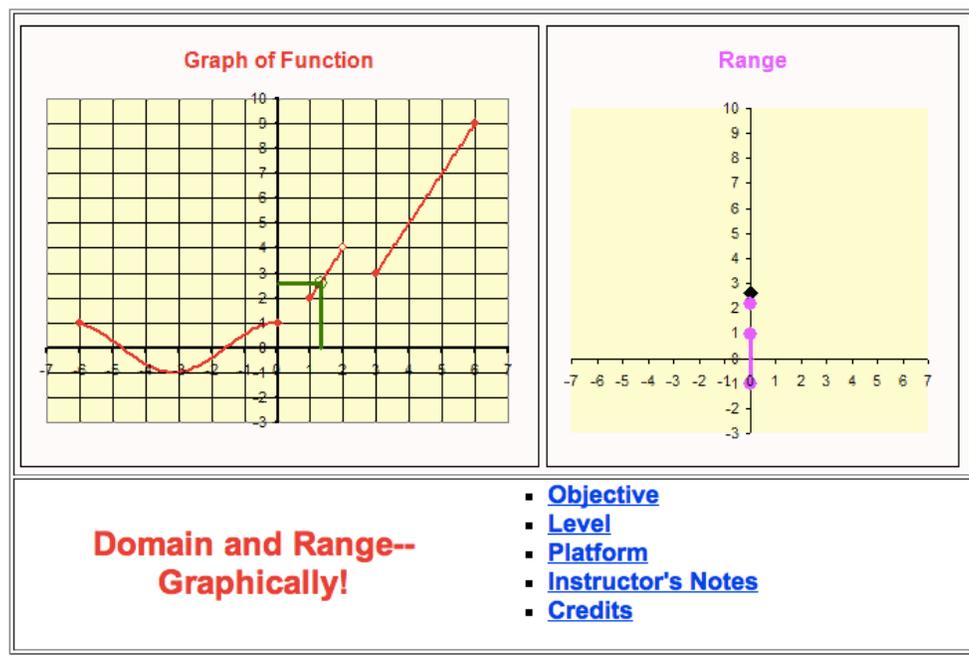


Figure 1. Presentation format for *Demos with Positive Impact*

The materials on the *Demos* website have been used by both instructors and students, and after fifteen years individual demos are still being used for teaching and learning. Some demos get many hits per month, often in predictable patterns. For example, from December 2011 to December 2012, the demo “*Domain and Range—Graphically!*” referenced in Figure 1 received over 1000 hits per month (see Figure 2a), with the maximum number of hits recorded in September. This is not surprising since domain and range would be covered early in a fall academic term. Figure 2b records the number of hits for applications of the definite integral, *Method of Shells*³. Note that in both examples, the demos are not accessed as often during summer months, which is also not surprising given that more students sit in school and college courses during the academic year than in the summer.

Demos with Positive Impact is accessed from locations all over the world. Figure 3 provides a snapshot of countries from which materials have been accessed. While the United States dominates, a significant number of hits come from countries such as

² Domain and Range—Graphically!

<http://www.mathdemos.org/mathdemos/domainrange/domainrange.html>

³ Method of Shells <http://www.mathdemos.org/mathdemos/shellmethod/>

Turkey, Pakistan, Saudi Arabia and others. Current usage data provide evidence that the collection is still being used in a significant way, worldwide.

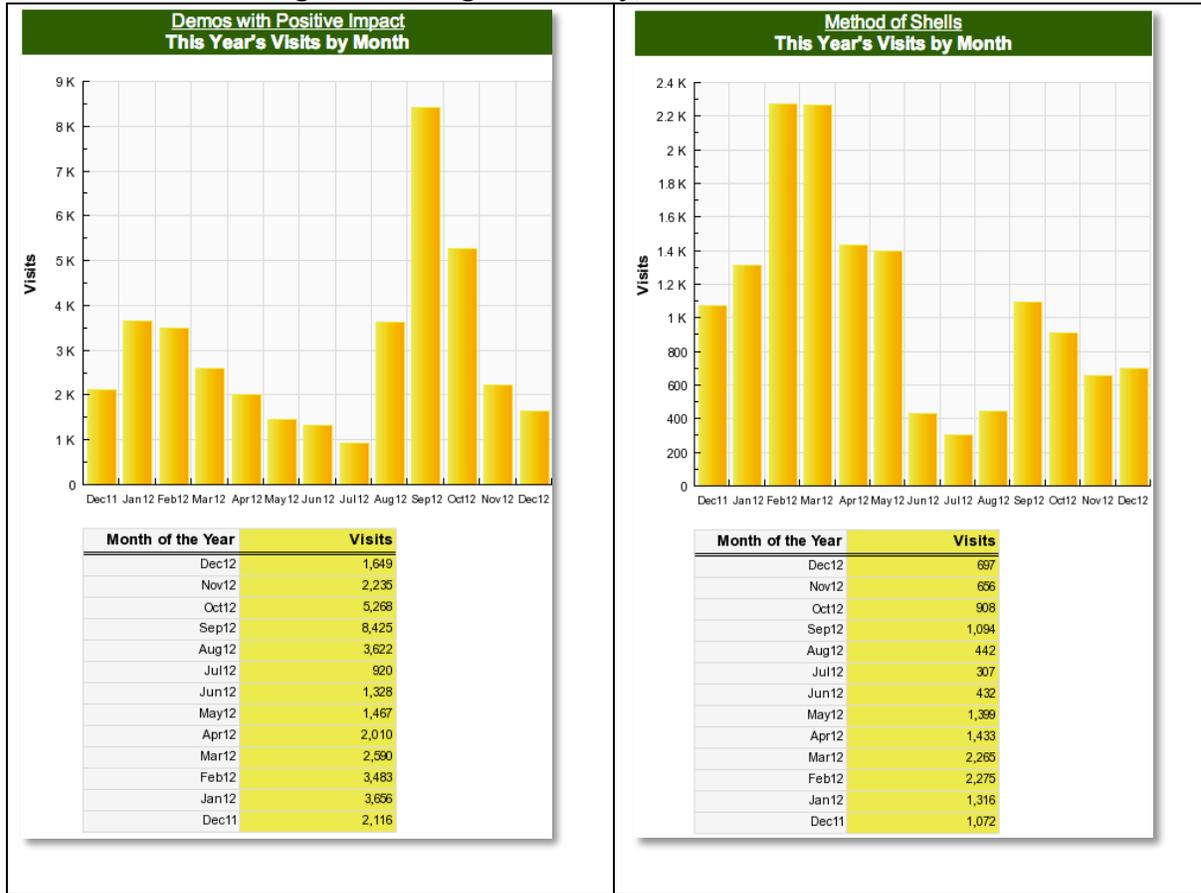


Figure 2. Web access metrics for two demos in the *Demos with Positive Impact* collection.

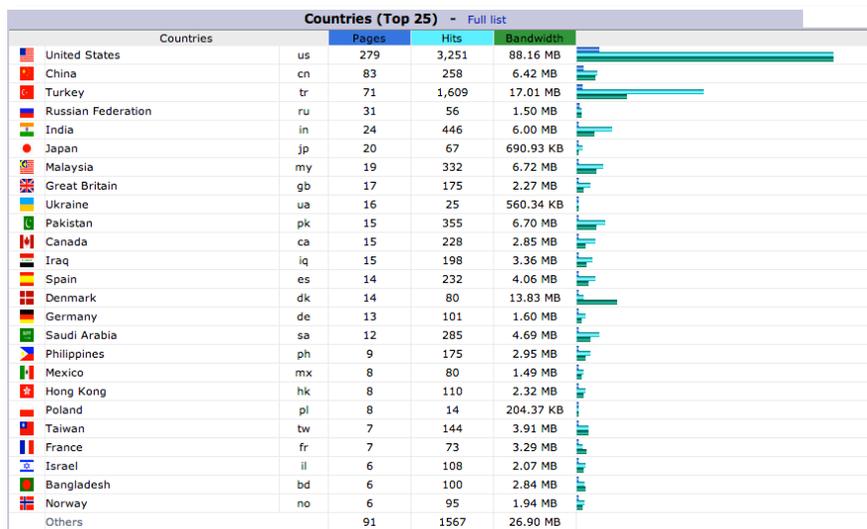


Figure 3. The top 25 countries from which one of the demos in *Demos with Positive Impact* is accessed.

Because *Demos with Positive Impact* was developed more than a decade ago, current best practices in web design either did not exist or were in their infancy. Many more devices are now available on which web material can be accessed and the older web page designs do not display in a consistently pleasing manner, as illustrated in Figure 4.



Figure 4. *Demos with Positive Impact* introductory page as displayed using a variety of mobile devices.

Despite the challenges with today’s mobile technologies, the goals of *Demos with Positive Impact* were on target for today’s mobile world. In particular, the demos were developed consistent with the following:

“Mobile content, then, needs to be “bite-sized,” visually stimulating and interactive. Because online you have maybe five to ten seconds to grab people’s attention.”⁴

Rethinking Demos with Positive Impact

Bringing the collection to a more contemporary format is not a trivial task because moving the content to a mobile-friendly format means more than just delivering the original content on tablet devices. Both content and presentation must be reconsidered. To improve access across a wide range of devices, it is necessary to account for different platforms including, for example, screen size, device orientation, and operating systems.

⁴ Retrieved from the World Wide Web on March 21, 2013. Todd Tauber. “The dirty little secret of online learning: Students are bored and dropping out,” <http://qz.com/65408/the-dirty-little-secret-of-online-learning-students-are-bored-and-dropping-out/>.

Use of Java applets and Flash must be eliminated for iOS devices and later Android operating systems and alternative interactive content developed. Original downloadable content must be significantly reduced for the mobile devices.

While still a work in progress, two approaches are being used to redeliver *Demos* content for mobile devices. iOS devices are more widely used at present so the initial focus is on developing materials suitable for iPad and iPad mini.

Web App

One of the approaches to content redesign is to develop a web app. When developed specifically for iOS, a web app looks and behaves as if it were a native app, but it is really a specially formatted website. The design currently being explored for *Demos with Positive Impact* is illustrated in Figure 5.

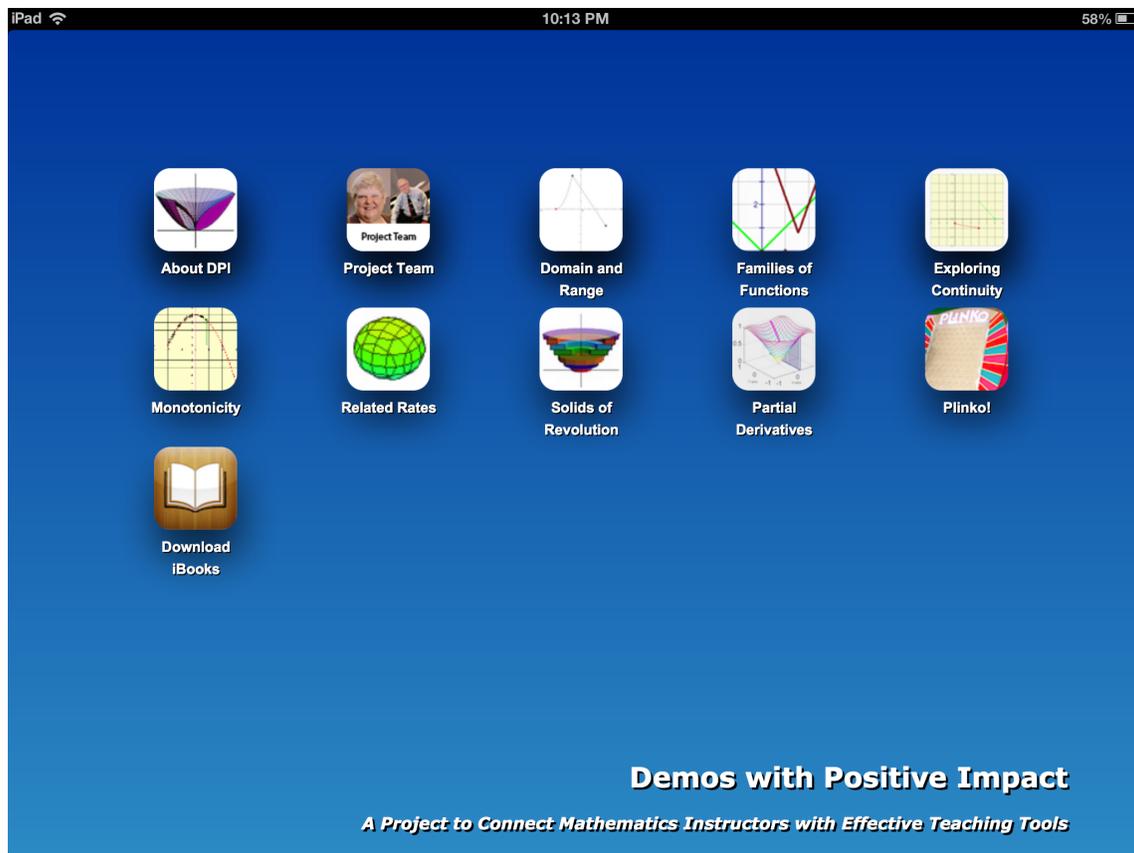


Figure 5. Experimental web app design (adapted from open source iPad simulator⁵ by @altryne at <http://alexw.me>)

When displayed on iPad, the web app (<http://www.mathdemos.mobi>) has the look and feel of a native app, but it is actually a web site designed using cascading style sheets (CSS) that give the desired effect. Currently the demos are designed to be displayed in landscape mode.

⁵ iPad 2 Simulator <http://alexw.me/iPad2>

The domain and range demo referenced earlier in the paper has been redesigned to take advantage of this format (Figure 6). Pull-down menus allow access to several examples including functions defined by formula and piecewise-defined functions.

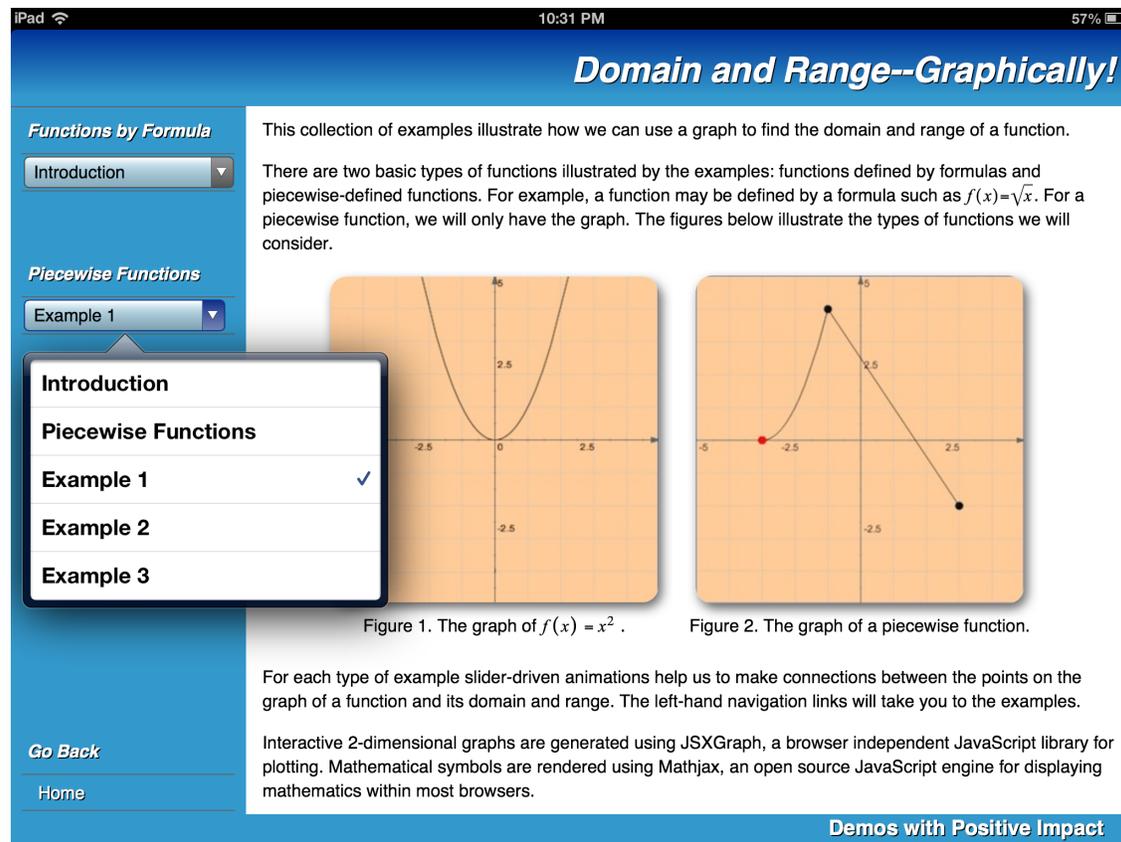


Figure 6. iOS version of Domain and Range—Graphically!

Interactivity in the graphs is achieved using JSXGraph⁶, a JavaScript “cross-browser library for interactive geometry, function plotting, charting, and data visualization.” JSXGraph supports a variety of browsers and multi-touch devices such as iPad and Android devices. Mathematical symbols are displayed using MathJax⁷, an “open source JavaScript display engine for mathematics that works in all modern browsers.” Neither JSXGraph nor MathJax require browser plugins or installations of fonts. Thus, both are outstanding choices for mathematics within the web app.

Figure 7 shows an example of a demo in which the domain and range of a piecewise function are explored. As the function graph on the left is traced from left to right, the x-coordinates and y-coordinates of the points on the function graph are plotted on horizontal and vertical axes, respectively, to illustrate the graphs of the domain and range

⁶ JSXGraph <http://jsxgraph.uni-bayreuth.de/wp/>

⁷ MathJax <http://www.mathjax.org>

of the function. The function trace can be animated and the student may display (and hide) the symbolic representation of the domain and range of the function.

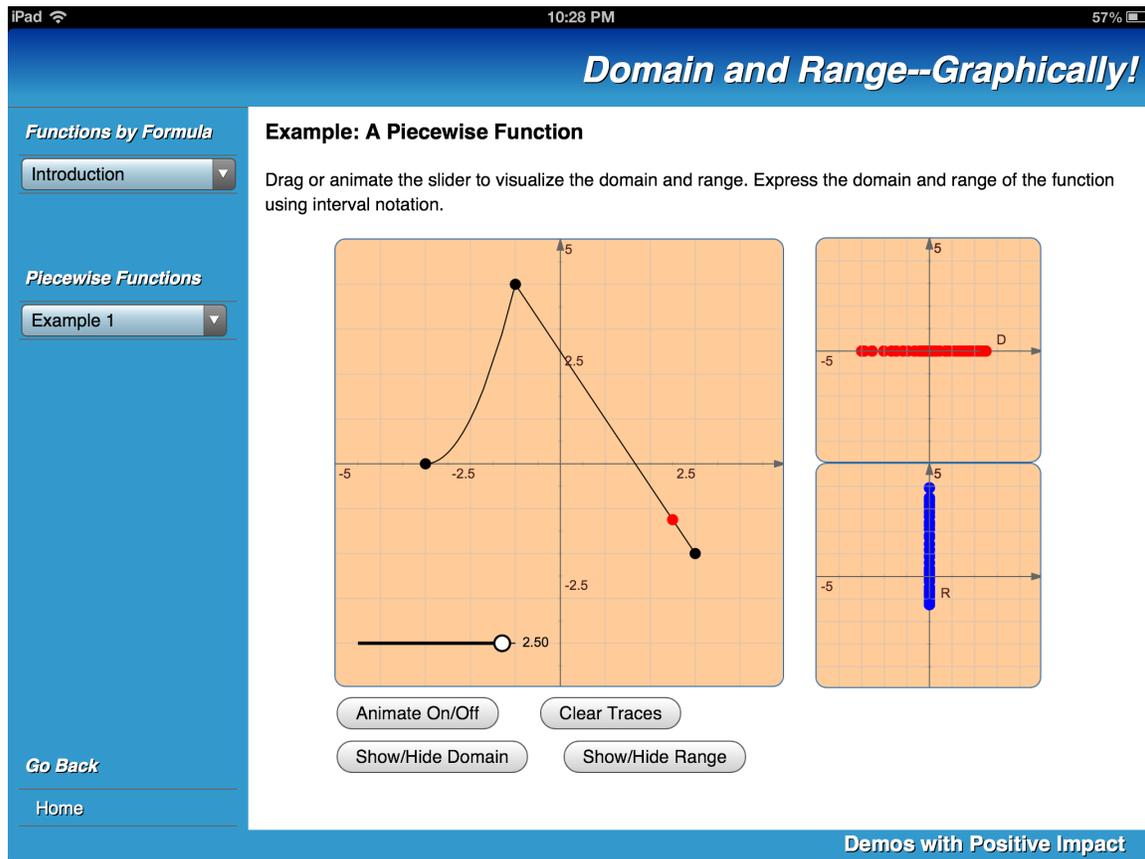


Figure 7. Interactive exploration of the domain and range of a piecewise function.

Another demo that explores continuity of piecewise functions is pictured in Figure 8.

In addition to providing hit count and visit data for individual demos, website analytics embedded into *Demos with Positive Impact* allow the identification of operating systems and browsers used to access the demos. Development plans include identifying and adapting those demos that are accessed often and from mobile operating systems.

Interactive iBooks

One of the most exciting applications of mobile devices is delivering ebook content. While static content on tablet devices can help alleviate heavy backpacks, the potential for developing interactive and engaging content within the ebook is particularly exciting.

iBooks Author is an Apple (Mac) application that is used to develop books that can be displayed in iBooks on iPad. iBooks Author allows the user to insert effective visualization and interactive tools within the ebook. Some of these tools include image galleries, videos, animations, interactive images and html widgets.

iPad 10:48 PM 55%

Exploring Continuity of Piecewise Functions

Functions by Formula

Introduction

Piecewise Functions

Example 1

[Go Back](#)

[Home](#)

In this collection of examples we explore the continuity of piecewise functions. Recall that a function is continuous at a point $x = a$ if $\lim_{x \rightarrow a} f(x) = f(a)$.

As an example, consider the function $f(x) = \begin{cases} x + 1, & 0 \leq x \leq 3 \\ 5 - x, & 3 < x \leq 5 \end{cases}$.

To investigate whether the function is continuous at $x = 3$, we want to find out if $\lim_{x \rightarrow 3} f(x) = f(3)$. Because the function has a different formula on the left and right of $x = 3$, we need to investigate the left and right hand limits as x approaches 3.

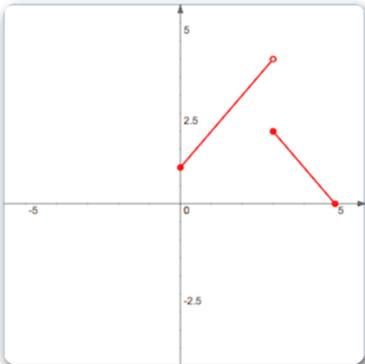


Figure 1. The graph of a piecewise function.

You can interactively explore continuity of piecewise functions. Just follow the left-hand navigation links.

Demos with Positive Impact

Figure 8. Continuity of Piecewise Functions

Since JavaScript is fully implemented in iBooks, it is possible to build real interactive explorations within the text, including using JSXGraph and MathJax.

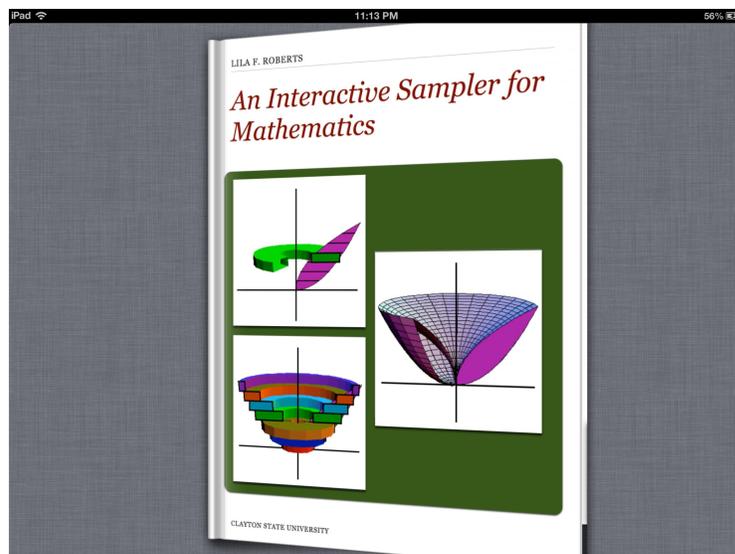


Figure 9. An interactive iBook.

Figure 10 shows how a video can be embedded into the iBook. This video also includes audio and captions to facilitate accessibility.

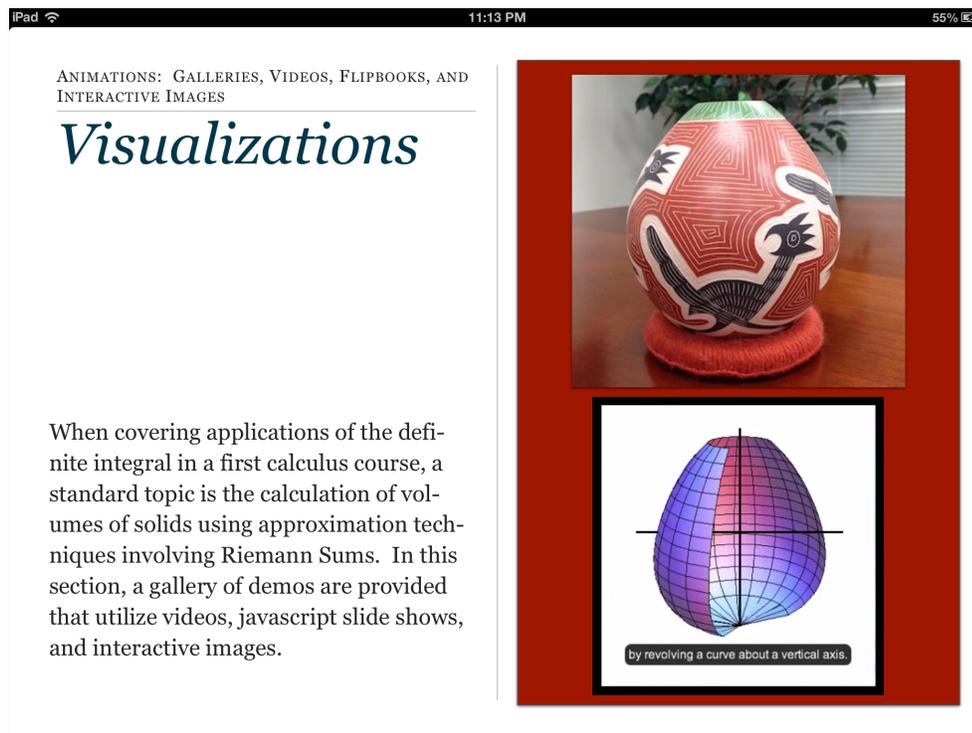


Figure 10. Embedded video with audio and captions.

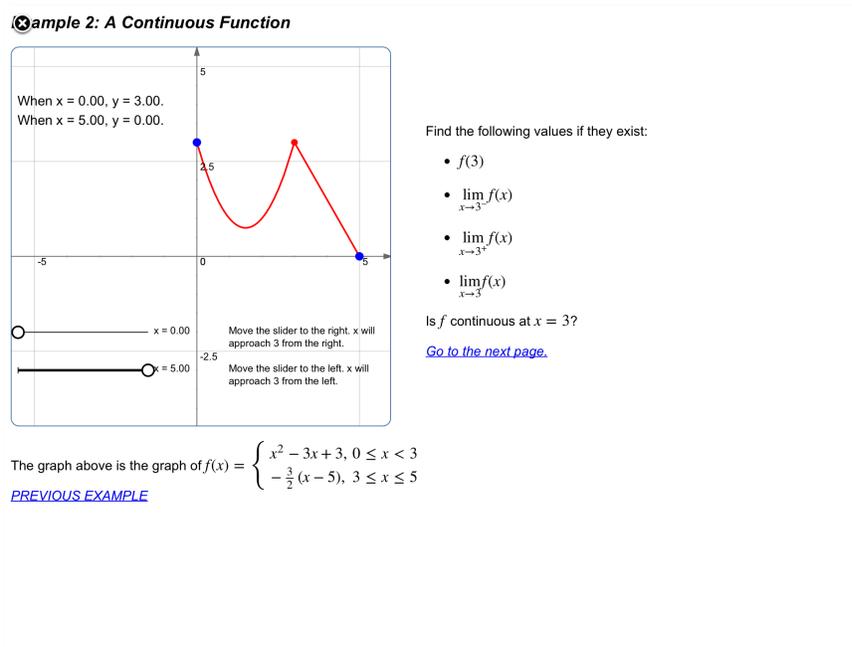


Figure 11. Interactivity via JSXGraph and MathJax embedded in an iBook.

Conclusion

Technology advances that facilitate development for mobile devices are making it possible to adapt the successful project *Demos with Positive Impact* for delivery on these devices. While the conversion of demos from original format to one that is advantageous to mobile devices is not a trivial task, work is progressing to adapt a significant number of demos for mobile delivery.

Acknowledgement: *Demos with Positive Impact* was developed by the author and David R. Hill (Mathematics Department at Temple University) using demos contributed by the developers and by mathematics instructors all over the United States. The project was funded by the National Science Foundation’s Course, Curriculum, and Laboratory Improvement Program under DUE-9952306. *Demos with Positive Impact* was recognized as “An Exemplary Online Model for Mathematics” by **MERLOT** (Multimedia Educational Resource for Learning and Online Teaching) and was a founding partner in the NSDL/MAA Math Gateway.