Final Report: The Voice Input Speech Output (VISO) Calculator

Students with visual impairment face increased challenges in mathematics education, a content area particularly important for success in school and beyond, in addition to one being assessed under *No Child Left Behind*. Often these students with visual impairments rely on calculators to assist them with mathematics; yet, accessible calculators are key to success. Unfortunately, few accessible calculator options exist, particularly considering calculators that can be operated on computers and that allow students to verbally input information and have information provided auditorily. Hence, the VISO calculator was developed by collaborations from gh, LCC and Purdue University through a grant from the 2008 NCTI Technology in Works award. This final report highlights the collaboration of individuals from two organizations to develop and then field test an assistive technology to aid students with visual impairments – and beyond – gain access to mathematics education.

Collaborators:

Collaborators on the VISO calculator, referred to as the Accessible Computer Algebra System in the 2008 NCTI Technology in Action awards, included Dr. Emily C. Bouck, Dr. Waseem Sheikh, and Dr. Dave Schleppenbach. Dr. Emily Bouck is an Assistant Professor in the Special Education Program at Purdue University. Her research focuses include assistive technology for students with disabilities, particularly in the content areas. She was the lead researcher on the research. Dr. Waseem Sheikh is a researcher and software engineer at gh, LLC and the programmer of the VISO calculator. Dr. Dave Schleppenbach is the President of gh, LLC. The three primary collaborators were assisted by graduate research assistants (Sara Flanagan and Gauri Kulkarni of Purdue University) as well as the principal, staff, and students at the school site.

Two of the collaborators – Waseem and Emily – first connected at an assistive technology conference in 2008 when Emily was presenting on a study exploring students with high incidence disabilities use of calculators as accommodations on assessments and Waseem was presenting with the company gh and their products (e.g., gh Player). From there, a dialogue was started among the collaborators about developing technology for students with disabilities relative to mathematics education, especially when it was discovered that Purdue University and gh were located in the same town.

The three collaborators were equally interested in creating a niche and filling a need, particularly as related to mathematics education and assistive technology. An idea was born from Waseem to develop an accessible computer-based graphing calculator as few existed on the market, and particularly ones affordable to many individuals with disabilities. Together a proposal was put forward to the NCTI Technology in the Works competition, and a relationship was forged among colleagues.

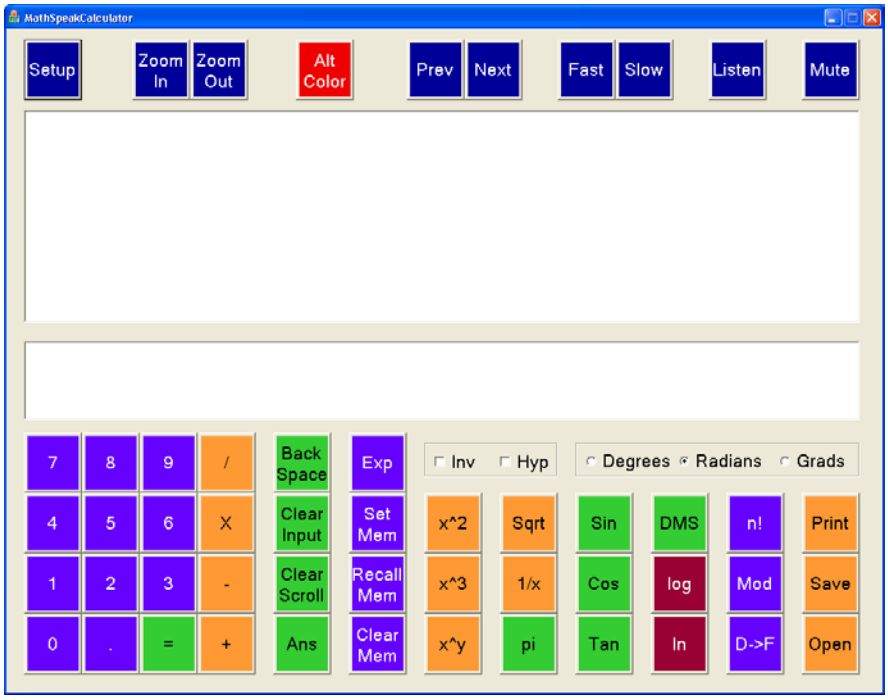
Upon receiving the 2008 NCTI Technology in the Works competition, the collaborators – assisted by graduate students at Purdue University and staff at gh – began to develop the VISO calculator. Waseem lead the effort at gh and Emily and her graduate students would give insight, particularly considering students with disabilities and the mathematical needs of this population.

During the construction of the originally proposed computer-based accessible graphing calculator, it became apparent that this project would require greater resources than provided by the 2008 Technology in the Works competition and the project was shifted to a computer-based scientific calculator. However, the collaborators have continued dialogue about finding a grant to support a computer-based accessible graphing calculators for students with visual impairments and other disabilities.

During the time of the grant, Waseem and Dave lead the effort on development and Emily, in conjunction with her graduate students, began to seek out school partners for conducting the research as well as developing the assessments for the research portion of the project. Furthermore, all collaborators worked together to beta-test the system and communicated about issues that needed to be addressed both with the technology as well as the research design and protocol. Once a school partner was located and development completed, Emily and her graduate students lead the effort in conducting the single subject research study with a school in the State.

The Technology

The VISO calculator refers to the Voice Input Speech Output calculator (see figure below for screen captures of the VISO calculator). It is a computer-based scientific calculator, operating off a Windows platform computer. Although called the VISO calculator, the tool is actually accessible through a mouse or keyboard short-cut commands, in addition to voice commands. The voice input (i.e., speech recognition) function of the VISO calculator utilizes a particular language developed previously by gh, LCC (2006) called MathSpeak. The MathSpeak language involves a set of standardized rules to complete mathematical functions and was originally designed for the purpose of adapting mathematics and science textbooks into more accessible formats. The lexicons for MathSpeak are different from typical spoken English. For example, to input 12 × 3 using MathSpeak, one would say “one-two times three” rather than “twelve times three.” Beyond the nuances for entering numbers using MathSpeak, the VISO calculators has its own set of language for operating commands, both in terms of calculations as well as accessibility features (see figure below).


MathSpeakCalculator
Setup
Zoom In
Zoom Out
Alt Color
Prev
Next
Fast
Slow
Listen
Mute
7 8 9 /
Back Space
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Degrees
Radians
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4 5 6 X
Clear Input
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x^2
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1 2 3 -
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Recall Mem
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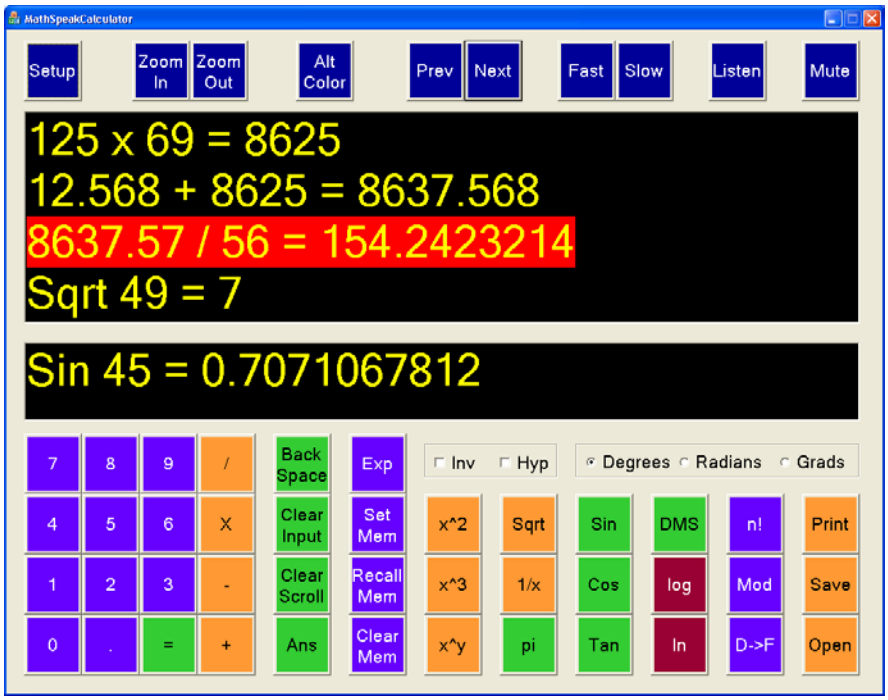
MathSpeakCalculator
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125 x 69 = 8625
12.568 + 8625 = 8637.568
8637.57 / 56 = 154.2423214
Sqrt 49 = 7
Sin 45 = 0.7071067812
7 8 9 /
Back Space
Exp
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Degrees
Radians
Grads
4 5 6 X
Clear Input
Set Mem
x^2
Sqrt
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Print
1 2 3 -
Clear Scroll
Recall Mem
x^3
1/x
Cos
log
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0 . = +
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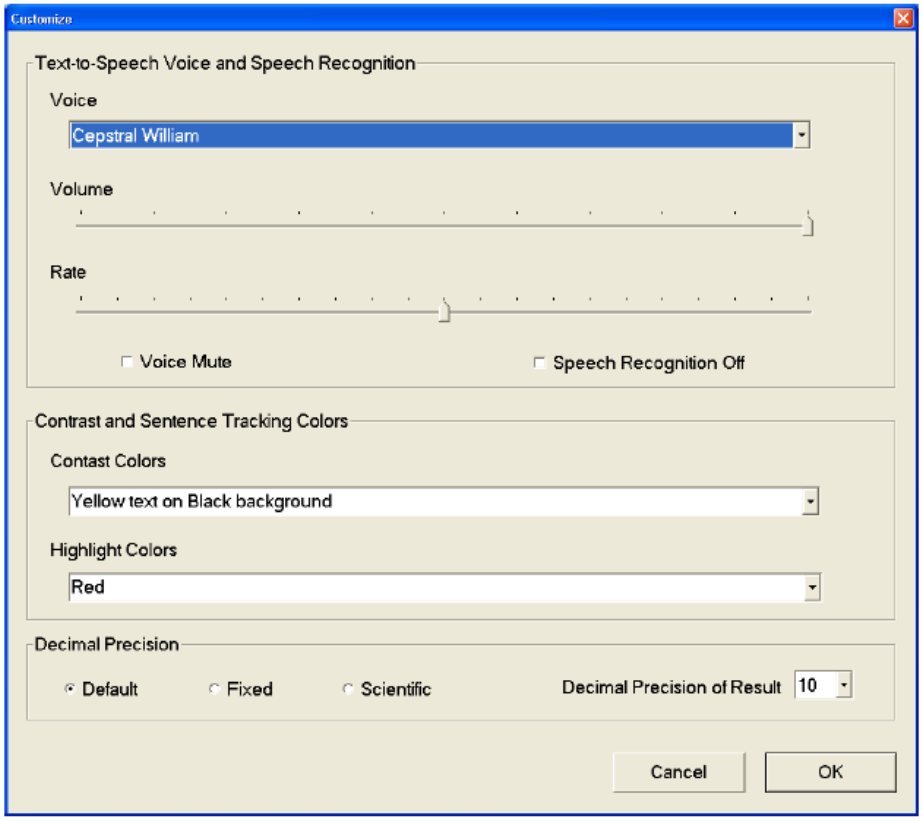
Clear Mem
x^y
pi
Tan
ln
D->F
Open

Button	Function	Voice Command	Menu	Keyboard Shortcut
9	Enters digit nine in the Input Scroll Box	Nine	Calculator	9
.	Enters a decimal point in the Input Scroll Box	Decimal / Point	Calculator	.
=	Evaluates an expression	Equal / Equals	Calculator	= / Enter
/	Division operator	Over / Divided by	Calculator	/
X	Multiplication operator	Times / Multiplied by	Calculator	*
-	Negative sign / Subtraction operator	Negative / Minus	Calculator	-
+	Positive sign / Addition operator	Plus	Calculator	+

In addition to allowing different means of inputting calculations, the VISO calculator has other accessibility features built-in, as it has its own accessibility menu. For example, users can elect to change the color of the screen or the text and even the color with which text is highlighted when read (i.e., speech output). Further, users can change the voices of the speech output as well as their rate of speech. However, it should be noted that because the VISO calculator utilizes the

free speech recognition voices standard on a Windows-platform machine, the options are limited to those free ones (see figure below).



The Project

While the project was functioning with the collaborators each working on their respective parts, the NCTI conference in November 2008 allowed them to showcase their tool and discuss it in a context with other individuals. This proved to be an exciting time for the project as the VISO calculator was well-received by attendees at the conference and many ideas were shared with Waseem, Emily, and Dave. These included options to expand the VISO calculators and considerations about making this accessible to other target disability populations.

The excitement generated from NCTI conference led to other grant collaborations among Emily at Purdue University and Dave and Waseem at gh, by themselves and also in conjunction with other organizations. In addition to considering grants aimed at continuing to improve the VISO calculator tool developed from the NCTI Technology in the Works award, the collaborators have also sought to develop other tools to aid students with disabilities – particularly students with visual impairments – in accessing and achieving in mathematics content.

To date, the project has completed one single subject research study using secondary students with visual impairments as the targeted population and examining the VISO calculator as compared to students' standard calculator at completing mathematical assessments when

considering the length of time to complete the assessments and the number of errors students committed in entering the calculations (Bouck, Flanagan, Kulkarni, Sheikh, & Schleppenbach, submitted). Specifically, three secondary students who resided at a state school for the blind and low vision participated in the project. The students were all ending their time at the state school and had completed or were finishing all the required mathematics courses for graduation. Two of students could not use a standard calculator; one could if held close to his face. All three students were not proficient in Braille.

The results of this study, particularly the interview comments ascertained by the students who participated in the study, were very positive in terms of the VISO calculator being an option as a calculator for students with disabilities and further fueled the collaborators interest in continuing to explore funding to expand the VISO calculator to include graphing capabilities. Specifically, all three students had a general **decrease in the time to complete assessments** with the VISO calculator from the beginning to the last assessment, although they were still faster with their traditional means of calculation. The students also **decreased the number of errors made** with the VISO calculator, but they still made more than with their traditional means of calculation. The collaborators have been accepted to present findings related to the project at two national conferences in the coming year and are submitting the results of the project to a peer-reviewed national journal.

Next Step

The collaborators have plans to replicate the study focusing on college students with visual impairment. Further the collaborators have discussed expanding the VISO calculator to include graphing capabilities and/or switch accessibility and have discussed potential grant opportunities to make the enhancements.

Final Thoughts

The collaborators agreed that although working together between the two organizations – an institution of higher education and a company – was sometimes speaking two different languages, the benefits were clearly notable. Companies have an interest in developing new products and particularly ones that have a research-based component when considering issues of education. Further, researchers do not always have the resources to develop products, but the interest and motivated to research their effectiveness. Both parties felt confident in the other's commitment to improving the education and lives of individuals with disabilities, particularly students with visual impairments and the content area of mathematics, and it was this common bond and passion that largely made the collaboration work.