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Instruction in Specialized Braille Codes, Abacus, and Tactile Graphics at Universities in the United States and Canada

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Abstract: *Introduction:* This study gathered data on methods and materials that are used to teach the Nemeth braille code, computer braille, foreign-language braille, and music braille in 26 university programs in the United States and Canada that prepare teachers of students with visual impairments. Information about instruction in the abacus and the preparation of tactile graphics was also gathered. *Methods:* A faculty representative from each university completed a 39-question online demographic survey during fall 2011. Frequency counts for each item were tabulated, and comments were reviewed and categorized. *Results:* All 26 university programs provided instruction in the Nemeth braille code. Most also provided introductory information on foreign-language braille, computer braille, and music braille. There was a high rate of consistency across the programs in what constituted a braille error. The university programs required students to prepare tactile graphics and learn computation on the abacus. The delivery of courses through a hybrid model was most common. *Discussion:* University programs are providing instruction in the Nemeth braille code, though there is variability in the topics that are covered, the books that are used, and the assignments that are required. Most university programs are also exposing their preservice students to specialized braille codes and are teaching them to produce tactile graphics and to perform computations on the abacus. Future studies are needed to look at the quality of instruction and, if the amount of instruction in the different topics is sufficient, to prepare future teachers of students with visual impairments adequately. *Implications for practitioners:* Data gathered from this study will assist university programs to evaluate the content of their courses on the topics that were studied. Adjustment in the content of courses may result, which may subsequently affect the skill set of practitioners as they complete university preparation.

The impact of visual impairment is widely recognized to be particularly significant for learning mathematics (Cavenaugh, 2006; National Science Foundation, 2009). Vision provides access to information that supports the development of a conceptual understanding in mathematics. Dick and Kubiak (1997) described the impact of vision loss on learning mathematics this way:

> Describing and categorizing direction, quantity, shape, and logical attributes are at the heart of mathematics. Much of the language of mathematics relies heavily on visual reference. Descriptions of mathematical concepts that appeal to visualization may enjoy immediacy for the sighted student, but they require significantly more cognitive processing for the visually impaired. . . . More than for any other sense, the impairment of sight poses the most difficult challenges to learning mathematics (p. 344).

Although students with visual impairments can experience success in mathematics education, they often face larger challenges than their peers without disabilities (Beal & Shaw, 2008; Blackorby, Chorost, Garza, & Guzman, 2003; Fisher & Hartmann, 2005). One issue of note is that students who are blind must learn to use the Nemeth Code for Braille Mathematics and Science Notation to gain access to and produce mathematical work. Therefore, not only do students with visual impairments need mathematics textbooks that are produced in a unique braille code, they need specific compensatory instruction by teachers of students with visual impairments to learn to read and write the Nemeth code. However, teachers of students with visual impairments have reported that they often do not have the skills and knowledge to prepare materials in (DeMario & Lian, 2000) or to teach the Nemeth code (Kapperman & Sticken, 2003). In 2002, Amato surveyed university programs that prepare teachers of students with visual impairments and found that one-fourth of the university braille instructors believed that their graduates were not competent in the Nemeth code because of a limited amount of instructional time. Because of the amount of instructional time that is necessary to teach literary braille and the fact that many university faculty who teach braille do not focus on teaching the Nemeth code (Amato, 2002), one may surmise that instruction in other braille "codes" (such as foreign-language, computer, and music braille) may be even less.

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Through this study, we sought to gather information on how university programs prepare future teachers of students with visual impairments in the areas of the Nemeth braille, foreign-language braille, computer braille, and music braille codes; the abacus; and tactile graphics. The study was approved by the Institutional Review Board of the University of Alabama at Huntsville. It is the first part of a larger study that will examine the minimum level of competence in the Nemeth braille code that individuals who are completing programs in teaching students with visual impairments should demonstrate.

Methods

Instrument

A 39-item instrument was developed for the study. Many of the questions came from a work group of the Personnel Preparation Division of the Association for Education and Rehabilitation of the Blind and Visually Impaired (AER) that was charged with conducting a study to determine the minimum number of competencies in Nemeth braille code that beginning teachers should demonstrate after completing their preparation as teachers of students with visual impairments.

Questions were asked in six topical areas: Nemeth braille, foreign-language braille, music braille, computer braille, the abacus, and tactile graphics. For each topic, the participants were asked to provide information about the level of instruction that students at their universities received, the books that were used, the resources that were shared, and the assignments or testing procedures that were used. Additional questions were asked about such topics as the types of course-delivery models that were used and what constitutes a braille error.

Recruitment

In August 2011, the study was announced on the electronic discussion group for the Personnel Preparation Division (Division 17) of AER. Invitational e-mail messages were also sent to university contacts who were listed on the AER website. Reminder e-mail messages were sent over a six-week period between August and September 2011. Individuals were directed to a website where they read a letter of invitation from the researchers, completed a consent form, and answered survey questions.

Results

Twenty-two individuals representing 26 universities completed the online survey. Twenty-five of the universities were located in the United States, and one was located in Canada.

Delivery of courses

The participants were asked to report how their universities delivered instruction: face to face, online, through video conferencing, or by a hybrid method (a combination of two or more methods); see Table 1 for their responses. Those who provided comments in this section explained the reasons why their courses were set up in a certain way and the positive aspects and challenges of the delivery methods. The participants were asked to indicate if course content was the primary focus of a course, embedded into a course, provided through a correspondence course, or not applicable to their

Table 1
Course-delivery methods, ways in which instruction is delivered, and the tools that are used.

Methods	Literary braille	Nemeth braille	Foreign-language braille	Computer braille	Music braille	Abacus	Tactile graphics
Course-delivery methods							
N	26	26	23	22	20	25	26
Face to face	7	7	8	8	6	7	7
Online	7	9	8	6	7	9	5
Video conferencing	1	1	1	1	1	1	1
Hybrid	11	9	6	7	6	8	13
Way in which instruction is delivered							
N	26	26	26	26	26	26	26
Primary focus	25	24	3	3	2	10	4
Embedded	1	1	18	18	16	13	21
Correspondence	0	1	0	0	1	3	0
Not applicable	0	0	5	5	7	0	1
Tools used to produce braille							
Perkins Brailler	26	26	14	10	9		
Slate and stylus	26	1	0	0	0		
Braille emulation software	22	18	8	11	9		
Braille-translation software	16	4	1	4	0		
Electronic tools	14	4	1	4	0		
Not required							

programs (see Table 1). Their comments indicated that it was difficult to find time to address all the topics. A typical response was "Of the embedded topics, tactile graphics and abacus receive more of a focus than music, computer, and foreign-language braille codes." Table 1 also includes data on the tools that the students in the programs used to produce braille, including the Perkins Brailler, slate and stylus, braille emulation software (such as Perky Duck), braille-translation software (like Duxbury Braille Translation for Windows, Braille 2000), and electronic tools (including a notetaker and the Mountbatten Brailler).

The participants were given a list of nine types of errors and asked which ones their universities considered to be errors on braille assignments using any code. They reported the following errors (the number of universities that reported an item as an error is in parentheses): omissions (26); misbrailling a symbol (26); the incorrect use of a symbol (26); an incorrect format (26); spelling errors (26); the incorrect use of contractions (26); poor erasures (24); the addition of words, numbers, notes, and so forth (25); and brailling the wrong example (24). Five programs reported other errors, all of which focused on formatting (such as spacing incorrectly and not centering a heading). Four programs reported that if a student makes the exact same error throughout an assignment, the error is counted only one time.

Nemeth braille code

The participants were given a list of eight books and asked which ones were

Table 2
Nemeth code books used by the university programs.

Book	Required	Recommended	Shown in class or discussed online	Not used	Not sure
Nemeth braille					
An Introduction to Braille Mathematics (Roberts, Krebs, & Taffet, 1978)	14	3	3	5	2
The Nemeth Braille Code for Mathematics and Science Notation (Laudenslager, 1972)	9	12	3	1	1
Mathematics Made Easy for Children with Visual Impairment (Mani, Plernchaivanich, Ramesh, & Campbell, 2005)	2	2	1	20	3
Braille Codes and Calculations (Pesavento, 1993)	5	2	6	11	3
Learning the Nemeth Braille Code (Craig, 1987)	13	4	3	6	0
Strategies for Developing Mathematics Skills in Students Who Use Braille (Kapperman, Heinze, & Sticken, 1997)	7	4	8	6	1
Chapter on Nemeth code in *New Programmed Instruction in Braille* (3rd ed.) (Ashcroft, Sanford, & Koenig, 2001)	11	3	1	10	2
Braille Code of Chemical Notation (Braille Authority of North America, 1997a)	1	0	8	16	1
Foreign-language braille					
Interim Manual for Foreign Language Braille Transcribing (BANA, 2002)	1	4	5	14	1
Computer braille					
The Computer Braille Code Made Easy (Dixon & Gray, 1993)	1	1	8	12	1
Computer Braille Code (BANA, 2000)	6	6	6	7	1
Music braille					
Who's Afraid of Braille Music? (Taesch & McCann, 2002)	1	1	5	16	3
How to Read Braille Music (Krolick, 1998)	0	2	10	11	3
Music Braille Code (BANA, 1997b)	3	7	8	9	2
Abacus					
Use of the Cranmer Abacus (Livingston, 1997)	10	2	8	4	3
The Abacus Made Easy (Davidow, 1988)	5	3	10	7	3
Abacus Basic Competency: A Counting Method (Millaway, 1994)	3	2	11	8	3
Tactile Graphics					
Tactile Graphics (Edman, 1992)	0	4	10	11	1

Table 3
Level of mastery of Nemeth code topics.

Skill	None	Basic	Mastery
Numerals	0	0	26
Numeral indicator	0	0	26
Punctuation indicator	0	0	26
English letter indicator	0	0	26
Fraction indicator	0	0	26
Fractions	0	0	26
Operations	0	0	26
Comparisons	0	0	26
Decimals	0	0	26
Problems in linear format	0	0	26
Problems in spatial format	0	1	25
Level indicator (for returning to baseline)	0	1	25
Groupings	0	1	25
Radical indicator	0	5	21
Multipurpose indicator	0	5	21
Radicals	1	5	10
Algebra variable	0	7	19
Algebra modifiers	0	8	18
Absolute value	2	7	17
Shapes	0	9	17
Arrows	0	11	15
Angles	0	11	15
Lines (line, line segment, ray)	1	13	12
Arcs	7	10	9
Functions	6	12	8
Logarithms	13	9	4
Advanced math	7	13	6
Matrices	14	10	2

required, recommended, discussed in class or online, or not used in their programs. Table 2 reports the responses.

The 26 participants were given a list of 28 Nemeth topics and asked to indicate the level of mastery that their students must demonstrate for each. Three levels of mastery were presented: none, which meant that the topic was not introduced; basic, which meant that the students were given introductory information on the topic; and mastery, which meant that the students were given assignments in which they had to read and braille on the topic (see Table 3 for the details). All the participants reported that the students in their programs must master 10 of the 28 topics. Levels of mastery for the other topics ranged from 2 to 25 universities. The participants at two universities shared comments that shed light on the challenges that are faced in determining in which topics to require future teachers of students with visual impairments to demonstrate mastery. One participant stated, "There is so much that I wish I had an entire course just for math, but then they would not get music and computer code and foreign language. We've got so much to teach and so little time!" Another participant commented, "Do they demonstrate mastery? not always; . . . are they EXPECTED to demonstrate mastery? YES!"

The participants were asked to list the resources they shared with students. In the order of the most frequently mentioned, the top five resources were the mathematics website of the Texas School for the Blind and Visually Impaired (TSBVI) (10), the website or reference sheet (or both) of the American Printing House for the Blind (APH) (9), the website or reference book (or both) of the National Braille Press (5), the website and various resources of the Braille Authority of North America (BANA) (5), and the website or videos (or both) of Project Math Access (4). Other resources included an online brailler developed by the Northeast Regional Center for Vision Education (NRCVE); the Hadley School for the Blind; and websites for specific products, such as Math Window and graphing calculators. Several universities listed specific books or indicated that they prepared their own materials.

The participants were asked about the assignments and tests that students must complete as they learn the Nemeth code. Twenty-three participants described regular homework assignments or weekly tests (or both), 18 indicated there was a final examination, and 5 also reported having midterm examinations. Other assignments mentioned included postings on discussion boards, adapting materials, and writing lesson plans.

The participants were asked the procedure if a student does not pass an assignment or test. Thirteen reported that students were allowed to resubmit some or all assignments, most often for a reduced grade. One program required students to prepare a written document explaining the corrections needed in the Nemeth document. Seven programs indicated that students were not allowed to resubmit assignments. In most cases, grades on midterm and final examinations could not be remediated, although four programs described processes for the remediation of final examinations. Several programs indicated that if a student did not demonstrate mastery to a specified percentage (such as 80%), he or she was required to repeat the course. In one case, a university program infused braille modules into multiple courses. At this university, the students were not allowed to move to the next module until they reached a mastery level of 85%. They also were required to reach a mastery level of 85% on a final comprehensive examination that included a Nemeth component.

Foreign-language braille

The participants were asked if their programs used the *Interim Manual for Foreign Language Braille Transcribing* (BANA, 2002) (see Table 2 for the details). Four programs reported using the foreign-language chapter in *New Programmed Instruction in Braille* (Ashcroft, Sanford, & Koenig, 2001). Approximately half the programs reported that students were referred to the BANA website for information on foreign-language braille. When a university program did require students to complete a foreign-language assignment, it was typically short (one to two pages). University programs that did require a foreign-language braille assignment required only one assignment.

Computer braille

The participants were asked if two computer braille books were used in their program (see Table 2). Few programs required students to produce computer braille. Typically, this was a code that was introduced to students, and the resources for its production were shared. Two programs reported that during a technology course, students did gain additional familiarity with the computer braille code.

Music braille

The participants were asked about three texts that teach braille music (see Table 2). Several programs reported using materials from the websites of Dancing Dots and the Library of Congress. A few programs reported having students braille from a few measures up to one to two pages of braille music. One program reported that students completed multiple music braille assignments.

Abacus

The participants were given a list of three books that are commonly used for instruction in the abacus (see Table 2). Six programs had students using Hadley School for the Blind's abacus course, one used the paper-compatible method, and three had their own materials or videos that students used as part of their abacus instruction. Additional abacus resources included the website of TSBVI, finger math, resource handouts compiled by Stuart Wittenstein, videos from APH, and video lessons developed by Sandy Smith and housed on the website of NRCVE.

There was variability in how competence in the abacus was evaluated. Of the 26 programs, 5 required students successfully to complete a course from the Hadley School for the Blind. Thirteen programs had quizzes, midterm examinations, or final examinations in which students computed math problems using the abacus, and 3 programs required homework assignments with the abacus. Finally, 3 programs required students to complete a lesson plan for abacus instruction and then teach the lesson to a child who is an abacus user. Eight programs allowed students to retake tests or redo abacus assignments, while 10 programs did not.

Tactile graphics

The participants were asked if they used the book *Tactile Graphics* (Edman, 1992) (see Table 2). Five programs reported sharing the BANA guidelines, 10 reported sharing the APH guidelines or materials (such as the Draftsmans Tactile Drawing Board or the Tactile Graphics Kit), 4 reported sharing models of tactile graphics (both commercially produced and teacher made), one program reported using materials from the National Braille Association, and 4 used materials from Tactilegraphics.org. A few programs referenced hardware or software that is used in the production of tactile graphics, including a Tiger embosser and QuikTac from Duxbury Systems. Nineteen programs shared specific courses and activities that involved students preparing tactile graphics for math, science, social studies, or orientation and mobility. Three programs reported that their examinations included questions about tactile graphics.

When asked how their programs assessed a student's ability to produce tactile graphics, the participants gave responses that fell into three categories. Twenty-three participants described tactile graphic projects or assignments that students had to complete, two noted that written examinations included questions on the production of tactile graphics as part of written examinations, and three stated that their universities required students to create tactile graphics and then use them with children.

The participants were asked how they assessed their students' ability to teach children to use tactile graphics. As one participant noted, "good question." Five participants reported that during student teaching or in the "Methods" course, the ability to teach children to interpret a tactile graphic was assessed. Several reported that activities occurred in class to assess the ability to teach. Finally, nine participants reported that this was not something specifically assessed in their programs.

Discussion

This article has reported data gathered from 26 university programs about their experiences preparing teachers of students with visual impairments in the Nemeth braille, foreign-language braille, computer braille, and music braille codes; the abacus; and tactile graphics. The study had several limitations. Not all university programs in the United States and Canada completed the online survey. No data were gathered about the quality of the materials that the students in the 26 programs prepared. A comparison of the assignments and tests that are used in different programs is not possible; thus, data on the rigor of the programs are not obtainable. No data were gathered on the qualifications of the individuals who were teaching these topics at the 26 university programs. Finally, as with any survey, all information was self-reported and thus could be skewed in favor of the universities.

The most common method of delivering courses was a hybrid method that combined two or more methods (such as face-to-face and online instruction). This finding is consistent with past research on the delivery methods used by personnel preparation programs in teaching students with visual impairments (DeMario & Heinze, 2001; Silberman, Ambrose-Zaken, Corn, & Trief, 2004). Universities that prepare teachers of students with visual impairments and other special education professionals need to be flexible in how they deliver their courses, as evidenced by the data reported by the participants.

The Perkins Brailler is still the "workhorse" of teacher training programs when it comes to braille production. Almost all the programs used braille emulation software, such as Perky Duck, for their students to complete some or all assignments. With many programs using online or hybrid course delivery, the use of electronic tools, such as braille emulation software, provides an easy way for students to submit assignments to instructors. An essential way to prepare braille materials is braille-translation software such as Duxbury or Braille 2000. More than half the programs required their students to prepare some assignments using braille-translation software.

As was found in Rosenblum, Lewis, and D'Andrea's (2010) survey of university programs, as a general rule, the programs set high standards when it came to what constituted a braille error. Although a few programs counted the same error only once if it was repeated, most programs counted each error as an individual error. Recognizing that university students are in the beginning stages of learning the various codes, most programs had a policy that allowed students to resubmit their work, often for a reduced grade.

University programs put a greater emphasis on providing instruction in the literary and Nemeth braille codes for their students than they do in the other three braille codes (foreign language, computer, and music). The programs varied in the number of assignments their students were required to complete and the testing methods used for the various codes. They also differed in the books used in their courses and the resources shared with the students. For the Nemeth code, the two books that were most frequently required were *Learning the Nemeth Braille Code* (Craig, 1987), which was required by 12 programs, and *An Introduction to Braille Mathematics* (Roberts, Krebs, & Taffet, 1978), which was required by 9 programs. APH and TSBVI are two resources for braille that university programs often share with their students.

All the university programs expected their students to master the use of the Nemeth code to write numerals, operations, fractions, comparisons, and decimals. Mastery was expected in the use of the numeric indicator, English letter indicator, fraction indicator, and level indicator. All the programs also expected their students to master preparing problems in a linear format, and 25 expected them to master preparing problems in a spatial format and to demonstrate the mastery of writing problems involving grouping. Less than half the programs expected their students to master more advanced mathematical symbols, such as lines (line segments and rays, for example), arcs, functions, logarithms, advanced math, and matrices.

Instruction in the foreign-language, computer, and music braille codes occurred considerably less frequently at the 26 universities. Books on these codes were infrequently required by the programs; rather, they were most often discussed in class or online. Most frequently, the students were given introductory information and resources on these codes, and if an assignment was required, there typically was only one that was short in duration. As one participant said, "I wish I had more time to really deal with music, foreign language, and chemistry. . . . I barely get through what I have to get through in [the] Nemeth code and abacus during the semester, including methods and strategies and adapted equipment for math and science."

For instruction in the abacus, all the programs required their students to read a book on or complete the Hadley School for the Blind's abacus course. The most common book, used by 10 programs, was *Use of the Cranmer Abacus* (Livingston, 1997). No data were gathered on the types of operations or other skills (such as decimals and fractions) that the programs required their students to demonstrate mastery in. Almost all the programs indicated that their students had to pass tests or complete assignments to demonstrate their competence with the abacus.

Learning to prepare tactile graphics for use by individuals with visual impairments was another requirement of the university programs. As would be expected, students in the programs had to produce tactile graphics, which were evaluated. The most commonly used resource was information from BANA on producing tactile graphics. We surmise that most university programs shared the previous version of the BANA guidelines with their students, not the document *Guidelines and Standards for Tactile Graphics* (BANA, 2010). The updated guidelines are more detailed and should help university programs and their students better understand how to produce tactile graphics. Many participants reported that evaluating students' tactile graphics and students' ability to teach users who are visually impaired to interpret them effectively is a challenge. A typical comment was, "This is a hard topic because there is a lot of subjectivity when it comes to preparing TG [tactile graphics] and grading them."

Implications for future research

This study gathered a wealth of data from 26 university programs in the United States and Canada. Future research that examines in more depth the material being taught in courses and its relationship to what teachers of students with visual impairments use in their work with students with visual impairments would be valuable. Rosenblum, Amato, and Hong (in preparation) are conducting a study to examine teachers' attitudes toward the abacus and the abacus skills they are teaching children with visual impairments. Studies similar to this one to examine how children with visual impairments are learning the various braille codes and how to interpret tactile graphics would be valuable to the field. In addition, a study that examines the content taught at each grade level in mathematics, foreign languages, and music, and that would compare this content to what braille knowledge is necessary, would yield valuable data for the field. A comprehensive study of this nature would be difficult because each state has different requirements for students for foreign languages and music. The National Council of Teachers of Mathematics' *Principles and Standards* (2000) or the *Common Core State Standards for Mathematics* (2010) could be analyzed for what beginning teachers of students with visual impairments need to teach the Nemeth code.

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