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Sharing Braille Math in the Classroom:
Two-way Braille-to-Print Math Communication
Friday, 1:30 - 3:00 PM

Presented by
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Developed for
Texas School for the Blind & Visually Impaired
Outreach Programs
Sharing Braille Math in the Classroom:

Two-way Braille-to-Print Math Communication

Sam Dooley

Pearson Assessment

Braille math is hard!
- Blind students need high-quality braille math
- Advanced preparation is costly and takes time
- Math teachers are often unfamiliar with braille
- TVIs are often unfamiliar with math notation

Braille math software is harder!
- Software translation can be problematic
- Forward translation takes many steps
- Real-time back translation is non-existent
- No support for online or classroom use

Braille math needs to be online!

Blind students need:
- A level playing field for STEM instruction
- To read and write online braille math
- To interact with sighted instructors and peers
- To participate in online activities

Braille math should be math!
- Math concepts are independent of notation
- Braille math codes capture all math notation
- Math software can be independent of notation

*Blind students only have full access to math if their math is treated the same as printed math.*

Classroom challenges for blind math students
- They cannot read math the teacher can write
- They cannot write math the teacher can read
- Speech solutions incur high cognitive load
- They need to read and write for themselves
Braille math translation

Visual math software is not truly accessible
- MS Word, MathType, Scientific Notebook

Braille math translation software
- is not instantaneous
- is not totally accurate
LaTeX, Duxbury, HIMS, HumanWare

Accessible Equation Editor
- Sighted user can create math for a blind user
- Blind user can create math for a sighted user
- Real-time, two-way braille math translation
- Instantaneous interactions with math content
- Discoverable braille math encoding rules

Technical Objectives
- Online equation editor software component
- Real-time translation from math into braille
- Real-time translation from braille into math
- Accessible to both sighted and blind users

Nemeth Braille (1952)
- Abraham Nemeth (AFB, APH, BANA)
- Tactile encoding for print math
- Math for technical publications
- Presentational math structures
- Consistent with content markup

TeX/LaTeX (1978/1985)
- Donald Knuth, Leslie Lamport
- Typesetting language for print math
- Math for technical publications
- Presentational math structures
- Fully programmable macro language

W3C MathML (1998)
- World Wide Web Consortium (W3C)
- XML element/attribute vocabulary
- Typical K-12 and higher ed. Math
- Presentation and content markup
Presentation v. Content
- Presentation encodes signs/symbols
- Content encodes functional structure
- \( x^2+1 \) v. \( 1346, 45, 23, 5, 346, 2 \)
- \( x^2+1 \) v. (plus (power x 2) 1)

QWERTY Keyboard Input
- Math symbols on the keyboard
- Other symbols on the buttons
- Keyboard cursor navigation
- Implicit and explicit selection
- Backspace, delete, clear

Braille Terminal Output
- Math output on the screen
- Braille output on the screen
- Braille output on the terminal
- Screen reader support

Braille Terminal Input
- Each braille cell is like a key
- Sequences of keys create the math
- Tooltips with text and braille
- Cursor position and routing

QWERTY Terminal Output
- Braille input creates math content
- Math content becomes math output
- Math output becomes braille output
- The math markup is exactly the same

Braille math is math!
- Blind students can read the same math
- Blind students can write the same math
- The math can be shared the same way
- The math can be scored the same way

*Blind* students can now have full access to math since their math is the same as printed math

Session Objectives
- Use of the equation editor
  - for real-time Braille math translation
- Use of the equation editor
  - to prepare math classroom materials
- How to assist Braille users
  - to prepare math for sighted evaluation
Basic Use
- Keyboard, palettes, mouse
- Creating math expressions
- Modifying math expressions
- Content MathML files

Braille Input Behavior
- Braille indicators
- Spacing rules
- Input sequences
- Structural input
- Contextual input

Braille Input Examples
- Numeric indicator
- Baseline indicator
- Type form indicators
- Shape indicators
- Negated operators
- Composed relations

Braille Input Testing
- Web browser input test page
- JavaScript equation editor
- Screen reader device drivers
- Web accessibility APIs
- Braille terminal input

Research Studies
- Two research studies in Fall 2015
  - (KY/AZ - Sep, TX - Oct)
- Goal - to collect feedback from multiple populations on EE functionality
- Populations - blind, low vision, regular print readers, learning disabled
- Criteria - high school students who had completed Algebra I

Research Outcomes
- Students had limited knowledge of Nemeth
- Erasing math content was unpredictable
- Working with grouping symbols was difficult
- Entering and closing fractions was unexpected
- Ending trigonometric expressions was unusual
Real-time Translation
- A sighted user can produce braille math
- A blind user can produce printed math
- Sighted and blind users interact in real time
- Math can be saved and exchanged with others

Classroom use
- Advanced preparation
- Extemporaneous content
- Shared presentations
- Online assessments
- Nemeth Braille curriculum

Advanced preparation
- Create math content in advance
- Share with students by email
- Include math content with slides
- Students use the equation editor

Extemporaneous content
- Teacher uses the equation editor
- Projects the screen to the class
- Blind student uses braille terminal
- Everyone can read the same content

Shared presentations
- WebEx, Google Hangouts, etc.
- Shared screens for visual users
- Individual work shown to the class
- Blind students can show their work
- Blind students viewing others work

Online assessments
- Common Core, PARCC, TestNav
- Spring 2015 admin (15m responses)
- Machine scoring for constructed math
- Blind students can use online forms
- Blind students create online responses

Nemeth Braille curriculum
- Interactive Nemeth braille exercises
- Immediate practice for lessons learned
- Experimentation with braille concepts
- Discoverability for unfamiliar encodings
Back translation
- Homework assignments
- TVI support
- Math teachers
- Group interactions

Homework assignments
- Blind student uses the equation editor
- Email homework files to sighted teacher
- Teacher reads using the equation editor
- Teacher marks up the math content
- Returns marks to the blind student

TVI support
- The role of the TVI remains essential
- The technical work load can be reduced
- The software can help assist the process
- Discoverability for print math notations

Math teachers
- The role of the math teacher is vital
- The technical work load can be reduced
- Engaging directly with blind students
- Discoverability for braille math encodings

Group interactions
- Effective group work with blind students
- Each student has an opportunity to contribute
- Each can learn from the work of others
- The software can help assist the process

Online Accessible Math!

Blind students can have:
- A level playing field for STEM instruction
- Tools to read and write online braille math
- Interaction with sighted instructors and peers
- Active participation in online activities

Technical objectives
- Real-time translation from math into braille
- Real-time translation from braille into math
- Accessible to both sighted and blind users
- Online equation editor software component
Braille math translation

- A sighted user can produce braille math
- A blind user can produce printed math
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Braille in the classroom

- Advanced preparation
- Extemporaneous content
- Shared presentations
- Online assessments
- Nemeth Braille curriculum

Braille back translation

- Homework assignments
- TVI support
- Math teachers
- Group interactions

Braille math is math!

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Please let us know how you would use it
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Notes:
Texas School for the Blind & Visually Impaired
Outreach Programs

Figure 1 TSBVI logo.

This project is supported by the U.S. Department of Education, Special Education Program (OSEP). Opinions expressed here are the authors and do not necessarily represent the position of the Department of Education.

Figure 2 IDEAs that Work logo and OSEP disclaimer.

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