The Math Description Engine Library and MathTrax: Accessible Software for Students

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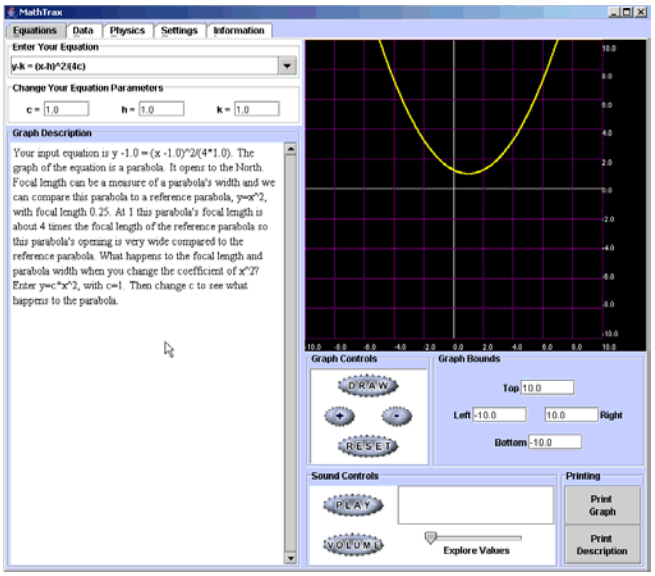
The Math Description Engine (MDE) is a library of interactive software modules that combines mathematical analysis, graphing, and sonification to represent math and science information. The purpose of the MDE is to dynamically generate accessible text descriptions of graphs to make data traditionally conveyed in visual graphs available to blind and visually impaired users. The MDE modules use rule- and computation-based artificial intelligence to synthesize text descriptions for graphs of mathematical equations, tables of data, and simulations. The sonification engine then renders the resulting planar curve(s) as a mixture of stereo tones.

The main library components of the MDE are the Solver, Solved Graph, Describer, Drawer, and Sonify. These components work together to determine what kind of "thing" an equation is, how to appropriately describe it, and how to display it. When the user enters an equation, the software puts the equation in canonical form evaluating signs, coefficients,

Robert Shelton demonstrates the Math Description Engine at the 2003 National Convention of the National Federation of the Blind.



Screen captiure of the MathTrax Software.

and discriminants. Through a process of algebraic reduction, the equation is then classified by the Solver into one of a set of identified cases or solved graphs. The Solved Graph module contains a number of cases for conic sections with specific attributes for each case. Based on the case type and specific attributes of the equation, the appropriate feature characteristics are generated in the Describer, Drawer, and Sonify modules. The MDE's description, sonification, and graphing components can be used independently or together. Its architecture supports solution synchronization among components when text, sound, and graphing are used in combination.

MathTrax is an educational technology tool that demonstrates the combined capabilities of the MDE library modules. Its primary audience is middle and high school students studying

algebra, pre-calculus, and calculus; in particular, it serves blind and visually impaired math students. MathTrax fulfills a compelling educational need to demonstrate the relationship between math and real-world science applications by translating and demonstrating math relationships in a tangible physical medium on a standard personal computer platform.

Students can create graphs by entering an equation, selecting an equation from a drop-down menu, entering raw data for analysis, or activating a physics simulation. MathTrax graphs the equations and provides descriptions of those graphs using text and sound. The curves currently described include all first- and second-order equations in two variables; for example, line, parabola, ellipse, hyperbola, circle, null set, single point, and two lines. The dynamic text descriptions and sonification make the graphs accessible to blind students who do not use pencil, paper, or written graphs to study math. The text descriptions can be read by Java-capable screen readers such as Jaws for Windows, or they can be input to speech synthesizing software to create self-voicing applications. MathTrax provides color and line settings for traditional "drawn" graphs to aid users with differing vision -impairments.

MathTrax is currently in classroom use and was featured at the NASA/National Federation of the Blind summer science camp Rocket On! as a sounding rocket mission planning and data analysis tool. MathTrax, which is one of four advanced educational technology products offered by the NASA Learning Technologies incubator, is free of charge and available online at http://prime.jsc.nasa.gov.