Nemeth in a Box: Unpacking Tools to Build Success in Math for Students with Visual Impairments

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Abstract: *Students with visual impairments can be successful in math learning if they are provided with accessible materials, appropriate accommodations, and knowledgeable teachers. Four teachers of students with visual impairment designed a set of activities to build middle school students' knowledge of the braille code while engaging in math activities. The activities are described, and the authors provide strategies for successfully including students in general education math classes.*

Keywords: *inclusion, braille, middle grades, visual impairment*

Introduction

"I've never had a visually impaired student who reads braille in my class. How will they learn mathematics and how I can support them in being successful?" This is a question teachers of students with visual impairments (TSVIs) often hear as they support K-12 students with visual impairments in their mathematics learning. TSVIs don't just support the student; they also work closely with mathematics teachers to ensure students with visual impairments have access to the curriculum and the foundational skills necessary to engage in learning (Holbrook & Rosenblum, 2017). Mathematics can be a challenging subject for students with visual impairments because of its visual nature (Jones et al., 2012; Smith 2017; Wild & Koehler, 2017; Wonjin et al., 2016). When mathematics teachers and TSVIs work collaboratively, it's not uncommon at the end of the school year to hear, "I don't know why I was so nervous about having a braille reader in my class. I've loved watching them learn and grow this school year!"

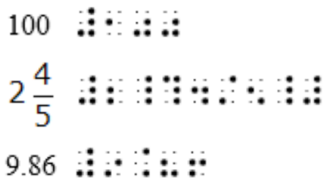
TSVIs are responsible for teaching braille readers the Nemeth Code within Unified English Braille Contexts (hereafter called Nemeth Code) which is a special type of braille used in science and mathematics that allows braille readers to read and write mathematics in the classroom. See Figure 1 for more information about the Nemeth Code. TSVIs work with braille readers to become knowledgeable of the braille symbols used during mathematics class so that the student can focus on the content to be learned from the mathematics teacher. As a way to support middle school braille readers in building their knowledge of the Nemeth Code symbols while also engaging them in mathematics learning, *Nemeth in a Box* was created.

Learning More about Nemeth Code

Students who are blind read braille, a raised dot system used for representing letters, words, and punctuation in addition to symbols used in mathematics and science. Braille is comprised of cells, each containing six dots in two vertical rows of three dots each. Dots are combined to represent numbers and symbols learned in the early grades (e.g., plus sign, equals) through advanced mathematical symbols (e.g., radicals, exponents, Greek letters, derivatives). Learning braille takes time, specialized instruction, and motivation on the part of the learner. This learning goes beyond the skills needed by all children to learn academic subjects including science, technology, engineering, and mathematics (STEM) subjects.

The braille code for mathematics is called the Nemeth Code. In the 1940s and 1950s, Abraham Nemeth was blind from birth and loved mathematics. He invented a code that enabled him to pursue higher education in mathematics, ultimately joining the mathematics faculty at the University of Detroit. In the 1960s, the United States, Canada and New Zealand adopted his braille code for mathematics and science, and it became known as the Nemeth Code. Today, PK-12 students and adults use the Nemeth Code to access and produce STEM materials. Examples are provided in Figure 1.

Figure 1: *Examples of Print and Braille Mathematics Expressions.*



Mathematics and other content area teachers are not expected to learn braille in order to effectively work with a braille reader. This article concludes with information about ways in which content area teachers can support students with visual impairments in their classes.

Project INSPIRE

Project INSPIRE: Increasing the STEM Potential of Individuals Who Read Braille is a 5-year funded project from the U.S. Department of Education. One of the goals of *Project INSPIRE* is to increase the Nemeth Code skills of transition age youth who are braille readers so they can participate more successfully in mathematics learning. The *Project INSPIRE* team designed *Nemeth in a Box* specifically for middle school braille readers. The students received a box of instructional materials prior to the first online session. All materials were provided in both braille and print so that sighted family members could access the content and support their child's participation in the program.

Nemeth in a Box combines instruction in Nemeth Code symbols with opportunities for the students to develop and refine mathematics problem solving skills. Topics for the sessions include:

Week 1: Fractions, mixed numbers, less than or equal to, greater than or equal to and not equal to;
Week 2: Decimals, percent, dollar sign, cent sign, and approximately equal to;
Week 3: Parentheses, negative sign, order of operations, and absolute value;
Week 4: Mathematical and science data tables, ordered pairs, and the mathematical comma (In Nemeth Code the mathematical comma is different than the comma used in literary materials);
Week 5: Exponents and degrees, including the superscript indicator, baseline indicator, and hollow dot (Specialized symbols are used in Nemeth to show precise location of numbers in expressions and equations);
Week 6: Principal square roots, including the opening square root and termination indicator.

Content for the sessions was derived from the Common Core State Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

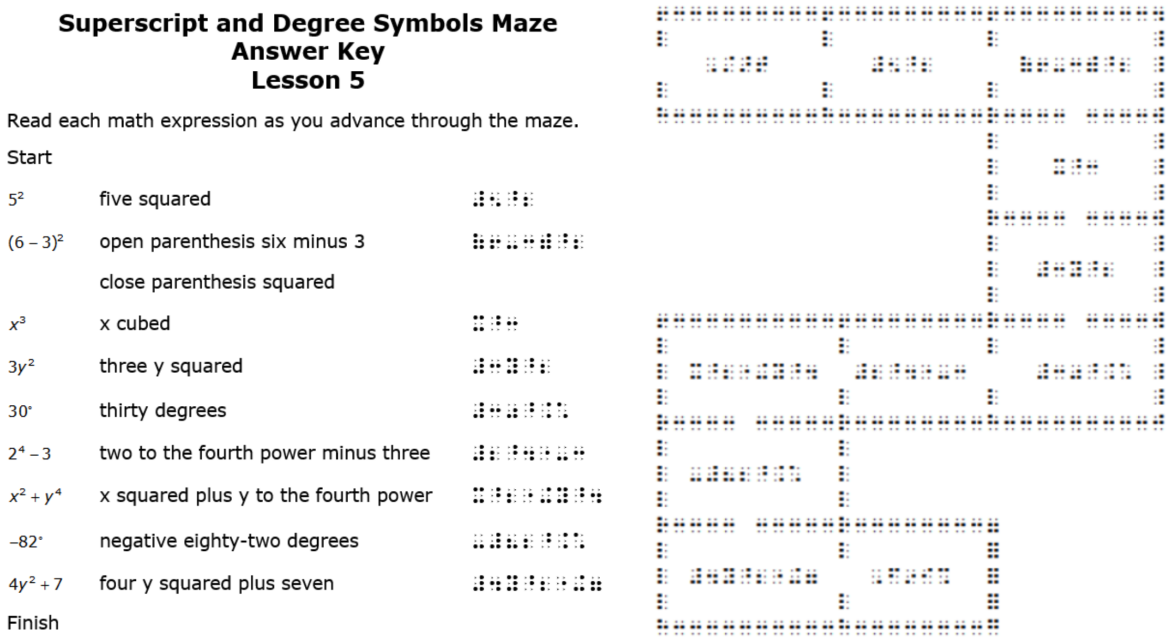
Structure of the *Nemeth in a Box* Sessions

Each session lasted 1.5 hours. Four TSVIs, all of whom are certified mathematics content teachers, shared the responsibility for facilitating the sessions. Since the sessions were held using ZOOM, a few minutes of the first session was used to familiarize and review accessible ZOOM functions so the students with visual impairments could actively participate in the session. Next, students got to know one another by participating in social icebreaker activities. Often students with visual impairments are the only ones in their school who read braille, so another benefit of participating in *Nemeth in a Box* was the opportunity to meet other middle school students who read braille. The facilitators then guided the students through the activities.

Overview of the Activities

A maze was used to introduce the Nemeth symbols that would be taught during each session. Braille readers may not be familiar with how to move through a maze so students were initially provided instruction about how to tactually navigate the braille maze (See Figure 2). The second game each session was a Nemeth adaptation of Craig Danielson's "Which One Doesn't Belong?" (https://wodb.ca/). In this game, students were given four expressions using targeted Nemeth Code symbols that had been written in different tactual boxes. Students were asked to share reasoning as to which one doesn't belong and why. There were no wrong answers as long as the reasoning was mathematically true.

Figure 2: *Example Maze in Braille and Print Equivalent.*



Superscript and Degree Symbols Maze
Answer Key
Lesson 5

Read each math expression as you advance through the maze.

Start

5^2	five squared	
$(6-3)^2$	open parenthesis six minus 3	
	close parenthesis squared	
x^3	x cubed	
$3y^2$	three y squared	
30°	thirty degrees	
2^4-3	two to the fourth power minus three	
x^2+y^4	x squared plus y to the fourth power	
-82°	negative eighty-two degrees	
$4y^2+7$	four y squared plus seven	

Finish

The third puzzle each session was titled "What is Wrong?" In this puzzle, expressions were again placed in four separate boxes, but there were mistakes in three of the expressions. This game focused not on mathematical mistakes, but rather on mistakes in writing expressions using Nemeth Code because students with visual impairments are sometimes penalized not for mathematical errors, but rather for errors in their Nemeth Code writing. Afterwards, the students completed an activity called "What is the Question?" This activity required students to creatively develop a mathematical problem

that would result in the answer provided. Students were encouraged to create problems using their braillewriter that incorporated as many different mathematical symbols as possible. For example, if the answer was -7, a problem could be as simple as $-2 + -5 =?$ or as complex as $2 + |-3| - 12 =?$ Then, the teachers selected students to share their problem and provide information about how they wrote the problem in Nemeth Code. In order to maintain a high level of cognitive demand (Smith & Stein, 2011), the teachers connected each response to key mathematical concepts and connected the different students' responses.

During two of the sessions, students also played Boggle™. This game required students to review the Nemeth Code symbols on a tactile game board and create mathematical expressions that were accurate, based upon the tactual boxes touching one another. The students could go up, down, left, right, or diagonal each time. Students had 10 minutes to develop as many mathematical expressions or equations as possible. Each student then read their problems. If a problem was unique and mathematically correct, they received a point. If another student had the same written expression or equation, they did not receive a point for that response. The student with the most points won.

During all games, students were encouraged to cheer one another on, give helpful hints for solving mathematics problems, and work collaboratively. Opportunity for teamwork led to increased student learning as well as practicing social skills with other students who were visually impaired. The *Project INSPIRE* team has made the *Nemeth in a Box* materials available for use by mathematics teachers, TSVIs, and family members. The materials are on the Paths to Literacy website at https://www.pathstoliteracy.org/nemeth-box-middle-school-students/.

Student Feedback

Some comments from the students about their favorite aspects of the program included:

- I think what I enjoyed most though, is the puzzle, "Which One Doesn't Belong?". I enjoyed this because I got to give out my own opinion on which one I thought was different, and I also got to listen to other's opinions and choices.
- I enjoy the fact that I learned a lot more [Nemeth] symbols while still having fun.
- I really enjoyed working as a team and figuring out the problems. And the games!

Considerations When You Have a Visually Impaired Student in Your Mathematics Class

Not all students with visual impairments use braille. Many have some usable vision though the amount of vision they have and how they use their vision in the classroom, school, and community varies. Mathematics teachers should communicate with the student, the TSVI, and other educational team members for specific suggestions on how to include students with visual impairments in all aspects of their class. Figure 2 provides tips for including students with visual impairments in mathematics and other content classes. Additional resources for learning Nemeth Code and teaching mathematics to students with visual impairments can be found below.

- What is Nemeth Code? https://www.washington.edu/doit/what-nemeth-code
- Overview of Nemeth Code Symbols with Tutorial: https://www.pathstoliteracy.org/resource/nemeth-tutorial-aph/
- Video about Nemeth Braille Code for Math and Science by Susan Osterhaus: https://www.youtube.com/watch?v=MWeMqwfbmG4&list=PL1CE33A64B05C4461
- Resources about Dr. Abraham Nemeth: https://sites.aph.org/hall/inductees/nemeth/
- Videos for making mathematics more accessible https://www.youtube.com/channel/UCeiPDWyquI4ogaCG7h5BSYQ?app=desktop

- Collaborate with the TSVI, paraprofessional, and other educational team members to establish how instructional materials for students with visual impairments will be prepared. Additional time may be needed when materials are prepared in braille.
- The TSVI may be able to provide additional adapted learning materials such as a talking scale, a textured graphing board, or a braille-print ruler. Use of adaptive materials will allow the student to more fully participate in instruction.
- Meet with the TSVI to preview upcoming content. The TSVI will be able to identify content that may be challenging for the student because of its visual nature. Collaborate with the TSVI so that they can pre-teach concepts and introduce new adaptive tools to ensure the student is ready for learning.
- Verbalize information that is on the white board, screen, and other locations so that the student with visual impairment can follow along with the lesson.
- Teachers often modify lessons at the last minute. Don't be afraid to make changes with your curriculum. Since there may not be time for the TSVI or other staff members to prepare material for the student with a visual impairment, be creative in thinking about different ways for the student to access the material. Oftentimes strategies for students with disabilities work with all students and enhance engagement!
- Periodically check in with the student to get their input.

Conclusion

Project INSPIRE personnel created *Nemeth in a Box* to support students with visual impairments in learning Nemeth Code. A variety of activities was used to introduce Nemeth Code symbols while engaging students in mathematics activities to build their creative thinking, mathematical knowledge, and knowledge of the Nemeth Code symbols. Mathematics teachers can use the *Nemeth in a Box* materials with all their students. Though a mathematics teacher may initially be uncertain when they learn they have a student with a visual impairment in their class, the TSVI and other educational team members can provide support so that the student has a successful school year.

References

Holbrook, M. C. and Rosenblum, L. P. (2017). Supporting differentiated instruction and inclusion in general education. In M. C. Holbrook, C. Kamei-Hannan, & T. McCarthy (Eds.), *Foundations of education: Instructional strategies for teaching children and youths with visual impairments* (3rd ed., Vol. 2, pp. 231–260). AFB Press.

Jones, G., Forrester, J., Robertson L., Gardner, G., & Taylor, A. (2012). Accuracy of estimations of measurements by students with visual impairments. *Journal of Visual Impairment & Blindness, 106*(6), 351–355. https://doi.org/10.1177/0145482X1210600604

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics*. http://www.corestandards.org/.

Smith, D. (2017). Mathematics. In M. C. Holbrook, C. Kamei-Hannan, & T. McCarthy (Eds.), *Foundations of education: Instructional strategies for teaching children and youths with visual impairments* (3rd ed., Vol. 2, pp. 479–509). AFB Press.

Smith, M. S. & Stein, M. K. (2011). *5 practices for orchestrating productive mathematics discussions*. National Council of Teachers of Mathematics.

Wild, T. & Koehler, K. Science. In M. C. Holbrook, C. Kamei-Hannan, & T. McCarthy (Eds.), *Foundations of education: Instructional strategies for teaching children and youths with visual impairments* (3rd ed., Vol. 2, pp. 449–478). AFB Press.

Wonjin, J., Hee I., Jang, R. A., Harianto, J., Hyun S., Hyebin L., Heon J. L., and Myoung-Woon M. (2016). Introduction of 3D printing technology in the classroom for visually impaired students. *Journal of Visual Impairment & Blindness, 110*(2), 115–121. https://doi.org/10.1177/0145482X1611000205

Dr. Tina Herzberg is a Professor at USC Upstate where she has coordinated the Visual Impairment Education Program since 2007. She has broad expertise in developing distance education materials and teaching braille in higher education. Dr. Herzberg is a certified teacher of students with visual impairments as well as a secondary mathematics and English teacher. She is a member of the Braille Formats Technical Committee for the Braille Authority of North America.

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Dr. Rosenblum is the owner of the consulting company Vision for Independence, LLC. Her current research focuses on a range of topics and professional development including STEM braille codes, teaching students to locate and interpret information in tactile graphics, preparing nondrivers with visual impairments to be independent travelers, the impact of the COVID-19 pandemic on individuals with visual impairments, and diversity, equity, inclusion, and accessibility. Dr. Rosenblum has more than 35 years of experience as a researcher, university professor, and teacher of students with visual impairments.