Title: Report on the "Science Technology Engineering and Math" 2017 NFB National Convention Tutorial

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**Introduction**

In school, a blind student must make up his/her unique accessibility solutions to access the various information sources used in each class. Because there are no standards for systems and class room materials to be accessible, schools seldom offer the blind student a portfolio of accessible educational

solutions to meet each semester's needs. The proposed Accessible Instructional Materials in Higher Education (AIM HIGH) Act (S. 2138 / H.R. 1772) would develop accessibility standards for schools and content providers.

Until a market-driven solution for accessible instructional materials is achieved, blind students must develop their own accessibility solutions. To do this effectively, students must have knowledge about current best practices on a wide variety of information systems.

Organized by John Gardner, many companies, agencies, and individuals got together during the 2017 NFB National convention to provide tutorials on innovative new STEM products. STEM is Science, Technology, Engineering, and Math, topics that seem to be particularly difficult for the blind.

On July 10, 2017, John Gardner had arranged an all-day tutorial on how blind professionals, and blind students, are succeeding in STEM careers. Also, throughout the convention week, he arranged hands-on tutorials for anyone who wished one-on-one training in these methods.

The speakers presented talks and demonstrations showing proficiencies in math, data analysis, efficient graphics production, and how to perform chemistry experiments as a blind person. Many of the speakers provided information related to their presentations. This information can be found at (http://access2science.com/indexAccessibility.html). Podcasts of the Monday symposium were recorded by Ben Dahle of Viewplus, and they are also available at this website. A summary of these presentations follows.

Please note that we have shamelessly copied words, phrases, and entire sentences from the audio recordings and writings of the presenters, from manuals, and from Wikipedia. In the academic publishing world, each citation is followed by a reference; however, this is not the Braille Monitor

Format.

**The Program**

After a welcome from John Gardner, Ashley Neybert, representing Independence Science,

discussed Making Science Laboratories More Accessible to the Blind. Independence Science works to provide information to educators who are teaching science to students who are blind or visually impaired.  Most notable among Independence Science's products is the Talking LabQuest, an adapted version of the commonly used Vernier LabQuest, which is equipped with speech capability and utilizable with approximately 75 probes. Talking LabQuest allows blind students to perform laboratory experiments. Ms. Neybert demonstrated the Talking LabQuest.

Steve Jacobs, President Ideal Group, Inc., discussed the Infty Reader (Math OCR), and the ChattyInfty (talking accessible math editor).

Many images of mathematical equations appearing on web pages, eBooks, and PDF documents:

Are not accessible by students using access technology;

Do not provide for alternative output modalities such as Braille or synthetic speech;

Cannot be easily altered to accommodate the learning needs of students with low vision (color and contrast changes); and,

Require authors to redraw images when even small changes are made.

InftyReader is an Optical Character Recognition (OCR) application that automatically recognizes and converts image-based STEM content into LaTeX, MathML, and Word XML.  ChattyInfty is a talking math editor used to edit the files generated by InftyReader.

These two tools can give the blind access to mathematics published as images.

Next, John Gardner (Retired Prof of Physics, Oregon State University and President, ViewPlus Technologies Inc.) described how ViewPlus's IVEO system can provide Audio-Tactile access to graphics.

The Audio-Tactile method

The requirements for audio-tactile access are a tactile copy of the figure, a computer file with information keyed to location on the figure, some type

of hardware device that communicates position on the figure to the computer, and a computer application that provides speech and/or braille information to the user.

In the past, the hardware device has always been a touch-sensitive tablet. A modification allowing the user to attach the graphic to a touch screen is under development. Essentially, the tactile graphic is produced with a ViewPlus Braille printer, and a file providing speech to describe the graphic. The user touches the graphic, and the computer reads the underlying description. The audio description file can be automatically generated for some circuit and molecule diagrams.

Mike Coleman, representing E.A.S.Y. LLC. Discussed

Their Interactive Tactile Graphic drawing tools.

The inTACT Sketchpad is an affordable and easy-to-use tool for creating tactile drawings by hand. As you draw on the sketchpad, raised lines appear on the Plastic drawing sheet, making it possible for you to feel your drawings as you go.

The inTACT Eraser is the first-ever eraser for tactile drawing. Working like a miniature iron, the inTACT Eraser flattens tactile drawing quickly, erasing your drawing to the touch.

Next, we heard from Jonathan Godfrey, (Senior Lecturer in Statistics, Massey University, New Zealand and National President, Blind Citizens NZ), on Statistics with Graphics in R. Jonathan is the first totally blind person to gain employment as a Lecturer in Statistics and that to date only one other person has done so.

Jonathan said that there are two statistics packages accessible to the blind. They are R and SAS. SPSS is another statistical software package that is somewhat accessible to the blind. Jonathan recommends that the blind use R for their statistics needs.

R is a free system for statistical computation and graphics. It consists of a language plus a run-time environment with graphics, a debugger, access to certain system functions, and the ability to run programs stored in script files.

Jonathan reported that R can generate accessible tables, graphs, and models.

Graphs can be embossed using Braille printers such as those available from ViewPlus.

Jonathan has developed a method of taking a Scalable Vector Graphic (SVG) plot output from R, generating an automatic description file, and making it available to the user. The description file contains a tree which describes the properties of the graph. The top node of the tree contains the title, other branches describe the X-Axis, the Y-Axis, and a description of the data in the plot. The computer describes the graphic as the user arrows through the description file.

He has an expert mode which can give summaries of the data in the plot.

His tools make histograms and time series plots accessible. He is working on making scatter plots readable.

His tools provide real-time operating-system and screen-reader independent methods for reading the graphical output of R.

He spent most of his lecture showing how his tools can describe a histogram.

Jonathan says that it is essential for a Blind user to be able to not only read graphs, but also be able to generate them. R fulfills this need.

Lloyd Rasmussen (Senior Staff Engineer, Library of Congress), and Louis Maher (Retired Software Engineer), discussed Reading Math from electronic documents.

Lloyd said that an accessibility certification standard is being developed for the EPub electronic book publishing format. He also said that publishers are beginning to require authors to write the descriptions for figures since the author understand the reasons for having those figures more than the publisher does.

MathJax is a JavaScript display engine for mathematics that works in all browsers. Lloyd mentioned that MathJax may be more popular than MathML to publish mathematics. He also mentioned that some education entities don't want scripts running in their environments due to the possible cheating issues that scripts might bring.

Lloyd concluded that STEM electronic publishing standards are in flux.

Louis Maher described how to read math in Windows with Jaws and NVDA, and iOS using Voiceover.

Recently JAWS has introduced a method to display, in voice and Braille, mathematics on the web.  When you encounter MathML on a web page, JAWS describes the expression, followed by the message "math content.".  Pressing ENTER while focused on the math content opens the Math Viewer where you can explore the expression in greater detail in both speech and braille.

Using Windows 10, Word 365, Firefox, MathPlayer, and MathType, NVDA has a rich set of features which speaks, navigates, and provides Braille output math from the web, in Word, and PowerPoint. These capabilities were summarized.

John Gardner introduced his LeanMath Editor (AKA LEAN) program for reading and writing math in MS Word using the Design Science MathType plugin.

LEAN is an interface to applications that can exchange MathML with LEAN. This first version is used only as an interface to MS Word plus MathType, which is, (according to the MathType manufacturer, the most used authoring environment in the world by a substantial margin.

For the web, LEAN can insert alt tags into MathType equations which allow the blind user to have descriptions of the equations independent of a screen reader's ability to read math on the web. Recently, it has become possible to read these equations directly with screen readers, so the need for such alt text is not as large as it once was.

LEAN is meant to write math, not just to read it. LEAN provides excellent speech access to editing MathType equations or authoring new MathType equations. LEAN has many features that help in the manipulation of equations to solve algebraic equations. One can also view equations in braille while in the LEAN application.

LEAN is intended for blind people who must read and write math and need to solve equations.

Sam Dooley (Pearson), Susan Osterhaus (Texas School for The Blind and Visually Impaired), Sara Larkin (Iowa Educational Services for the Blind and Visually Impaired), and Tina Herzberg (University of South Carolina Upstate) described how to do real-time Nemeth Braille input / output by using the Pearson " Accessible Equation Editor".

The Accessible Equation Editor is a program that allows a user to create math expressions within a web page. The equation editor is used in many Pearson products, most notably the TestNav assessment delivery system used for high-stakes testing.

The equation editor is accessible to blind and visually-impaired users because it translates printed math notation into Nemeth braille, which can be displayed on a braille terminal, and it accepts Nemeth braille input, which it translates into printed math notation that it displays for a sighted user. A blind user can create math expressions that can be immediately read by a sighted user, and vice versa.

Mathematics can be entered either from a QWERTY or Braille keyboard.

Pearson is developing an online curriculum to teach the Nemeth code in conjunction with mathematics using the equation editor. There is a test at the end of each module to check the student's progress. Students, parents, and teachers should all be able to use this tool. Current pre-kindergarten and kindergarten modules have been completed.

Pearson is also working on an online glossary of mathematical terms in a searchable database. A user would enter a mathematical term, and the database would demonstrate how to write that term in the Nemeth code.

At the time of the presentation, it was not possible to generate the mathematical output of the equation editor as a separate stand-alone file. This capability would be an invaluable tool for doing math homework. The equation editor is currently used as an interface to other on-line applications.

Jonathan Godfrey introduced Latex and Markdown.

LaTeX, is a document preparation system for high-quality typesetting. It is most often used for medium-to-large technical or scientific documents, but it can be used for almost any form of publishing.

Markdown is a lightweight markup language with plain text formatting syntax. It's designed so that it can be converted to HTML and many other formats using a tool by the same name.

Any text editor can be used to prepare input files for both LaTeX and Markdown. The difference is that Markdown uses a much simpler syntax than does LaTeX. It should be noted that

the mathematics in Markdown is done using a version of LaTeX. LaTeX has a steeper learning curve than does Markdown.

Both LaTeX and Markdown can produce pdf documents; however, pdf documents are usually difficult for the blind to read. The preferred output for both languages is html. PDF documents are page oriented whereas html has one continuous flow. HTML files are much easier to search than is page oriented PDF.

Markdown also forces you to put in alt text descriptions for URLs; that is, Markdown forces the author to provide accessible descriptions for his/her web links and graphics.

LaTeX has a lot of structure to make it work. markdown has defaults which work. You can have Markdown Output LaTeX if necessary.

Jonathan recommends using Markdown for most files, only using LaTeX for longer documents such as research dissertations, theses, and books.

Jonathan pointed out that a blind individual must be able to read and write scientific material without sighted assistance. Markdown is a powerful tool that can help achieve this goal.

Finally, William Freeman (American Printing House for the Blind) discussed using BrailleBlaster for Scientific Braille Translation.

BrailleBlaster™ is a braille transcription program developed by the American Printing House for the Blind to help transcribers provide blind students with braille textbooks on the first day of class.

BrailleBlaster takes advantage of the rich markup contained in NIMAS (National Instructional Materials Accessibility Standard) files to automate basic formatting and gives you tools to make advanced tasks quicker and easier. Designed primarily for editing textbooks that meet the specifications published by the Braille Authority of North America, the purpose of BrailleBlaster is to help braille producers ensure that blind students receive their books on-time.

BrailleBlaster relies on Liblouis, a well-known open-source braille translator, for translating text and mathematics to braille.

BrailleBlaster can be used by an instructor to prepare Braille documents for their blind students.

BrailleBlaster is fully accessible. It can accept math in MathML. It can convert MathML into ascii math, which is a simplified LaTeX. This allows users to edit their math directly before the final Braille output.

BrailleBlaster now runs on PC's. There are plans to make it work on the MAC, and on Linux.

BrailleBlaster works with JAWS and NVDA. It can output Nemeth or UEB.

BrailleBlaster was started by John Gardner.

BrailleBlaster is a powerful tool towards the goal of making sure blind students have their classroom materials at the same time as their sighted Peers.

**Summary and Conclusions**

Many companies, agencies, and individuals got together during the 2017 NFB national convention to provide tutorials on innovative new STEM products. The project began with a symposium on Monday, July 10, 2017 and then individual tutorials were offered at available times during the rest of the week.

This was an experiment in “bringing tutorials to the students”, because it is much less expensive to take them to where the students are already congregated than having special events to which students come. But the convention seems not to be the best place to do this. Although many students told us how much they needed and wanted to learn more about how to do STEM, their time was simply too full for very many to find time to participate.

The need for knowledge about methods of accessing STEM material is essential for having a career in science. The methods discussed in this tutorial will provide an invaluable resource for these methods.

I am grateful to John Gardner who originated this tutorial and reviewed this paper, to the National Federation of the Blind for making space available for these tutorials, to the many people who donated their time and paid their own expenses to speak or tutor during the project, and to my wife Helen Maher who edited this paper.