



# MATHEMATICS EDUCATION AND NEMETH BRAILLE CODE

Mrs. Puja

Special Educator

Department of Visual Impairment

Faculty of Special Education

Dr. Shakuntala Misra National Rehabilitation University

Lucknow, Uttar Pradesh, India

## **Abstract:**

Education is an important aspect for everyone's development. It helps in all round development of an individual. It opens various opportunities in life. Similarly mathematics education is important for everyone as it is more closely to our daily life as compared to other subjects. Mathematics is so valuable, important, psychologically based and so closely connected with our day to day life, justified to be included in school curriculum.

A sighted person acquire around 80-85% of information through vision. In case of visual disabilities (divyangjan) it is not so, they face various kinds of difficulties in acquiring information from their environment. They use their remaining senses to get information from their surroundings. They use multi-sensory approach to learn their subjects. Their teachers should make them to learn converting visual ideas to non-visual information through multi-sensory approach.

Mathematics is a subject which has its own language, symbols, full of pictorial representations, abstract nature, and graphs/ diagrams etc.. The nature of mathematics itself is a barrier for students with visual disabilities. To make the student with visual disabilities to understand the concept, Nemeth Braille Code plays major role to access Mathematics. Adequate and effective use of Nemeth Braille Code can overcome the hurdles in mathematics education among students with visual disabilities. They can learn almost each and every mathematical concepts by using this Code. This paper gives an overview of Nemeth Braille Code in getting mathematics education among students with visual disabilities.

**Key words: Mathematics, Student with Visual disabilities, Nemeth Braille Code, Divyangjan**

*I believe that I could not have reached my potential in mathematics without the Nemeth Code. With it, I am able to read and write mathematics, as well as other sciences, at all levels, limited only by my talent and my ambition.*

-Dr. Abraham Nemeth, creator of the Braille code for mathematics and science notation

## **Introduction**

Education is imparted for achieving certain goals and mottos of life. Various subjects of the school or college are different means to achieve these goals. Among those subjects, mathematics plays vital role and it is more closely related to our daily life as compared to other subjects. Mathematics helps to develop the student as social and intellectual citizens.

Thorough review of the literature reveals that achievement in mathematics among student with visual disabilities (Drishti Divyang) is, and always has been extraordinarily low. This is mainly due to the nature of subject mathematics, as it is visual in nature, abstract nature, mostly pictorial representation, diagrams, graphs, its own symbols and languages.

To make the student with visual disabilities (SWVD) to understand the mathematical concept, Nemeth Braille Code plays major role to access Mathematics. Adequate and effective use of Nemeth Braille Code can overcome the hurdles in mathematics education among students with visual disabilities. They can learn almost each and every mathematical concepts by using this Code.

### Mathematics

Mathematics is the science of measurement, quantity, and magnitude. It is a systematic, organised and exact branch of science. It deals with quantitative facts and relationship. It is the gateway and key of all sciences. In view of these importance it is considered as father of science. Application of mathematics learning is very useful in everyday human activities, such as in the activities of buying and selling transactions, measuring, calculating the distance, and so forth (Herwanto, 2013). Mathematics is necessary for our daily lives, regardless of our educational background or social status (Mensah, 2017). The benefits of mathematics are not just limited to knowledge in computing, but more importantly, when every individual can master mathematics well, then their thinking patterns are more rational and critical.

Mathematics holds an important place in school curriculum as it has numerous importance and values. It is the subject which helps in development of all the mental abilities. We can say that all natural phenomena are based on mathematics. In this modern era of science and technology the knowledge of mathematics is very much essential and useful.

### Visual Disabilities (Divyang)

Visual disabled are those who have loss of vision, severity of impairment decide whether person has low vision or total absence of sight. There are various kind of definitions by different agencies throughout the world. In our country India, Rights of Persons with Disabilities Act 2016 has given latest definition of visual disabilities, which are follow:

- (a) "Blindness" means a condition where a person has any of the following conditions, after best correction—
  - (i) Total absence of sight; or
  - (ii) Visual acuity less than 3/60 or less than 10/200 (Snellen) in the better eye with best possible correction; or
  - (iii) Limitation of the field of vision subtending an angle of less than 10 degree.
- (b) "low-vision" means a condition where a person has any of the following conditions, namely:—
  - (i) Visual acuity not exceeding 6/18 or less than 20/60 up to 3/60 or up to 10/200 (Snellen) in the better eye with best possible corrections; or
  - (ii) Limitation of the field of vision subtending an angle of less than 40 degree up to 10 degree.

### Mathematics Education of SWVD

Mathematics education aims to study the factors that influence the learning of mathematics and to develop programs to improve the teaching of mathematics. "Mathematics education is aimed to study the factors affecting the teaching and learning of mathematics and to develop programs to improve the teaching of mathematics" (Godino & Batanero, 2007). Mathematics is an important subject to be learned by children because it is useful for everyday life activities such as in the sale, purchase, measurement, and other activities. In the era of science and technology, visually impaired children need to understand the basics of mathematics in order to play a role in society well (Sanchez & Flores, 2004).

Several academic studies have concluded that, in general, visual impairment has a negative impact on educational attainment" (Stewart, 2014; Tauda, Soedwiwhjono, & Putri, 2017).

It has been found through the literature that achievement in mathematics among SWVD is, and always has been, very poor. In this context Kapperman & Sticken, (2002, 2003) stated that achievement in mathematics among SWVD is, and always has been, extraordinarily low compared to sighted students. There are many reason behind this condition of these students viz. visual nature of the subject, lack of resources material, teacher's attitude, student's negative attitude towards the subject, lack of assistive devices and technologies of mathematics, lack of specialized teacher, mathematics phobia, inadequate mathematics instruction and many more. The acquisition of mathematical skills can be more difficult for SWVD due to the abstract nature of many essential concepts and the highly visual presentation of the subject (Kapperman, Heinze, & Sticken, 2000). But the utmost cause is the visual and abstract nature of the subject creates main hurdle in mathematics education of SWVD.

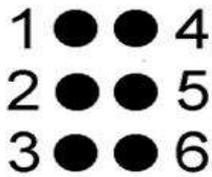
Vision allows access to information that helps build a conceptual understanding of basic mathematical concepts. Consequently, SWVD tend to face more challenges than their peers without disabilities, even when learning the most basic mathematical concepts (Beal & Shaw, 2008). These difficulties include gaining access to the problem information, representing problem information, problem solving and calculating the answer. The subjects that are difficult to learn by visually impaired children are mathematics (Diyansyah, 2017).

The study of mathematics is difficult for SWVD as it requires considerably more effort than the study of fields which are more verbal in nature. It is fact that, in order to achieve at reasonably high levels in mathematics, SWVD must possess greater aptitude for the subject than their sighted counterparts.

### Nemeth Braille Code

Braille is a tactile script used by visual disabled people around the world for reading and writing. It was developed by Sir Robert Louis Braille in the year 1829. The standard braille is comprises of a cell having 6 dots. Using these 6 dots, we have 63 unique characters. 3 Dots in the left column are numbered 1-2-3, and remaining 3 dots on the right column are numbered 4-5-6, as it is shown in the below figure.

### The Braille Cell

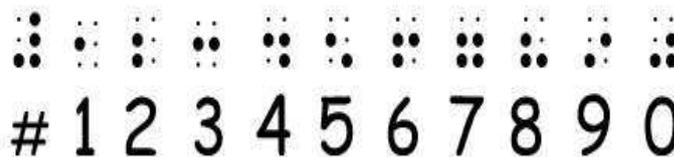


[Braille Alphabet - Braille Works brailleworks.com](http://brailleworks.com)

Around 1950s the Nemeth Braille code was initially devised to provide Braille readers a method to represent mathematical characters in Braille. This code was developed by Abraham Nemeth, it was first written up in the year 1952. In the year 1972 revised form of NBC and Scientific Notation prepared by Abraham Nemeth. It has been revised so many times to make improvement to earlier versions. To allow for the many mathematical characters, the Nemeth Braille Code employs well-defined sequences of Braille characters to represent one mathematical symbol. It is use for encoding mathematical and scientific notation linearly using standard six-dots of Braille cells for tactile reading by the visual disabilities. The Nemeth code is based primarily on the presentation, appearance, or notation of the mathematics, in contrast to semantics. As Dr. Nemeth has written,

“A Nemeth Code transcriber need not be proficient in mathematics; all that is required is to look up the symbols and follow the rules. That is what has attracted so many transcribers and what accounts for such a large collection of braille books in math and other natural sciences.” *Braille Into the Next Millennium*

It is a comprehensive six dots combinations which include arithmetic, algebra, geometry, permutation combination, trigonometry, functional analysis, coordinate geometry, ordinary and vector calculus, differential equations, linear algebra (matrices, determinants, and systems of equations), group theory, set theory, number theory, symbolic logic, topology and many more. Following are some images of NBC-



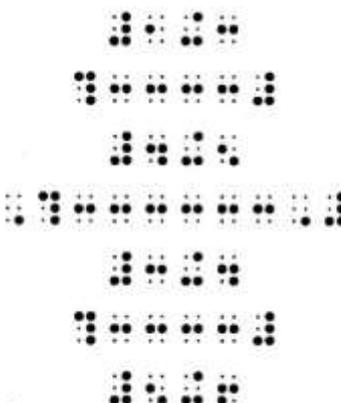
[Summary of Nemeth Capabilities dotlessbraille.org](http://dotlessbraille.org)

#### NEMETH CODE SIGNS & SYMBOLS

|  |                             | -2- |                     |  |                                  |
|--|-----------------------------|-----|---------------------|--|----------------------------------|
|  | # Number sign or pound      |     | / Slash or diagonal |  | Shape Indicator<br>∠ Acute angle |
|  | ° Degree Sign or Hollow Dot |     | ⊃ "contains"        |  | ○ Circle                         |
|  | ⊂ "is contained in"         |     | ⊆ "is subset of"    |  | △ Triangle                       |
|  | ∩ Intersection Sign "Cap"   |     | □ Square            |  | ▭ Rectangle                      |
|  | ∪ Union Sign "Cup"          |     | ⬠ Pentagon          |  | ⬡ Hexagon                        |
|  | ∈ "is an element of"        |     | ⬢ Octagon           |  |                                  |

[braille, visually impaired children ...pinterest.com](https://pinterest.com)

(12) 
$$\frac{\frac{1+3}{4+5}}{\frac{3+4}{5+6}}$$



(a complex fraction)

[Nemeth Braille Code for Mathematics ...vocalinkglobal.com](http://www.vocalinkglobal.com)

### Importance of Nemeth Braille Code

There are various ways to perform mathematical skills and calculation but among these Nemeth Braille Code has more importance as it helps in representing almost every mathematical character and symbol of primary mathematics education to higher mathematics education. Students with visual disabilities use the Nemeth Braille Code of Mathematics and Science Notation (Nemeth code) (Nemeth, 1972) to gain access to and produce mathematical work.

"Without the ability to read and write the symbols that represent mathematical concepts, the field of mathematics is closed to persons who are visually impaired" (Kapperman & Sticken, 2003). NBC provides a complete system of mathematics symbols and characters needed for the necessary mark-up encoding to express math at any level. Documents printed in Braille consist of raised embossed dots more appropriate for haptic perception using the fingertips (American Federation for the Blind, 2011).

An extensive survey done by (Bell & Mino) in the year 2013 on rehabilitation and employment of visual disabilities concluded that the ability to use Braille results in a significantly higher likelihood of employment (58% for Braille readers vs. 44% for non-Braille readers). Additionally, Braille readers have higher average earnings (\$45,947 for Braille readers vs. \$34,826 for non-Braille readers). Despite the complexity of the Nemeth Braille Code, it is extremely useful and very beneficial for SWVD in learning mathematics.

### Teaching and learning of Nemeth Braille Code

The teaching of Nemeth Braille code is similar to that of linear Braille. However, there is no such research which can describe the sequence of teaching NBC dots, i.e. which symbol of Nemeth Braille should be taught first. Rapp & Rapp (1992) asserted that the amount of time that is required to produce Nemeth materials and to instruct students in their use is considerably more than the time needed to provide print materials and instruction to sighted one.

Stanley (2008) clearly identifies the most salient issue confronting visual disabilities students and professionals to learn and to teach mathematics. He strongly stated that lack of vision does not hinder the individual from learning math so much as it hinders the ability to communicate math-related concepts in a sighted environment. Means proper visualisation of mathematical content in tactile form and if possible in auditory form can make their learning process easier and more accessible.

Students who have visual disabilities use the Nemeth Code for Braille Mathematics and Science Notation (Nemeth code) (Nemeth, 1972) to do and produce mathematical work. Kapperman and Jodi (2002) described a software tutorial that can be used by SWVD to learn the Nemeth Braille code. The program was designed for use with the Braille Lite, a note taker that has speech and a refreshable Braille display, manufactured by Freedom Scientific. It is easy to handle and user friendly.

Contents of Nemeth Braille Code:

Chapter One: First Grade

The Numeric Indicator  
Punctuation  
Comma  
Plus and Minus Signs  
Equals Sign  
Signs of Comparison

Chapter Two: Second Grade

Abbreviations  
Decimal Point  
Monetary Sign: Dollar and Cent

Chapter Three: Third Grade

Multiplication Cross  
Division  
Parentheses  
Simple Fractions  
Omission Symbol  
Roman Numerals  
Mixed Fraction  
Introduction to Nemeth Indicator

Chapter Four: Fourth Grade

Variables  
Shapes Omissions  
Ratio and Percent  
Degrees  
Basic Geometric Symbols

Chapter Five: Fifth Grade

Basic Exponents  
Segments, Lines, Rays and their Relationship  
Directed Signed  
Ordered Pairs

Chapter Six: Sixth Grade

Absolute Value  
Brackets and Braces  
Horizontal Bar

Chapter Seven: Seventh Grade

Complex Fractions

Chapter Eight: Eighth Grade

Real Numbers  
Plus/Minus and Not Equal Sign

## Chapter Nine: Algebra

Set Notations: Complements, Subsets, Union, Intersection  
 Ratios and Proportions  
 More Sets: Union, Intersections and the Infinity Symbol  
 Matrices  
 Factorial

## Chapter Ten: Geometry

Signs of Comparison: Approximately Equal To, Similar To, Congruent To  
 Conjunction, Disjunction, Conditionals, and Bi conditionals

## Chapter Eleven: Advanced Mathematics

Subscripts  
 Function Name Abbreviation  
 Vectors  
 Circles and Arcs  
 Additional Shapes  
 More Complex Radicals  
 Sigma Notation  
 Limits  
 Integrals  
 Logic and Set Theory  
 Caret and Partial Derivative  
 Logical Operators For All, There Exists, and Therefore  
 Greek Letters  
 Tally Marks  
 Type Faces

**How to Teach Nemeth Braille Code to SWVD, Following are some Instructions for Teachers:**

- It is essential for the Teacher of Students with Visual Disabilities (TSVD) to communicate and collaborate in order to prepare for upcoming instructional units to prepare the student for upcoming symbols and formats they will encounter.
- Teacher should create Braille friendly atmosphere in the classroom.
- Teacher should make their student to read and write correctly with appropriate fluency.
- They should prepare proper sequence of teaching maths symbols/characters. Phase wise practice should be implemented.
- They must aware of the latest technology related o Nemeth Braille Code so that they can able to use these things in their classes.
- They should prepare their students to read and write braille with the help of assistive devices of braille.
- Teachers may need to refresh their skills as they can go years without working with a student who needs instruction in or the use of the Nemeth Code.
- If needed teachers should go through in-service training program related to Nemeth Braille if needed.
- Ideal learning environment should be created by teacher so that he braille reader learns each new Nemeth symbol as the print math symbol is introduced in each sequential math course from elementary to middle to high school to adulthood.
- Teacher should provide braille textbook because as the student matures, they can anticipate the new symbol on their own by reading ahead. The student should also be encouraged to be their own self-advocate.
- Teacher should be have patience while dealing with SWVD.
- Maths teacher and support teachers must be very familiar with the Braille mathematical writing in order to know exactly what and how to dictate to the SWVD so that both confusion and time wasted in useless explanations can be avoided.
- They should always behave positively and try to remove their mathematics phobia if anyone of them have.

- Teacher should provide extra class or should give tutorial class to learn mathematics if anyone student faces difficulty in learning Nemeth Braille code.
- It is necessary that the person in charge with assisting the SWVD in learning Mathematics (the Maths teacher, the class teacher, the support teacher, the parents or someone else) should master the Nemeth Braille writing very well in order to understand their difficulties.
- Teacher should help their students to develop focusing and attention, the sense of observation, logical, creative thinking, creativity, initiative, perseverance, independence of thought, action, critical and aesthetic sense so that they could do mathematics with high zeal and enthusiasm.
- Teacher should encourage their SWVD to actively participate in classroom activities.
- Teacher should relate their teaching of mathematics to real life situations.
- Teacher should respect their student's individuality.

#### **Basic Guidelines for SWVD to Learn Nemeth Braille Code:**

- They must have pre-requisites skills of braille reading and writing.
- They must aware of braille reading and writing devices.
- They must got extra time to do mathematics because it takes comparatively more time than that of printed one.
- The student's reading and writing speed in Braille should be as high as possible. To achieve this, they must practise, write and read a lot in their spare time.
- Ample amount of mental exercise by the student.
- They must have their own textbook and other relevant materials in braille so that they could practice themselves in free time without the help of any sighted person.
- SWVD should aware of new assistive technologies related to mathematics.
- They should attend their mathematics class with positive attitude.

#### **Conclusion**

SWVD performance in mathematics is relatively low in comparison to their sighted peers but it can be minimized or nullified if they use Nemeth Braille code for learning of mathematics with ample amount of practices.

There are a lot of rules about how to learn Nemeth Braille code. Students not only have to learn how to do mathematics, but they have to learn the rules for reading and writing it in Nemeth Braille too. Mastery of Nemeth code will make them comfortable in mathematics. Doing well in Mathematics will help them to score high marks and get top ranks. This will help the SWVD to get recognition from peer group. This will also help them to develop self-esteem. Therefore it is necessary to access Nemeth Braille code by students.

#### **References**

- [1] American Federation for the Blind. (2011). What is Braille? Retrieved September 9, 2021, from <http://www.afb.org/section.asp?SectionID=6&TopicID=199>
- [2] Beal, C., & Shaw, E. (2008). Working memory and math problem solving by blind middle school students: Implications for universal success. In K. McFerrin, R. Webber, R. Carlsen, & D. Willis (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2008* (pp. 5011-5016). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE). Retrieved from <http://www.editlib.org/p/28059>
- [3] Bell, E. C., & Mino, N. M. (2013). Blind and visually impaired adult rehabilitation and employment survey: Final results. *The Journal of Blindness Innovation and Research*, 1(1 (2013)).
- [4] Diyansyah, G. (2017). Pengaruh Media Numicon Terhadap Peningkatan Prestasi Belajar Matematika Anak Tunanetra kelas III di SLB A YKAB Surakarta Tahun Ajaran 2016/2017. Universitas Sebelas Maret.
- [5] Godino, J. ., & Batanero, C. (2007). The Onto-Semiotic Approach to Research in Mathematics Education. *ZDM Mathematics Education*, 39, 127–135.

- [6] Herwanto, S. (2013). Peningkatan Prestasi Belajar Matematika Materi Perkalian Melalui Media Abakus Bagi Siswa Tunanetra. Retrieved from <https://eprints.uns.ac.id/1884/1/1803-4030-1-PB.pdf>
- [7] Kapperman and Jodi (2003) A Case for Increased Training in the Nemeth Code of Braille Mathematics for Teachers of Students who Are Visually Impaired
- [8] Kapperman, G., & Sticken, J. (2003). A case for increased training in the Nemeth code of braille mathematics for teachers of students who are visually impaired. *Journal of Visual Impairment and Blindness*, 97(2), 110
- [9] Mensah, F. (2017). Ghanaian Senior High School Students' Error in Learning of Trigonometry. *International Journal Of Environmental & Science Education*, 12(8), 1709–1717.
- [10] Nemeth, A. (1972). The Nemeth braille code for mathematics and science notation, 1972 revision. Louisville, KY: American Printing House for the Blind.
- [11] Sanchez, & Flores. (2004). AudioMath: Blind Children Learning Mathematics through Audio. In 5th Intl Conf. Disability, Virtual Reality & Assoc. Tech., Oxford, UK (p. 184).
- [12] Stanley, P. (2008). Assessing the mathematics related communication requirements of the blind in education and career. Paper presented at the 11th International Conference on Computers Helping People with Special Needs (ICCHP 2008), Linz, Austria.
- [13] Stewart, J. (2014). Visual Impairment and Educational Attainment. Research and Information Service, 2.
- [14] Tauda, Y. A., Soedwiwhjono, & Putri, R. A. (2017). Kesesuaian Pemenuhan Kebutuhan Difabel Tunanetra dan Tunaakarsa di Kota Surakarta terhadap Kriteria Kota Ramah Difabel. *Region*, 12(2), 181–193. <https://doi.org/10.1016/j.molcatb.2009.06.001>
- [15] <http://www.dotlessbraille.org/NemethSummary.htm>
- [16] <http://disabilityaffairs.gov.in/content/page/acts.php>