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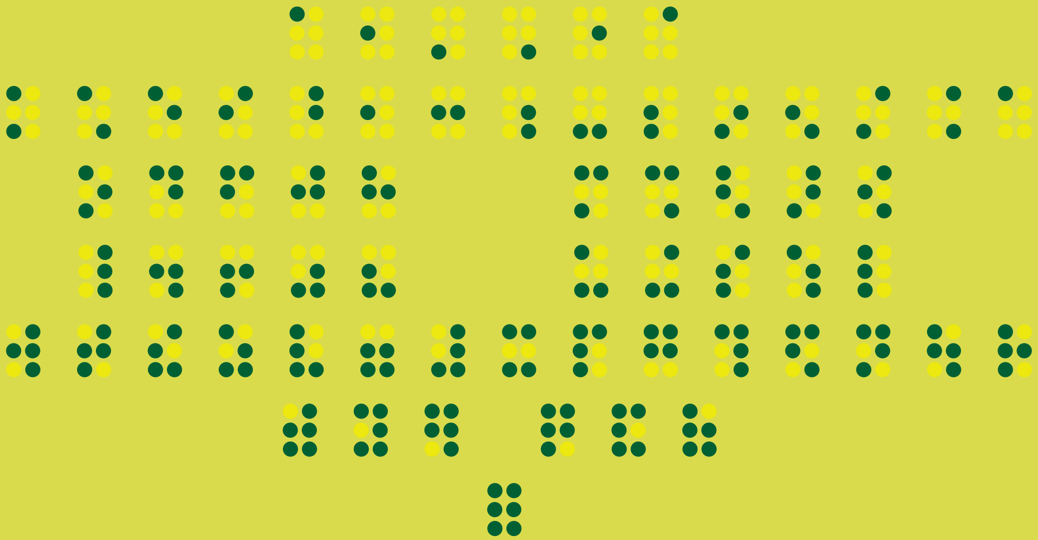
6 x · = 64

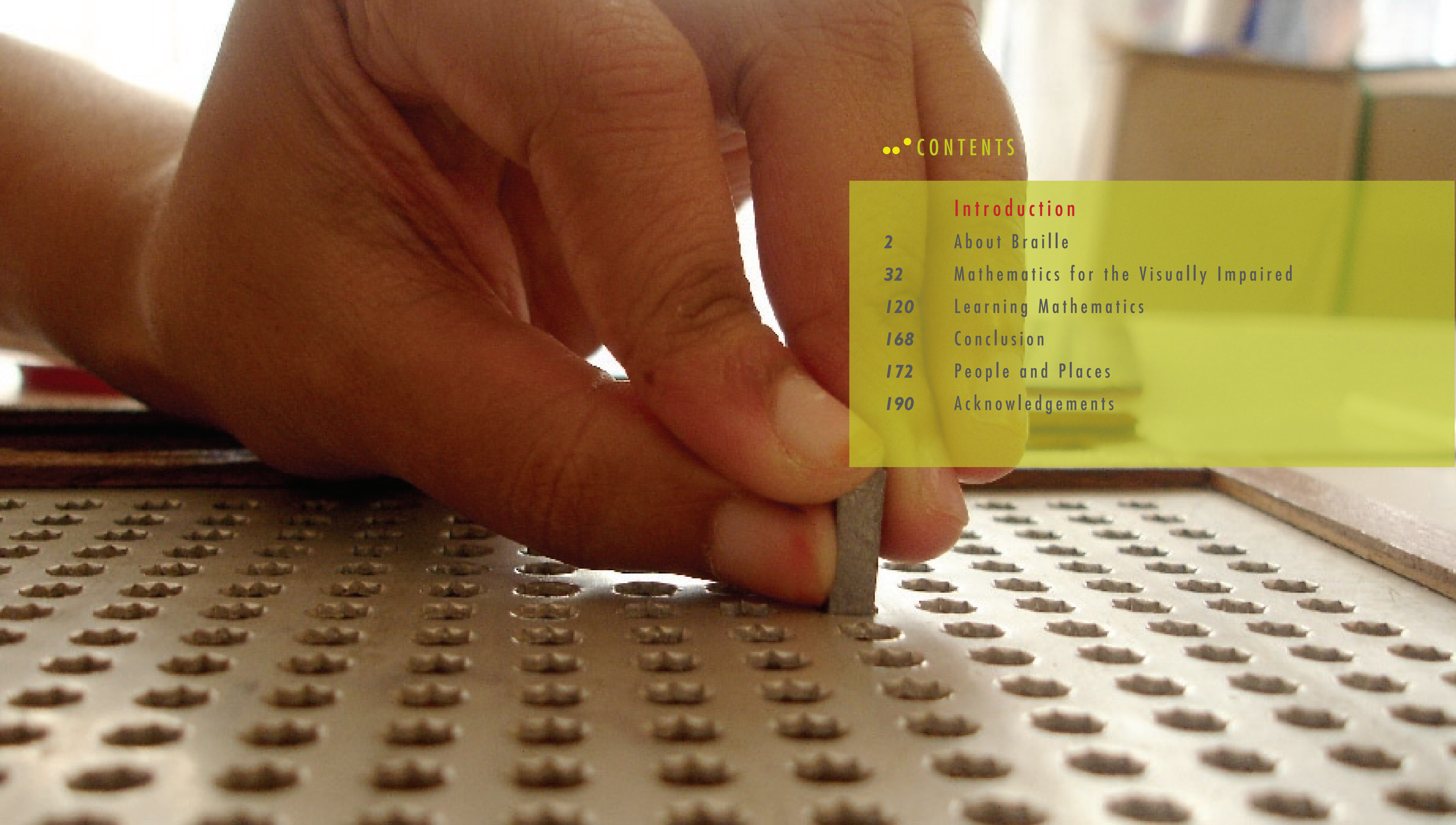


6 x • = 64

This book is a compilation of research, in “Understanding and Tracing the Problem faced by the Visually Impaired while doing Mathematics” as a Diploma project by Aarti Vashisht at the Srishti School of Art, Design and Technology, Bangalore.

6 DOTS 64 COMBINATIONS

A Braille character is formed out of a combination of six dots. Including the blank space, sixty four combinations are possible using one or more of these six dots.



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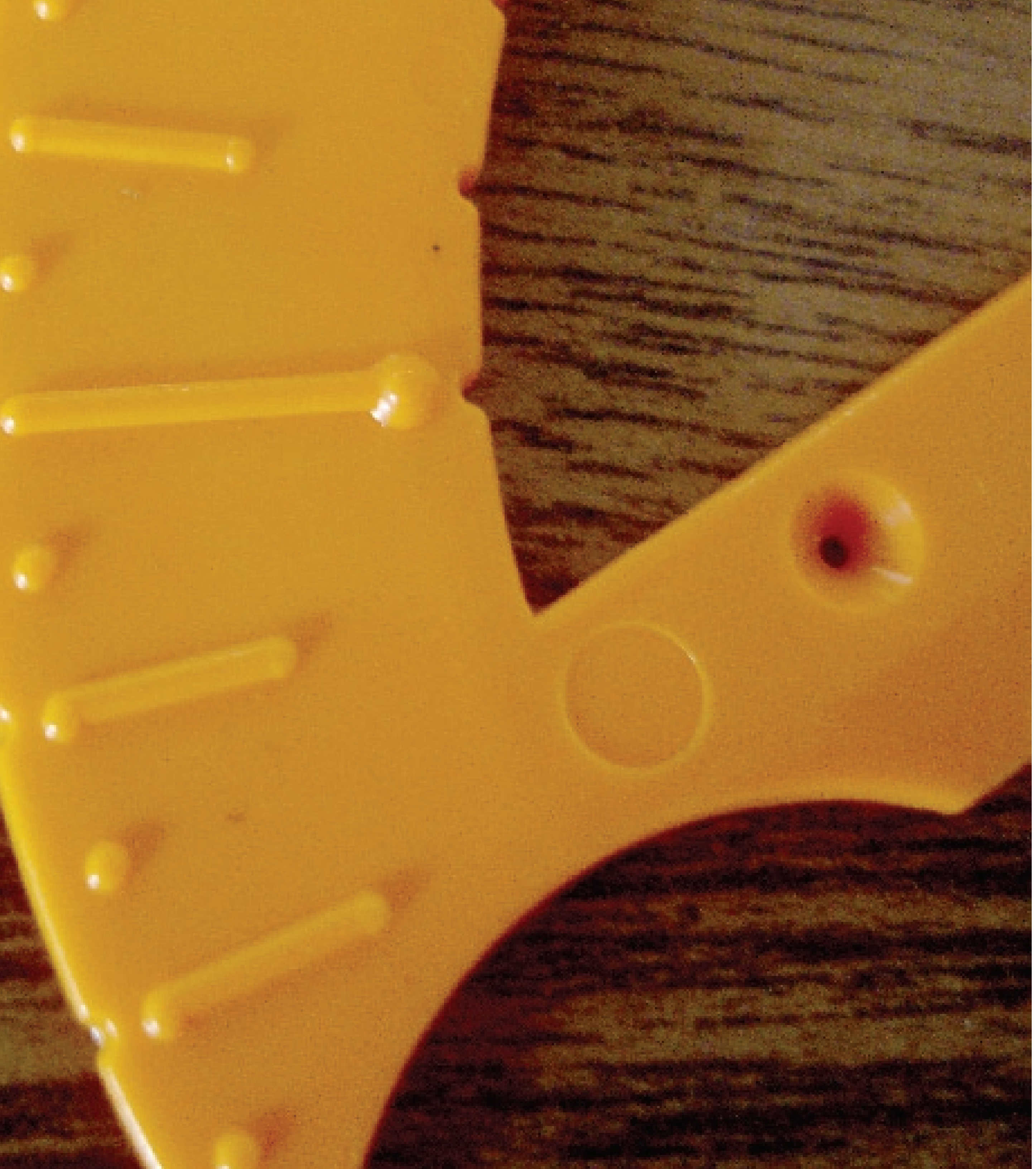


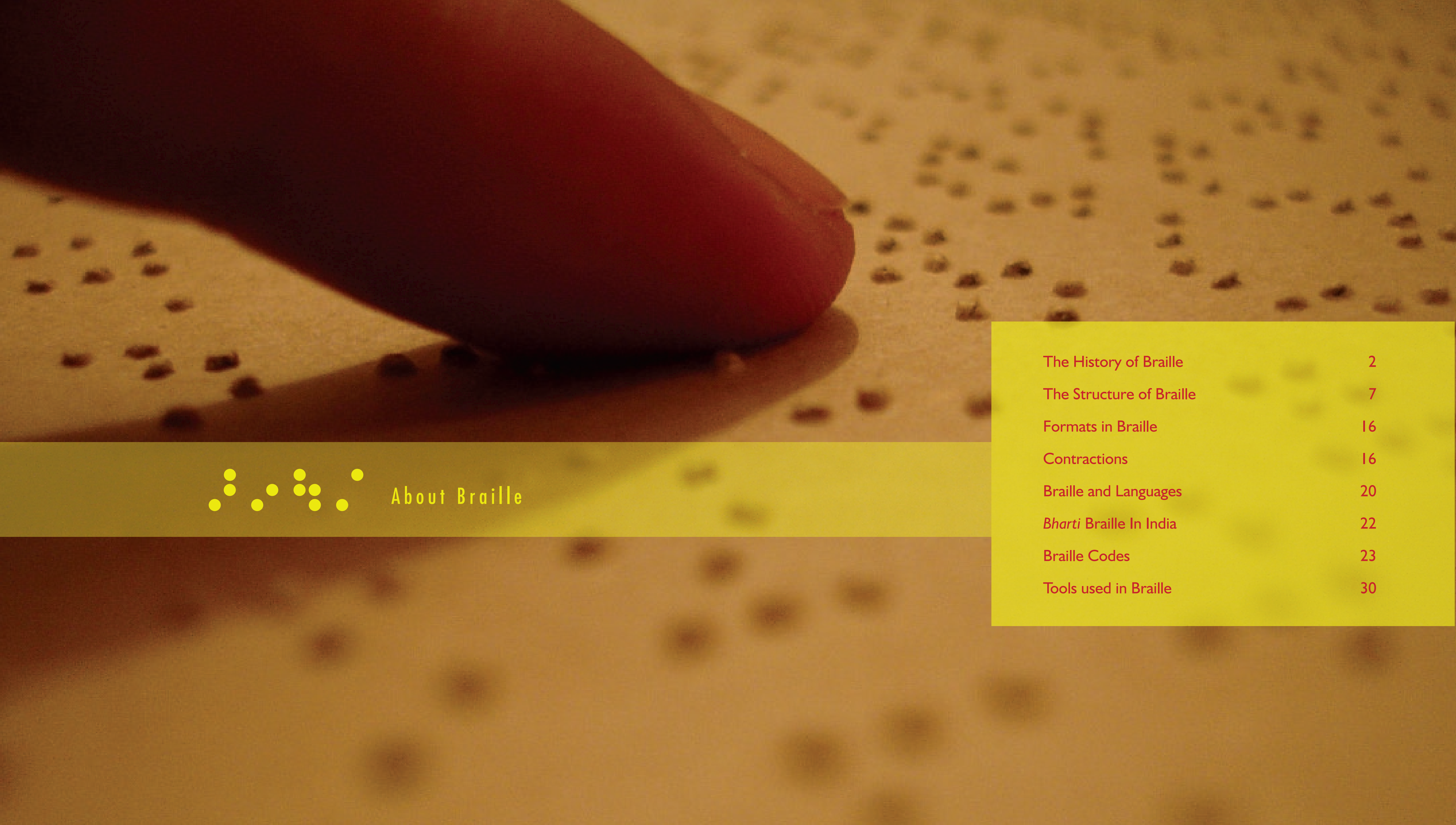
INTRODUCTION

This project tries to understand the nature of the problems that are faced by the visually impaired within the realm of mathematics. It is a summary of my understanding of the problems in this field that may be taken forward to guide those individuals who are concerned about this subject.

My education in design has encouraged interest in this field. As a designer I have learnt to be aware of my community and its needs, to detect areas where design can reach out and assist, if not resolve, a problem. Thus began, my search, where I sought to grasp a fuller understanding of the situation by looking at the various mediums that would help better communication.

During the project I realized that more often than not work happened in individual pockets which in turn would lead to regionalization of many ideas and opportunities. Data collection got repetitive, which would delay or sometimes even hinder the process. Being a communication designer, bridging this gap became my principal aim.

Currently, I choose to document my research and resources in a book hoping to reach out and create some interest in people who may be ignorant about the problem addressed and simultaneously provide substantial information to those interested; encouraging them to initiate similar exchanges and take it forward.



About Braille

"Braille has been a most precious aid to me in many ways. It made my going to college possible it was the only method by which I could take notes of lectures. All my examination papers were copied for me in this system. I use Braille as a spider uses its web, to catch thoughts that flit across my mind for speeches, messages and manuscripts."
Helen Keller

Braille is the most popular and widely used system of writing and reading by the visually impaired. This system was devised in 1821 by Louis Braille. The structure is made up of 6 raised dots in a Braille cell. The raised-dot patterns created are read using the fingertip.

History of Braille[1]

1260

The history of Braille can be traced from early eleventh century when King Louis the Ninth reigned. King Louis the Ninth of France was influential in bringing the first formal institutions for the blind to the world in the year 1260, the "Quinze-Vingts" hospice (in English, "fifteen score" or 300).

Valentin Haüy and his blind school

Valentin Haüy was born in 1745 into a family of weavers and was a skilled linguist who spoke ten living languages. In 1783 he was named interpreter to the king.

[1] *The History of Brialle has been taken from* **www.brailler.com/braillehx.htm** *and edited.*

Due to his enthusiasm with the blind he became aquatinted with the founder of the school for the deaf and learnt the manual Braille. In 1784 he encountered the perfect student in a beggar boy and 17-year-old François Lesueur, became Haüy's first pupil. He taught François' to read by using wooden letters. François was a very quick study and also the source of a major new insight.

Theresia von Paradis, a young blind girl with an international reputation as a piano prodigy shared her own literacy methods, which included a writing system of pinpricks. She also told him of her correspondence with a talented blind German student named Weissenbourg, who acquired considerable education through the resourcefulness of his tutor, Christian Niesen who used bent-wire alphabets and tactile maps made from silk embroidered onto cardboard. Initially Haüy started at home but then later he gained sufficient royal support and opened his first school in Rue Coquilliere which later moved to Rue Notre-Dame-des-Victoires. He soon had 48 students.

Louis Braille

Haüy originally operated the school from his home, but as more pupils came, he was able to attract sufficient royal support to expand. He moved the school first to the Rue Coquilliere and then to the Rue Notre-Dame-des-Victoires. Haüy soon had 48 pupils, both boys and girls.

Louis Braille, the fourth child of a saddle maker was born in the year 1809. At the age of three, Louis injured his eye in an accident while playing with his father's tools. Fortunately, some new people at Coupvray a priest, Abbé Jacques Palluy, and a schoolmaster, Antoine Bécheret asked Louis Braille's parents to allow him to attend regular school. Both Louis' parents could read and write, and his older siblings had all attended the same school as children. Louis did so well there that when the government decreed new local school methods that would have prevented Louis from continuing his education, Bécheret and Palluy approached the local nobleman for help.

The nobleman was Marquis d'Orvilliers, a survivor of the recent smallpox epidemic, who, having seen Valentin Haüy's students perform at Versailles years before, agreed to write to the current director of the school, Sébastien Guillié. Louis became the youngest student at

Some examples of Barbier's code

the school. He adjusted quickly to the life at school and made many friends there, one he would keep all his life was a fellow student Gabriel Gauthier, who was a year older. The conditions of the school were not good and hygienic, this would later become the reason for Louis Braille's tuberculosis at young age of 22.

Haüy's embossed books

Haüy's original method of embossing books was to apply soaked paper to raised letter forms, so that the tactile shape of the specially crafted large round cursive letters remained after the paper dried. Pages were then glued back-to-front to produce a two-sided sheet. These books were, of course, extraordinarily slow and difficult to make and almost as slow and difficult to read, since the shape of each letter had to be traced individually. The letters were widely spaced and used surprisingly ornate fonts. The finished books were often too heavy for the smaller students to lift. At the time of Louis Braille's admission, the school, now over thirty years old, had one hundred pupils and a total of fourteen embossed books.

Charles Barbier and his night-writing

Charles Barbier was interested in fast, secret writing which was grounded in his war experiences. He published a table for quick writing or "expediography," followed a year later by a book describing how to write several copies of a message at once.

Barbier and the students of the Institution for Blind Children probably first encountered each other when they were exhibiting their communication methods at the Museum of Science and Industry, then located in the Louvre. Barbier had a device that enabled the writer to create messages in the dark; at a time when students were reading Haüy's books of embossed print letters with usual painful slowness.

Barbier decided to take his own dot and dash-based "night writing"artillery code to the Royal Institution for Blind Children where he interested Pignier, the new director, in his system. Pignier arranged a demonstration and passed around a few embossed pages of dots to the students.

Louis Braille and his six dots

Louis Braille was thunderstruck when he first touched the dots of the night-writing samples. He had often played around with tactile writing at home on summer vacation in Coupvray. Neighbours later recalled that as a child Louis had tried leather in various shapes and even arranged upholstery pins in patterns, hoping to find a workable tactile communication method, but with no success.

Louis met with Captain Barbier to talk about his ideas to improve the code, but he was intimidated by the Captain. Louis stopped asking his advice altogether and instead went to work experimenting with the code on his own. He had little spare time; he worked late into the night at home in Coupvray during the summer, Louis tried various modifications that would enable the unique letter symbols to fit under the fingertip.

In October, 1824, Louis, now 15 years old, unveiled his new alphabet right after the start of school. He had found sixty-three ways to use a six-dot cell, though some dashes were still included. His new alphabet was received enthusiastically by the other students and by Pignier, who ordered the special slates Louis had designed from Captain Barbier's original one. Gabriel Gauthier, still Louis' best friend, was probably the very first person ever to read Braille.

Later Pignier appointed Louis as a teacher. Despite his busy schedule, he kept tinkering with the code. By 1828, he had found a way to copy music in his new code and eliminated the dashes.

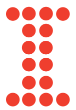
In 1829, at age 20, he published "Method of Writing Words, Music, and Plain Songs by Means of Dots, for Use by the Blind and Arranged for Them" his first complete book about his new system. A few years later, he, Gabriel Gauthier and another blind friend and former pupil, Hippolyte Coltat, became the first blind full professors at the school. This meant they could leave the school occasionally without asking permission, got their own rooms, and had gold braid added to their uniforms as a mark of rank. All three new teachers used the new alphabet in their classes.

He had little spare time; he worked late into the night at home in Coupvray during the summer, Louis tried various modifications that would enable the unique letter symbols to fit under the fingertip

Louis's last days

Louis was a popular teacher, generous to his students with both his time and money. As the students typically had no way of writing home to their families without dictating a letter to a sighted teacher, Louis invented "raphigraphy", a system which represents the alphabet with large print letters composed of Braille dots. Raphigraphy was labor-intensive. The letter "I" alone required the Braillist to punch 16 dots. A blind inventor, Pierre Foucault, had been a student at the school back in the Quinze-Vingts days. He returned in 1841 and when he saw what Louis Braille was doing, he invented a machine called a "piston board," to punch complete dot-drawn letters. In 1847, he would invent the "keyboard printer" (essentially, a typewriter) enabling blind people to write to sighted people in black type. Louis Braille used it to compose letters to his mother back in Coupvray.

Letter 'i' in Raphigraphy



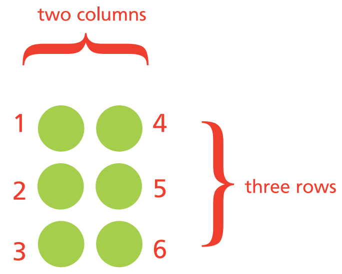
Ironically, the first working print typewriter had actually been devised in 1808 in Italy to help a blind countess produce legible writing for sighted people, but print typewriters were not produced on any scale until the 1870's. In the meantime, the piston board (although expensive) itself became a common device throughout Europe.

Louis Braille spent the last eight years of his life teaching occasionally and Brailling books for the school library as he battled his declining health. People were starting to call the dot system by his name, "Braille," and a growing number of inquiries about it were reaching the school from all over the world. Louis Braille died on January 6, 1852, just two days past his forty-third birthday.

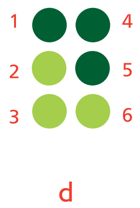
His system survived, and in 1854, France adopted Braille as its official communications system for the blind. There on Braille spread across the world. It often encountered tremendous resistance in some other countries, mostly for the same reason: Braille's seeming opacity to the sighted because of its lack of resemblance to print. The need for the blind to write and read incredibly seems never to have occurred to many of these educators. Braille is easy to write manually, while raised print letter forms are nearly impossible had become a huge factor in securing Braille's lasting place in its users' hearts.

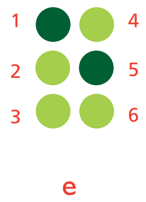
THE STRUCTURE OF BRAILLE

There are six dots which are paired in two columns, each column containing three dots. Hence, they are arranged in a grid of two dots horizontally and three dots vertically this is called a Braille cell. Various combinations of these six dots represent a character. For ease in understanding, each dot is numbered 1, 2, and 3 from the top to the bottom of the left column and 4, 5, and 6 from the top to the bottom of the right column.



Braille Cell



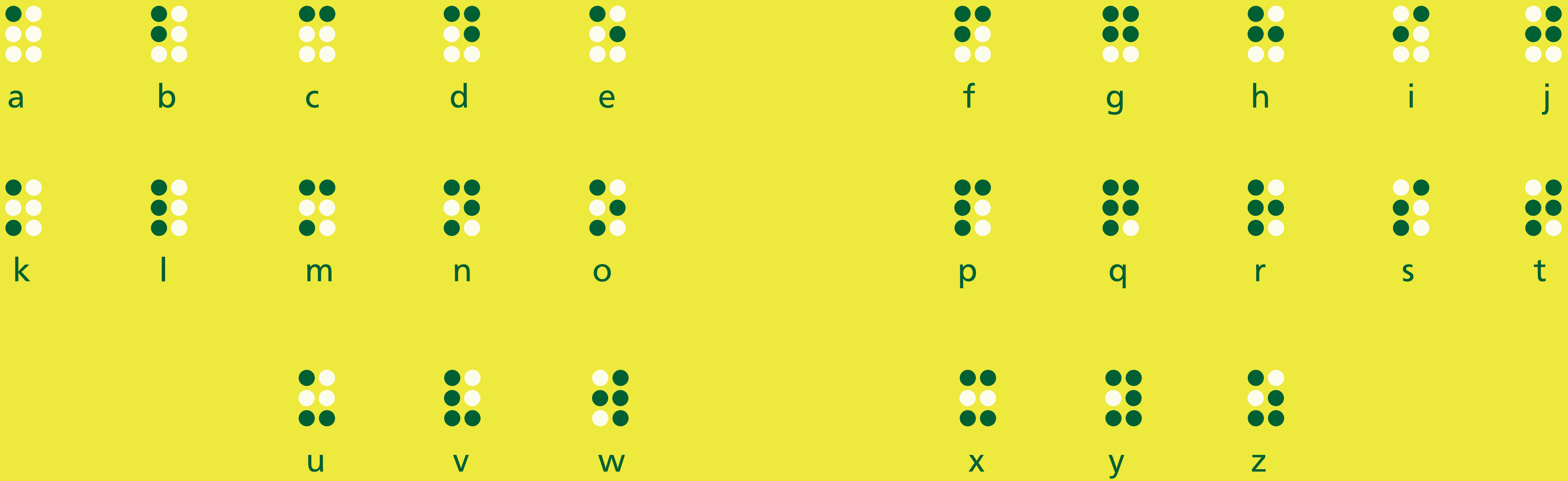


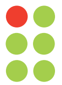
Raised dots 1, 4 and 5 are assigned the Roman letter 'd' and 1 and 5 are assigned the Roman letter 'e'. (Dots in dark green represent raised dots in braille)

A Braille character is formed out of a combination of these six dots. In Braille, an unused Braille cell or a blank Braille cell is used as a space. Including the blank space, sixty four combinations are possible using one or more of these six dots

Alphabets

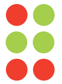
In Braille, characters written are formed out of a single cell or multiple cells. All the alphabets are represented in one Braille cell.





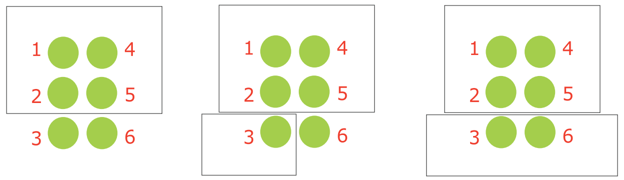
a

k = a + dot 3



u = a + dot 3 and 6

One way to learn the alphabet in literary Braille is to memorize the dot patterns for the first ten letters, that is, a-j. The dot patterns for the next ten letters, k-t, are the same as the first ten but with an additional dot in position 3. The dot patterns for the letters u, v, x, y and z are the same as the letters a-e with additional dots in positions 3 and 6. The letter "w", dot pattern 2-4-5-6, is out of alphabetical order because the French alphabet did not have that letter when Louis Braille invented the Braille alphabet in 1829.

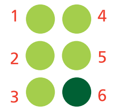


a-j in first four dots | k-t is a-j + dot 3 | u, v, x, y and z is a-j + dot 3 and 6

Capital letters

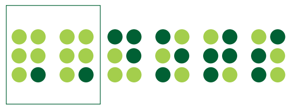
There are no capital letters in Braille

There are no capital letters in Braille. The "**capital sign or capital indicator**" is inserted before the specifically required letter, to indicate as to what will be read will be the Capital of that letter. When two capital signs are inserted in front of a Braille word it indicates that the entire word is capitalized. There are Braille indictor signs for italics, letters that mean words, single cell words, etc.

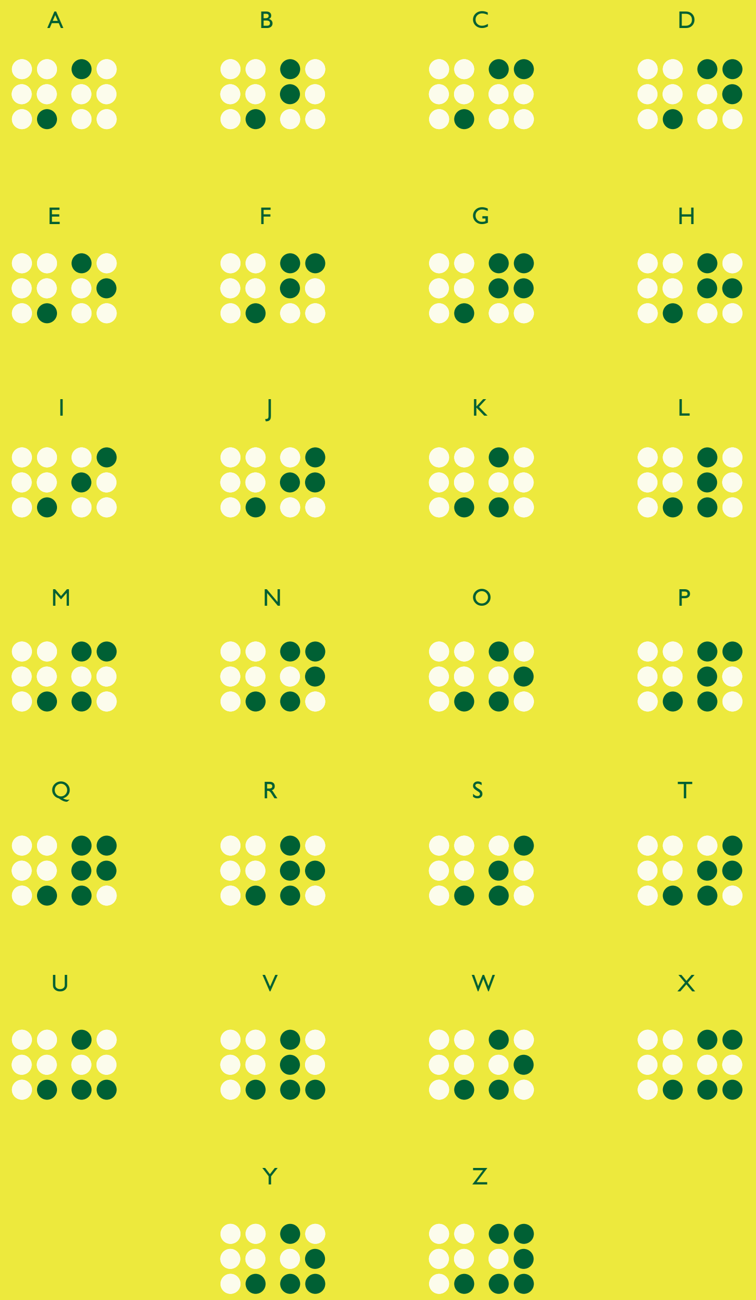


Dot 6 is a Capital Sign or a Capital Indicator

DOTS



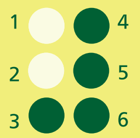
Two capital symbols denotes a whole capitalised word



Capital Alphabets in Braille

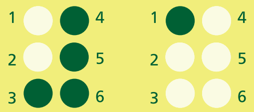
Numbers in Standard English Braille

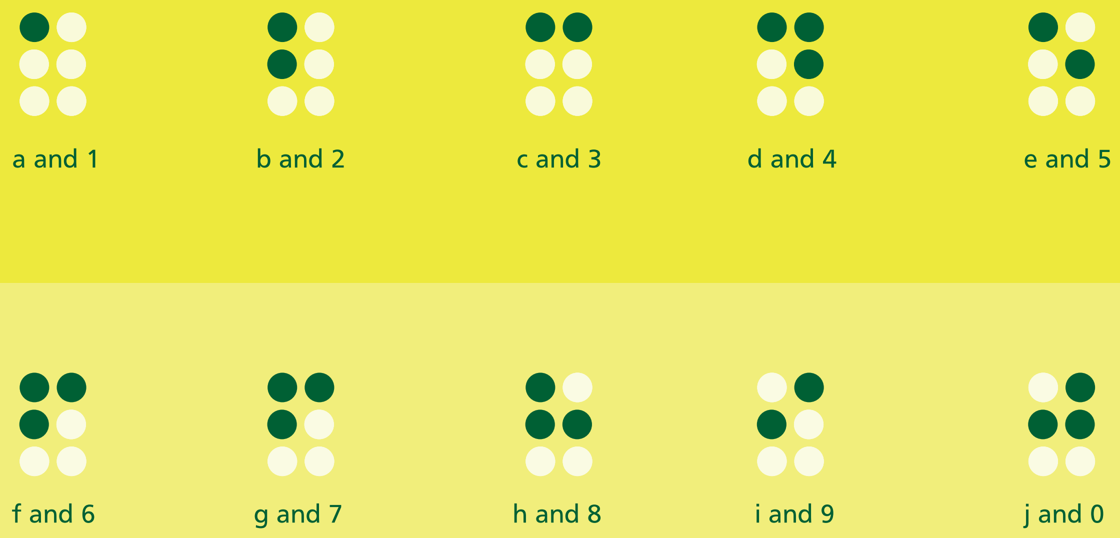
Unlike the alphabets (excluding the capitals) numbers in Braille occupy two cells. Numbers in Braille have the same pattern as the first ten alphabets of the Roman literary Braille that means that alphabets 'a' to 'j' look the same as number '0' to '9'. What helps in distinguishing a number from an alphabet, is the use of an additional symbol that precedes the symbol 'a' to 'j'. When this symbol is read before any of the alphabets the reader automatically knows that what they had read was a number and not an alphabet. This symbol is known as a **numeric indicator**.



Dot 3, 4, 5, 6 is a Number Sign or a Numeric Indicator

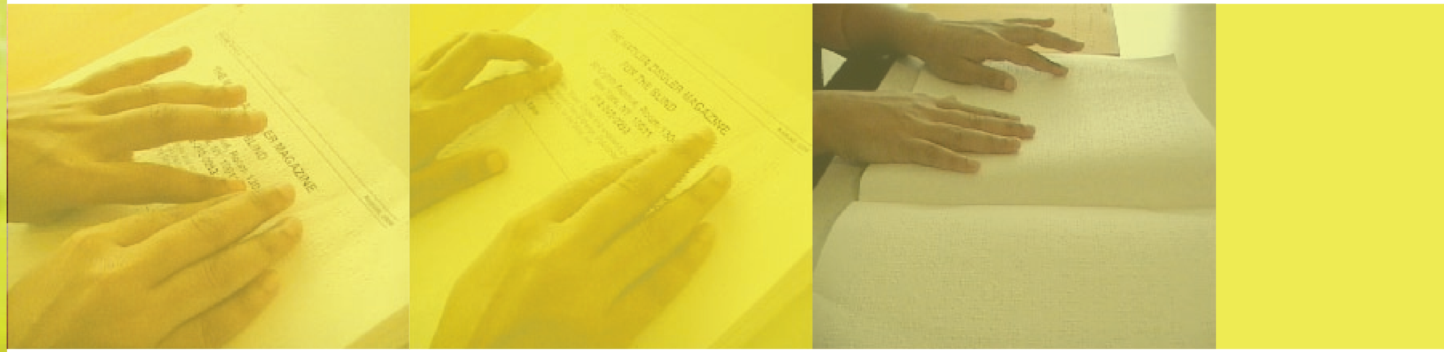
digit I





Size

Unlike print, the size of each cell in Braille remains constant. The reason for the constant size is primarily, to aid readability. Braille is designed such that, each cell fits within the finger-tip. This aids quick recognition of the character making reading faster. Braille is usually written in a standard size which is approximately equivalent to 7 to 8 mm (even though there are slates that can write in jumbo sizes) for publishing books in Braille the standard size is used.



Books in Braille

The Braille script occupies approximately 3 to 4 times the amount of space that ordinary print requires. A Braille book is much larger and longer than printed books. An ordinary pocket size dictionary comes in 16 volumes. This makes Braille books heavy and bulky for regular use. Also these books don't last forever as the raised dots flatten out with time or with constant use. To increase the longevity of the Braille books it is recommended that the books be kept vertically and not stacked horizontally one over the other. Raised dots can also be maintained by embossing on plastic transparency sheets but this is an expensive method. Braille is usually embossed with the help of various tools on thick paper of 140 gsm board. Thick paper helps in better emboss quality and also allows longevity of the dots. The standard printed Braille paper measures 11" by 11.5" (28 cm × 30 cm) and can accommodate 25 lines which is a maximum of 40 to 43 characters.

The Braille script occupies approximately 3 to 4 times the space that ordinary print requires

Formats in Braille

There are two types of formats in Braille, the **Literary** (which is not related to the Literary Code) and the **Textbook**. The Nemeth Code uses some parts of Textbook format but has some idiosyncrasies of its own.

The Textbook format includes the page numbers of the print version whereas the literary format does not. In the literary format the Braille representation for the alphabet, numbers, and punctuation marks are the ones that are commonly used in general writing. Examples, novels and non-technical manuals.

The **Alternate** Format is an industry term referring to any alternate approach to presenting print information to a person with a disability. The standard alternate formats are (braille, large print, audio narration, oral presentation, electronic file) along with other "aids and services" for other disabilities (sign language interpretation, sighted guide) among many others.

To aid faster reading and reduce the bulkiness of books in Braille the 'Contracted' form was introduced

Contractions

The form of Braille in which every character of the word is written without any short forms is known as non-contracted Braille or grade I Braille. This form of Braille is mainly used by beginners.

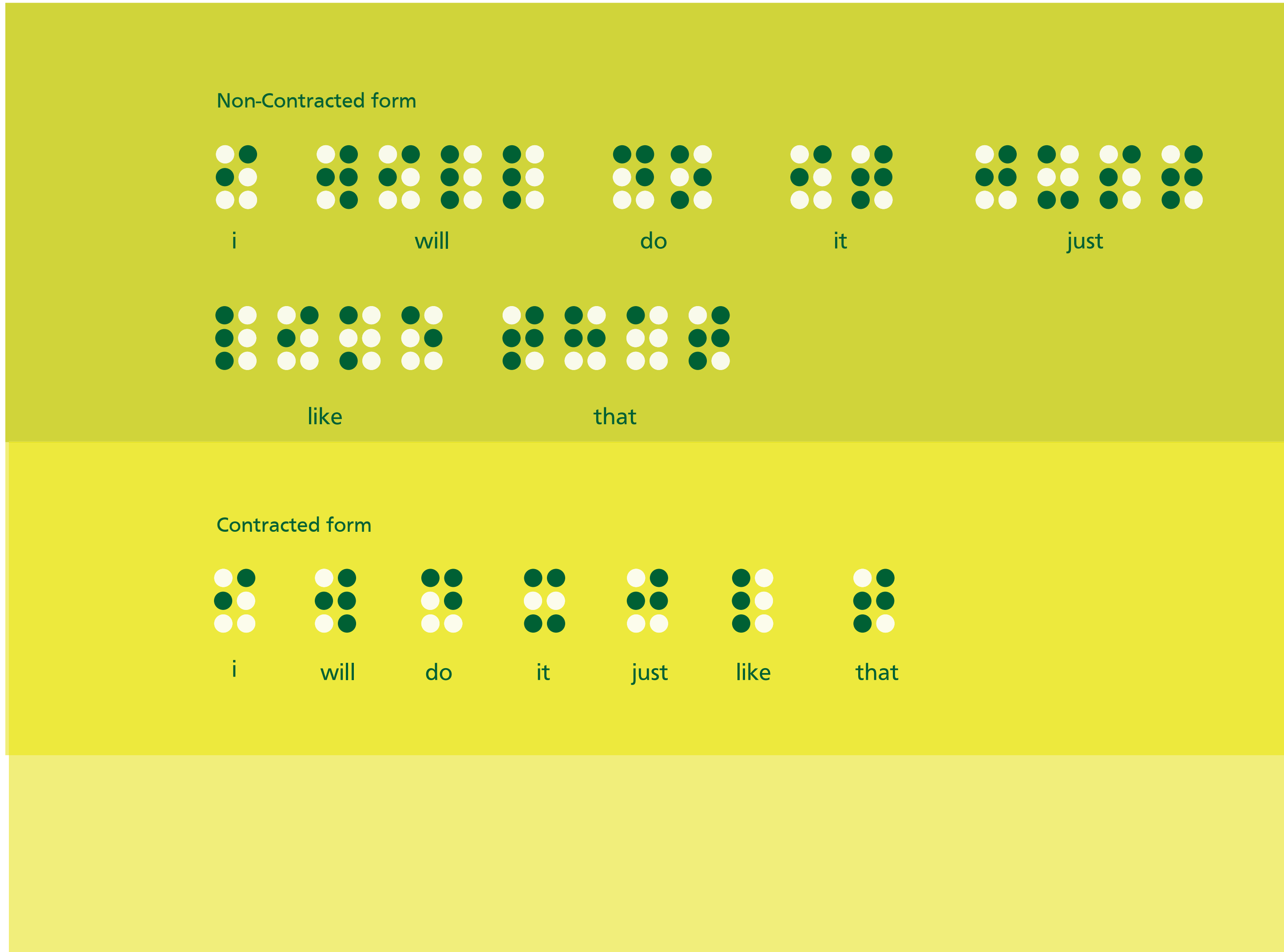
The most commonly used form of Braille in publishing and personal use is the contracted form. This form arose out of the problems faced by the restricted character size and the space taken while writing Braille.

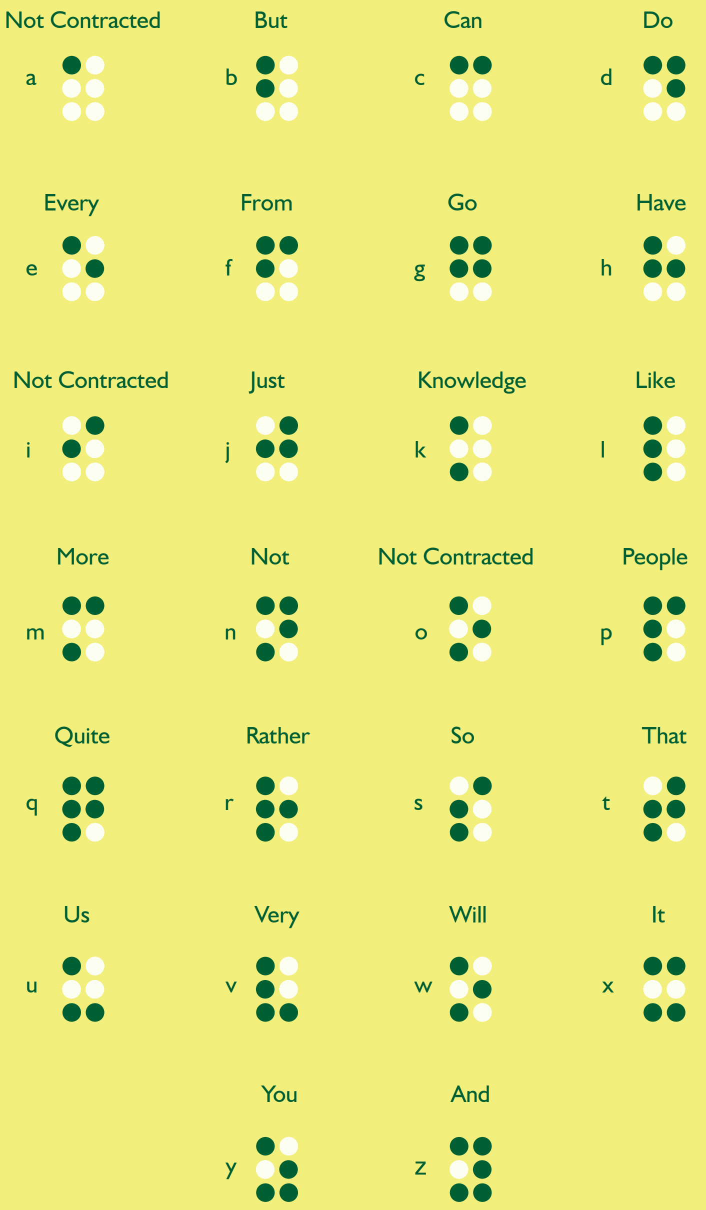
This led to the bulkiness of the books and in order to avoid these problems this form of Braille was introduced. The other advantage of this form is that it aids faster reading and writing.

The contracted form of Braille can be further divided into grade II & grade III Braille. Grade II contractions consists of a strict set of rules and is mainly used for publication and transcription.

Grade III braille however includes many additional contractions and is used almost like shorthand.This form is mostly used by individuals for their personal convienience.

An example of Braille in its Non-Contracted and Contracted forms.





Stand Alone Contractions for Alphabets

Stand Alone Contractions

A **Contraction** is a set of rules in Braille that helps reduce the size of text, so that it can be understood universally. For instance a single letter can signify an entire word or a set of letters within a word. These are called **Stand Alone Contractions**.

Contractions are used contextually. For example, names in word formulas such as "distance = rate x time" are never contracted nor are acronyms and abbreviations.

$$\frac{\text{distance}}{\text{time}} = \text{rate}$$

a = b, but b = c

In the above example the word 'but' cannot be contracted

Problems using Contractions

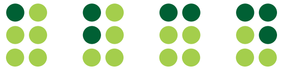
There are some people who have biases using contractions. Most people feel that they build a gap in learning when compared to their sighted counterparts. Their spellings are usually very poor due to constant usage of contractions. It is important to remember that contractions are dependent on the language and user.

A Braille cell on its own has no meaning; the meaning of a particular braille cell is determined by the Braille code it is being used in. A Braille cells conveys different kinds of information in different languages

Braille and Languages

A Braille cell on its own has no meaning; the meaning of a particular braille cell is determined by the Braille code it is being used in. A Braille cell conveys different kinds of information in different languages. That is, the interpretation of a Braille cell will be language dependent. Since this jumble of dots moulds it self to the local script to be read and written tangibly, the meaning of the cell becomes dependent on the language in which it is being used.

Braille on its own is not a language, however, it has been adapted into many languages. It is just another means with which to read a language, just like English, French, Greek, Hindi, Arabic etc…



A	B	C	D	English
А	Б	Ц	Д	Russian
?	β	?	Δ	Greek
अ	ब	च	द	Hindi

The languages that use Latin are very easy to adapt with few changes, however some languages that do not use Latin script for example Greek, Hebrew, Russian, Arabic etc…in this case the cells are generally assigned to the new alphabet according to their sound value in Latin alphabet. The alphabetic order of the national script is disregarded when that language is being transliterated in Latin. For example, in Greek, gamma is written as Latin g, despite the fact that it has the alphabetic position of gamma is c in the national order (alpha, beta and gamma). However there are some languages that do not maintain Latin sound values when they are making Braille compatible to their script and languages. These languages are Japanese *kana*, Korean *hangul* and the Tibetan Braille.

Greek Braille

The Greek alphabetical order changes when transliterated into Latin for Braille. 'Gamma,' has the third position in the national alphabetical order becomes seventh when adapted to Braille; thus getting the code for 'g' as assigned in the Standard English Braille. Similarly, 'zeta' has the sixth position in the Greek alphabetical order, but is given the code 'z' in Greek Braille. (Look at the example on the right-hand.)

Greek English

Α alpha = a

Β beta = b

Γ gamma = g

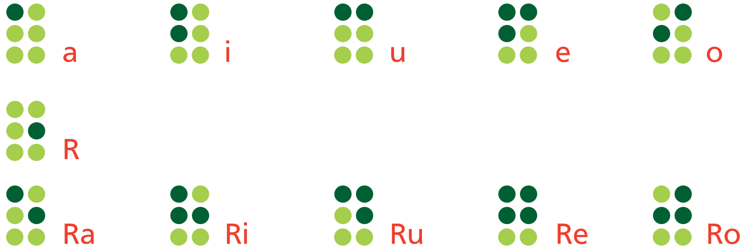
Δ delta = d

Ε epsilon = e

Ζ zeta = z

Japanese Braille

Basic Japanese Braille code is very logical because of the differences in phonology and orthography between English and Japanese, the code is very different. The coding uses the three dots in the upper left corner to represent a vowel and those in the lower right corner to represent a consonant which are combined to construct the syllable. (See example below.)



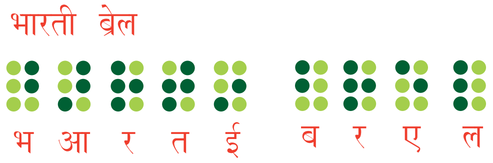
Bharti Braille in India

The adaptation of Braille to Indian languages is known as Bharti Braille. Educating the visually impaired in India had begun much before independence. Due to the complexities of the writing system in Indian languages,(they are phonetic in nature) Braille did not exist in the Indian context. After the conference held at Beirut in 1951, attended by world scholars, it was concluded that the possibility of adapting languages that are phonetic in nature did exist. This included Indian and South Asian languages.

It must be noted that *Bharti* Braille has taken the best approach to presenting Indian languages through conventional Braille, by using the phonetic equivalents from standard English Braille. However, since there are only 63 different combinations available, only the basic vowels and the consonants of the Indian languages, which are about fifty in number, have been accommodated. Ligatures or *mataras* have therefore been eliminated.

Bharti Braille assigns the cells to the basic sounds of the Indian languages (called *aksharas*) in a manner, where vowels and consonants that find direct equivalents in English are given the same representation as in English. It retains all the basic conventions relating to the representation of numerals, punctuation and special symbols just as in Standard English Braille. The problem that is faced is that since all the Indian languages share the same Braille representation, it will be difficult to identify when a language switch occurrs in multi-lingual texts. The issue is being debated and one of the cells might be used to indicate a change of context. Barring Hindi, Marathi and Gujarati, (which have some contraction) there are no contractions available in Bharti Braille. This would mean that Bharti Braille is written in grade-I system.

Bharti Braille assigns the cells to the basic sounds of the Indian languages (called aksharas) in a manner, where vowels and consonants that find direct equivalents in English are given the same representation as in English.



Braille Codes

Braille is also described as a code due to its nature. Infact it is also considered to be one of the first binary encoding schemes used to represent characters of a writing system. There are many codes that together form the writing system in Braille. Unified English Braille Code (UEBC) is an English Braille code which uses 8dots, Nemeth Braille (NC) is used for representing mathematics and scientific notations, GS8 Braille uses eight-dot Braille cells for encoding mathematical and scientific notation, Computer Braille Code (CBC) is used to read computer material and to communicate with computers when necessary. Braille music is used to represent musical notations as some of the main codes commonly used. Many languages having adapted Braille have formed codes for example Japanese Braille encodes the Japanese *hiragana* character, Cantonese Braille is used for the Cantonese language in Hong Kong and Korean Braille encodes the *Hangul* alphabet of the Korean language.

Universal Code for Braille

One of the limitations of the Braille system is that the number of existing print symbols exceeds the number of combinations possible by the original six-dot Braille system, which is restricted to a maximum of 64. This limitation has led to the development of different codes for literary, mathematical, music, and foreign language codes.

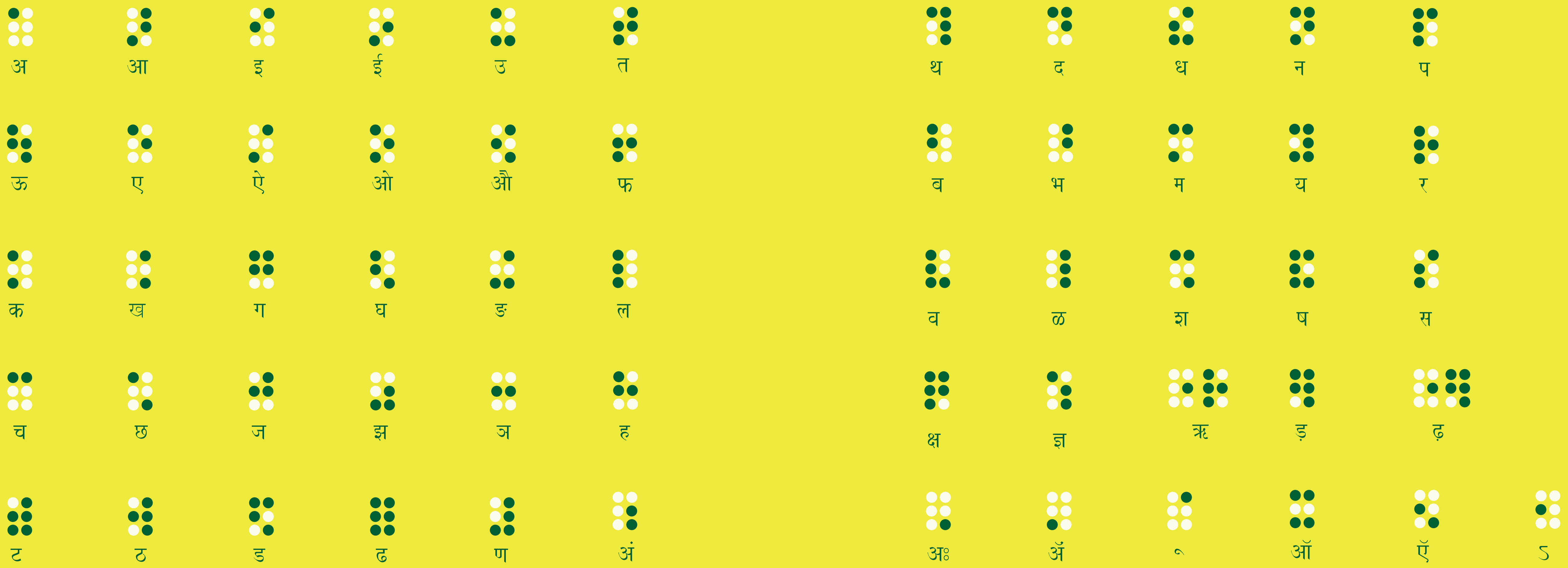
There is an urgent need to structure a universal code for Braille. However in many cases the proposed construction like the unified English Braille code (an 8dot system) has met with a lot of criticism from the community. One main criticism is with regard to mathematics and scientific notation; the unified Braille code disregards the existing code for mathematics and science which is the Nemeth Code.

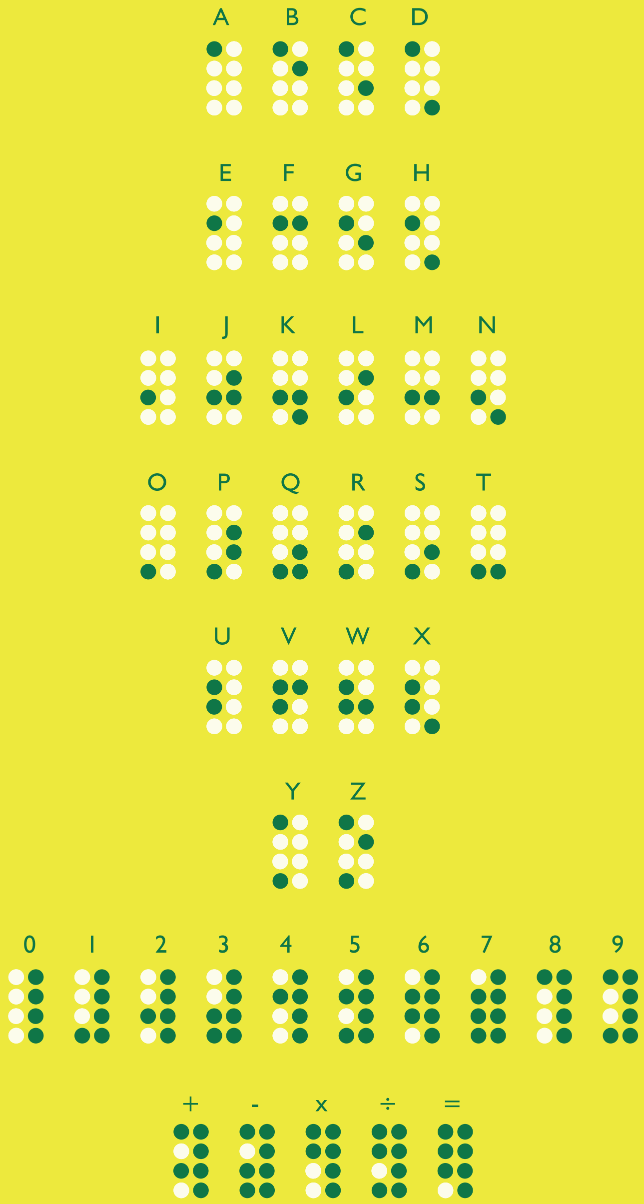
Another point is that languages across the world are different. However languages are essentially phonetic in nature. India , made a recommendation to UNESCO to consider a universal standard for Braille, based on a Phonetic representation of sounds using the six dot system.

The limitation with the Braille system is that the number of existing print symbols exceeds the number combinations possible by the original six-dot Braille system, which is restricted to a maximum of 64.

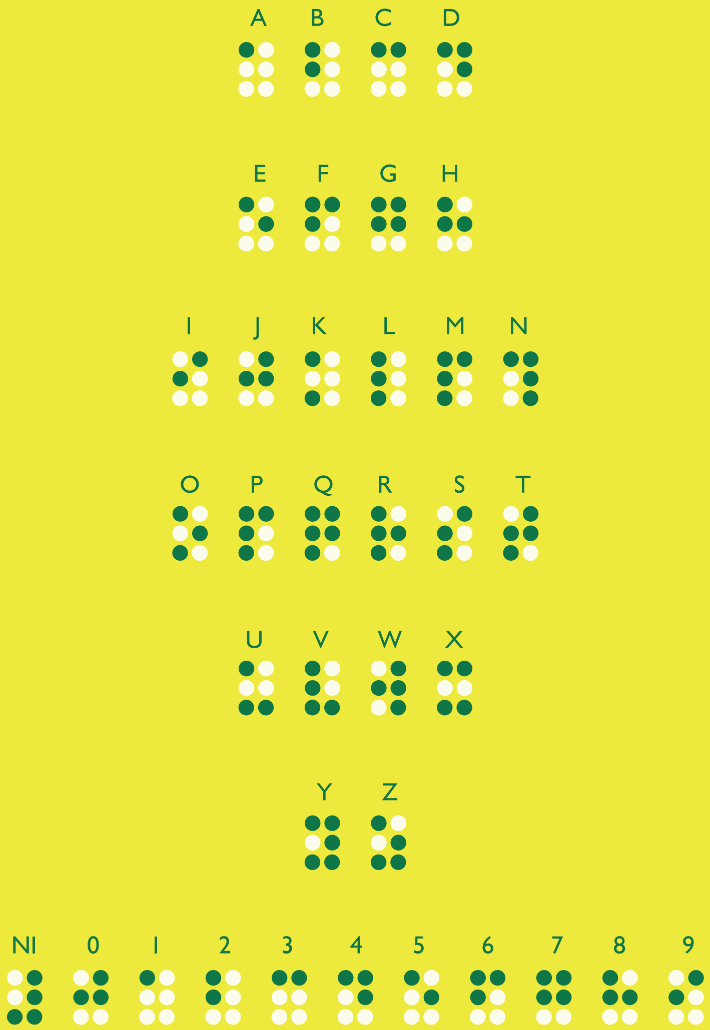
Bharti Braille

The adaptation of Braille to the Indian languages is known as Bharti Braille.



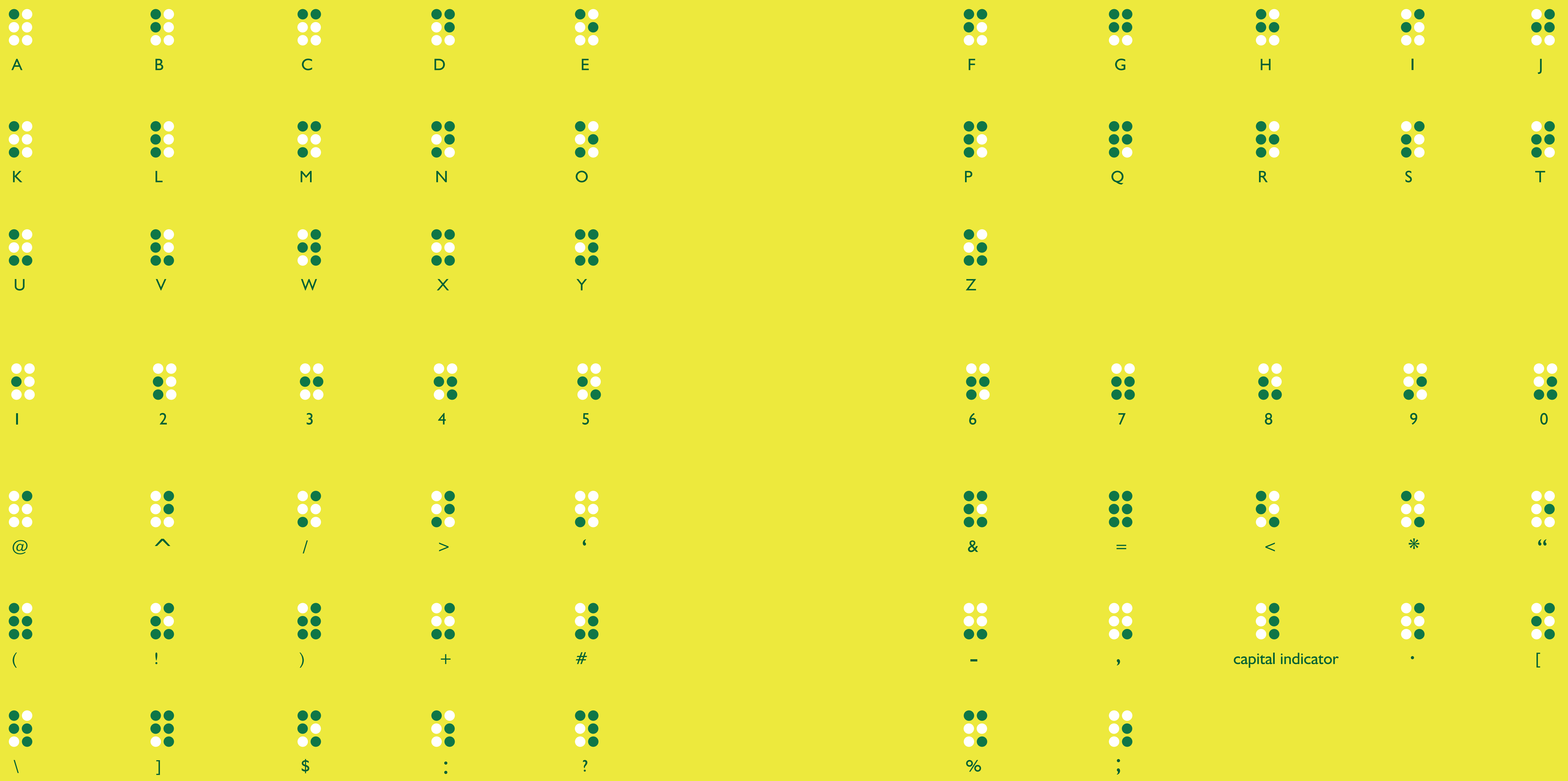


Unified Braille Code (8 Dot System)



Standard English Code

Computer Braille Code

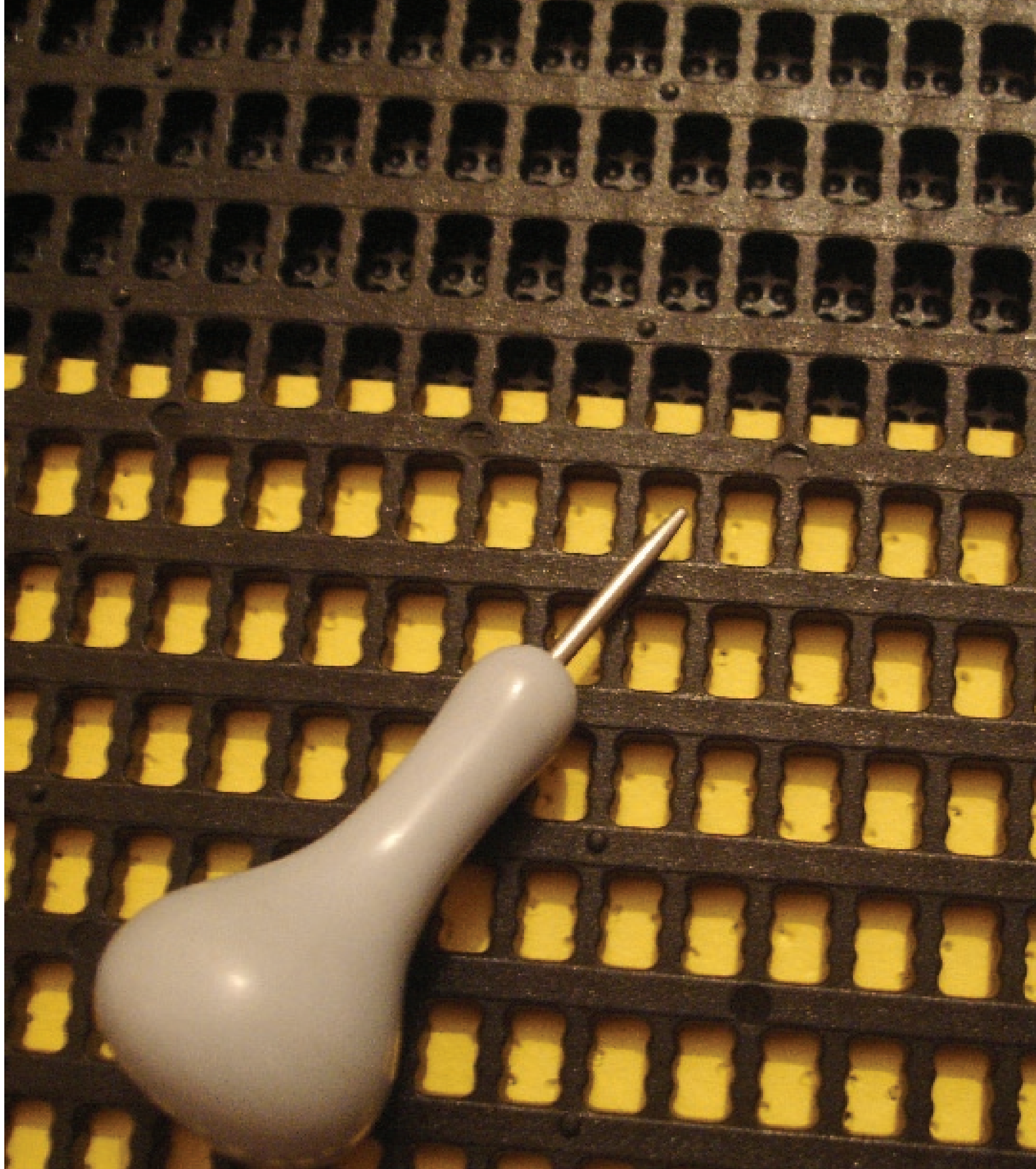


Tools used in Braille

Braille is produced using a number of different ways. The Braille slate and stylus is the oldest way of producing Braille text. It is the Braille equivalent of paper and pencil. Another tool used is the Perkins Brailler or simply the Brailler. This looks very similar to the typewriter. Technological developments in the computer industry have provided and continue to expand additional avenues of literacy for braille users.

The Braille slate and stylus is the oldest way of producing Braille text.

Software programs and portable electronic Braille note takers allow users to save and edit their writing, have it displayed back to them either verbally or tactually, and produce a hard copy via a desktop computer-driven Braille embosser. There are two methods of producing Braille on a computer: using the direct chordic Braille input and translation of files created by software, such as a word processing program. The direct input software (POKADOT, Edgar, etc.) changes the normal computer keyboard so that it will accept six key chordic Braille input, although not all keyboards will work this way. The "f" key is pressed for dot 1, the "d" key for dot 2, the "s" key for dot 3, the "j" key for dot 4, the "k" key for dot 5, the "l" key for dot 6 and the spacebar works normally. As in the case of the Braille writer, up to six "dot" keys are pressed simultaneously, creating one Braille cell for each keystroke. Of course, the person entering the Braille by the direct input or six key chordic Braille data entry method must know Braille code. The process of entering data is as follows; the material is entered into a computer by being scanned or typed. The files are then translated into Braille using one of the 9 translation programs, such as Duxbury or Megadots. The material is then proofread and corrected. No translation program is 100% accurate. Because of the rules of Braille, particularly those regarding contractions, some words may be incorrectly translated.



Mathematics for the Visually Impaired

"The value of an education ... is not the learning of many facts but the training of the mind to think something that cannot be learned from textbooks."
Albert Einstein

Learning mathematics and sciences have been a difficult challenge for visually impaired students. Since it is hard to provide the conceptual framework through mediums needed to solve mathematical and scientific problems, visually impaired students often shy away from choosing disciplines that require manipulation of graphic or symbolic information.

Nemeth Code

Reason for Nemeth Code

Standard Literary Braille Code does have its limitations. It was originally developed so that blind people could read but the original intentions missed out on mathematical and scientific notations in the Braille code. In the standard Braille code numbers "0" through "9" are equivalent to the first ten letters of the alphabet for example A is also written as 1. The numbers from 0 to 9 had the same symbol as A to J. To avoid confusion a numeric indicator[1] precedes the number distinguishing it from an alphabet. Even basic mathematical operations of addition, subtraction, multiplication, division and the equal-to sign did not exist[2]. This made education in mathematics not only difficult but almost impossible.

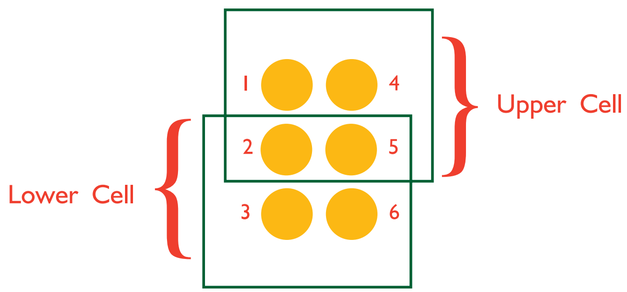
Nemeth Code

Nemeth code is a code developed for only mathematical and scientific notations. It is used for mathematics and science material only. For this purpose it has symbols that are not available in Literary Braille. It was developed by Dr. Abraham Nemeth as part of his doctoral studies in mathematics in the year 1946. It was in 1952, the Braille authority of North America (BANA) accepted the Nemeth Code as the standard code for representing math and science expressions in Braille. It provides a conceptual framework for the blind to use in solving higher mathematical equations.

[1]Braille indicators are a sign in Braille which does not correspond to any sign in other languages. The numeric indicator is one such Braille indicator. Refer to pg 12
[2] See Standard Braille Code.

The Nemeth Braille Code is not an expanded version of the Literary Braille Code; there are many significant differences. One noteworthy difference from the literary Braille code is that the numbers in nemeth code are not the same in both. The nemeth code uses the concept of the dropped or lower-cell numerals rather than the upper-cell ones.

Besides the numbers which are different, Literary Code contractions must not be used under certain circumstances, and some symbols are different. Besides the new symbols, the most significant difference is the use of context-dependent rules that require shifting back and forth between the Nemeth code rules which are applicable in a literary context and the Nemeth code rules which are applicable in a mathematical context. The Nemeth code rules used in a literary context are not identical to those for standard literary Braille although there are many similarities.



Lower Cell Numbers In Nemeth Code

Math code for India

Braille mathematics code for India was complied in the National Institute for Visually Handicapped (NIVH) in collaboration with National Association For Blind (NAB) as part of the project "Adoption and Introduction of an appropriate Braille Mathematics Code for India". A national workshop on "Adoption and Introduction of an appropriate Braille Mathematics Code for India" was held in September 1988 at NIVH, Dehra Dun. The workshop unanimously selected 'The Nemeth Braille Code for Mathematics and Science Notation-1972 revision' for adoption in India. One of the out comes of this project was a manual called Braille Mathematics Code for India. This manual is published by NIVH.

Dr. Abraham Nemeth[1]

Dr. Abraham Nemeth was born in1918 in New York City into a large family of Hungarian Jewish immigrants. He is blind from birth.

He attended public schools at first but did most of his primary and secondary education at the Jewish Guild for the Blind school in Yonkers, New York. His undergraduate studies were at Brooklyn College where he studied psychology. He earned a Master of Arts degree in Psychology from Columbia University.

Dr. Nemeth studied mathematics and physics at Brooklyn College but he did not major in mathematics because his academic advisors discouraged him. However, tired of what he felt were unfulfilling jobs at agencies for the blind, with encouragement from his wife, decided to continue his education in mathematics.

Nemeth taught part-time at various colleges in New York. Though his employers were sometimes reluctant to hire him knowing that he was blind, his reputation grew as it became apparent that he was a capable mathematician and teacher.

Nemeth distinguished himself from many other blind people by being able to write visual print letters and mathematical symbols on paper and blackboards just like sighted people, a skill he learnt as a child.

[1]*The above information is edited taken from www.wikipedia.com*

Nemeth says that it is this skill that allowed him to succeed in mathematics, in an era without technology, during which even Braille was difficult to use in mathematics. During the 1950s he moved to Detroit, Michigan to accept a position at the University of Detroit. He remained there for 30 years, retiring in 1985.

Nemeth continues to be an active, doing work on the code named after him. He has been active in the Jewish community since childhood, and since his retirement from academic mathematics he has been translating Hebrew prayer books into Braille. He is also an active member of the National Federation of the Blind; and has written several short stories and made speeches for the NFB about his life as a blind mathematician.

During his education, as the mathematics coursework became more advanced, he found that he needed a Braille code that would be more effective to handle the kind of math and science material he was now tackling. Ultimately, he developed the Nemeth Braille Code for Mathematics and Science Notation in 1952. The Nemeth Code has gone through four revisions since its initial development and continues to be in wide use today.

Dr. Nemeth is also responsible for the rules of Mathspeak, a system for orally communicating mathematical text. In the course of his studies, Dr. Nemeth found that he needed to make use of sighted readers to read otherwise inaccessible math texts and other materials. He also needed a method to dictate his work in math and other materials for transcription into print. The conventions Dr. Nemeth developed for efficiently reading mathematical text out loud have evolved into Mathspeak.

Dr. Nemeth was instrumental in the development of the Unified English Braille Code though he eventually parted ways with others developing the code and is currently working on a parallel effort which he calls the Universal Braille System.

Meanwhile, as the mathematical concepts, and therefore the notation, became increasingly intricate, I found that the braille techniques for expressing mathematical notation were either inadequate or non-existent just as my counselors warned me. Little by little, however, I began to improvise new braille techniques to make it possible for me to write down all the notation that was buzzing around in my head. My mother's early training in sending me to the grocery store was excellent, but there was a limit to one's mental capacity. Finally, I settled on a braille system that was both consistent and served my needs. One day, a colleague who was a nuclear physicist and who was blind asked me if I had a table of integrals. I told him that I had one, but that it was written in a private braille code that he would not be able to read. Would I brief him on the code, he implored; he needed the table of integrals desperately. Within a half hour, he was having no difficulty reading the table of integrals with all its fractions, radicals, superscripts, Greek letters, and all the other arcane notation involved. Impressed, he asked me to write up a short expository paper of how the code worked, highlighting its underlying principles. I complied, but the result was not as short as he had wished.

Dr Abraham Nemeth

TEACHING MATHEMATICS AS A BLIND PERSON

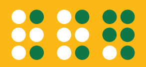
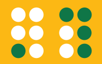
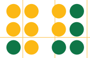
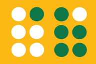
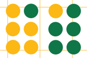
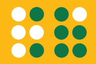
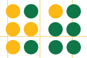
Nemeth Code for mathematical and scientific notations.

Nemeth Code

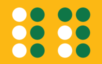
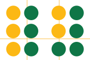
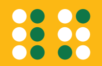
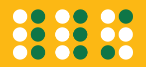
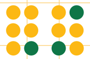
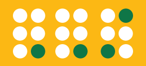
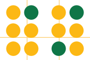
Asterisk	*
Mathematical Comma	,
Mathematical Ellipsis	...
Plus	+
Minus	-
Multiplication Cross	×
Multiplication Dot	·

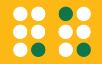
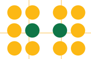
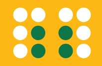
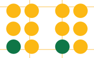
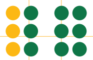
Divided By	÷
Is Equals To	=
Decimal Point	.
Radical (Square Root)	$\sqrt{\ }$
Index of Radical Indiactor	$i\sqrt{\ }$
Inner Radical Indiactor (first)	$\sqrt{\sqrt{\ }}$
Inner Radical Indiactor (second)	$\sqrt{\sqrt{\sqrt{\ }}}$
Inner Radical End (first)	

Nemeth Code

	Inner Radical End (second)	
	The NOT Operator	/
	Division (long)	
	Factorial	
	Simple Fraction (opening)	
	Simple Fraction (closing)	
	Complex Fractions (opening)	
	Complex Fractions (closing)	
	Round Brackets (opening)	(
	Round Brackets (closing)	)
	Square Bracket (opening)	[
	Square Bracket (closing)	]
	Curly Brackets (opening)	{
	Curly Brackets (closing)	}
	Hyper Complex Fractions (opening)	
	Hyper Complex Fractions (closing)	

Nemeth Code

	Fractional Part of a Mixed Number (opening)
	Fractional Part of a Mixed Number (opening)
	Diagonal Line used with Simple Fractions
	Horizontal Line used with Simple Fractions
	Diagonal Line used with Complex Fractions
	Horizontal Line used with Complex Fractions
	Horizontal Line used with Hypercomplex Fractions
	Since

	Therefore	
	Ratio	:
	Proportion (as)	: :
	Prime	
	Minute(of an arc)	′
	Second (Angular Measure)	″
	Infinity	∞
	Varies as	

Nemeth Code

Degree	°
Percentage Sign	%
Checkmark	✓
Punctuation Indicator	
Superscript Indicator	
Subscript Indicator	
Baseline Indicator	
Omission Indicator	

Cancellation Indicator (opening)	
Cancellation Indicator (closing)	
Run Over Indicator	
Directly Over Indicator	
Directly Under Indicator	
Begining Indicator	
Termination Indicator	
Is Greater Than	>

Is Less Than	$<$
Is Greater Than or Equal To	$\geq$
Is Less Than or Equal To	$\leq$
Bar Over Greater Than	$\overline{>}$
Bar Over Less Than	$\overline{<}$
Numeric Indicator	
Less Than or Equal to (2nd form)	
Greater Than or Equal to (2nd form)	

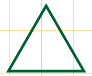
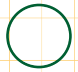
Is Equal to or Less Than	$>$
Is Equal to or Greater Than	$>$
Is Greater Than followed by Less Than	$><$
Is Less Than followed by Greater Than	$<>$
Is Greater than followed by equal to followed by less than	$>=<$
Is Less than followed by equal to followed by Greater than	$<=>$
Is not Equal to	$\neq$
Is not Greater than	$\ngtr$

Nemeth Code

Name	Symbol
Single Tilde (is related to)	∼
Double Tilde (is related to)	≈
Equals sign under Single Tilde	
Plus or Minus	±
Minus or Plus	∓
Is Parallel to	∥ ∥
Is Perpendicular to	⊥
Angle	∠

Name	Symbol
Angle (Right Angle)	∟
Arc upwards	◡
Arc downwards	◠
Quardilateral	
Square	□
Rectangle	▭
Parallelogram	▱
Rombus	◇

Nemeth Code

Name	Symbol
Trapezium	
Triangle - Equilateral	
Triangle - Right Angled	
Circle	
Ellipse	
Arrow - Right Pointing	→
Arrow - Left Pointing	←
Arrow - Pointing Upwards	↑
Arrow - Pointing Downwards	↓
Short right pointing arrows	
Two way Arrow	↔
Arrows in Reverse	⇌
Implication	⇒
Sine (sin)	
Cosine (cos)	
Tangent (tan)	

Secant (sec)	
Cosecant (cosec)	
Cotangent (cot)	
Logarithm (log)	
Alpha	
Beta	
Gamma	
Delta	

Theta	θ
Mu	μ
Nu	ν
Pi	π
Rho	ρ
Sigma	σ
Omega	ω
Capital Sigma	Σ

Capital Delta	Δ
Epsilon	ϵ
Lambda	λ
Upsilon	υ
Phi	φ
Is a element of (membership)	ϵ
Reverse membership (contains the element)	϶
Is a subset of	⊂

Reverse inclusion (contains the subset)	⊃
Union of (sets)	∪
Intersection of (sets)	∩
The null set	∅
Empty set (another indication)	{ }
Bar Under Inclusion	
Bar Under Reverse Inclusion	
Circle with interior plus sign	⊕

Nemeth Code

Circle with interior cross	⊗
Square with interior dot	⊡
Intersecting lines	
The at symbol	@
Ditto symbol	
Tally mark	|
Plus Minus	+-
Minus Plus	-+-

Such that	
Bar under single Tilde	
Identity (is identical with)	≡
Vertical Bar	|
Horizontal Bar	—
Vertical Bar used in Modulus	| |
Dot	.
Regular Pentagon	

Nemeth Code

Irregular Pentagon

Regular Hexagon

Irregular Hexagon

Heptagon

Octagon

Nonagon

Acute angle

Obtuse angle

Triangle acute

Triangle Obtuse

Triangle Scalene

Paragraph Sign ¶

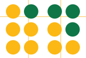
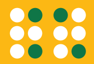
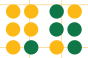
Section Mark

Hexagonal Star

General Reference indicator

Italics Font mark

Nemeth Code

	Bold sign mark	
	Letter sign (english)	
	Integral sign	∫
	Partial Derivatve sign	∂
	Composite Function	
	Matrix or Determination	

"I attended the regular New York City Public School System during my grade school and high school years. In these schools, there was one room called a resource room staffed by a teacher trained in blindness skills. I attended regular classes with my sighted friends for such subjects as geography, history, arithmetic, and spelling, but when the subject was art or penmanship, I returned to the resource room where the teacher taught me braille, typing, and other skills of blindness. I was a competent typist by the age of nine.

I was always interested in mathematics, even in elementary school. But when I entered Brooklyn College, I heeded the advice of my counselors who told me that a field like psychology was much more realistic for a blind person than mathematics. Accordingly, I followed their advice and in due course received an M.A. degree in psychology from Columbia University. But I couldn't get math out of my system"

Dr Abraham Nemeth from Teaching Mathematics as a Blind Person

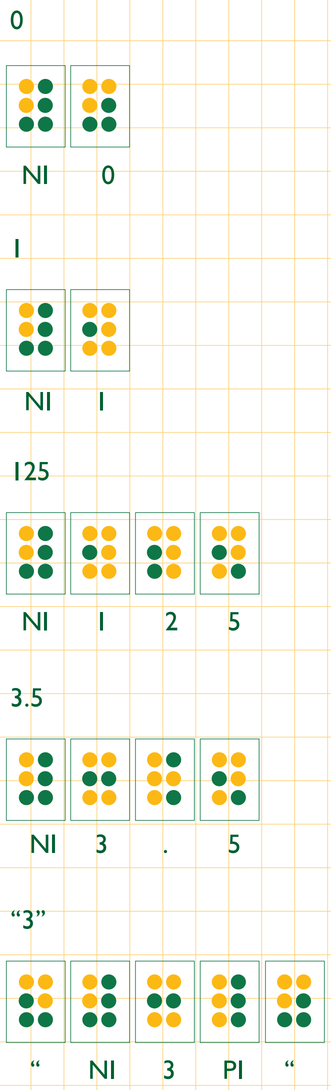
Illustrating Nemeth Code

Braille mathematics code for India is a book prepared under the project 'Adoption and Introduction of an appropriate Braille Mathematics Code for India' it is published by National Institute for Visually Handicapped Dheradun and National Association for the Blind, India. This book can be attained from both these places.

There are some important examples and rules that I have selected from this book for the reader to visualize and understand.

The numerals are represented in the lower portion of the Braille cell. However, numerals on the title page and at the corners of page must be transcribed as in English Braille.
The numeric indicator must be used at the beginning of a Braille line or after a space.
The numeric indicator must not be used in table and in a work arranged in column.

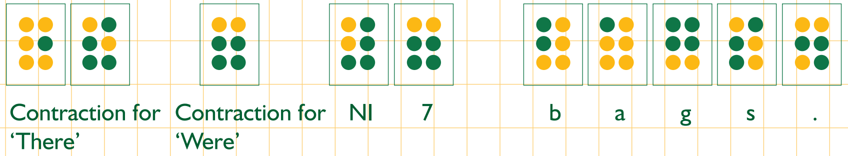
NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator



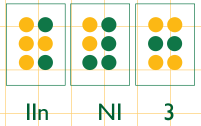
Illustrating Nemeth Code

NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator

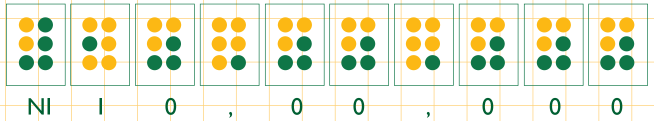
There were 7 bags.



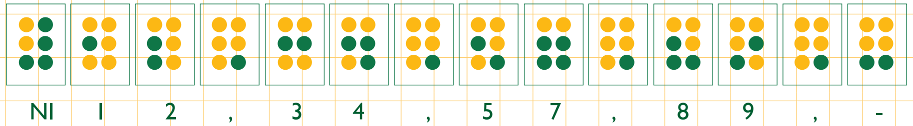
3

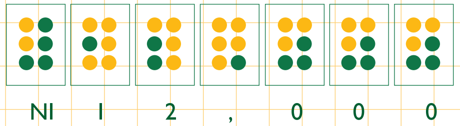


10,00,000



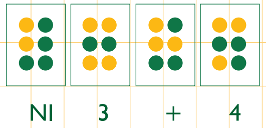
12,34,57,89,12,000



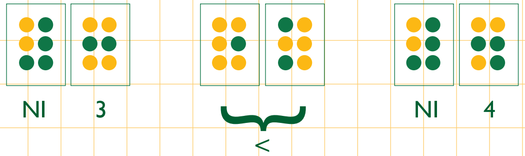


If a number is too long to be accomodated in a single braille line , it is divided at the end of the first line by putting a hyphen.

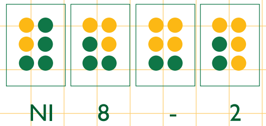
3 + 4



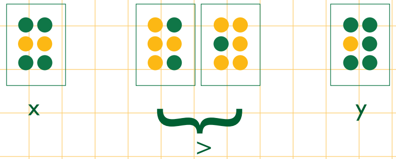
3 < 4



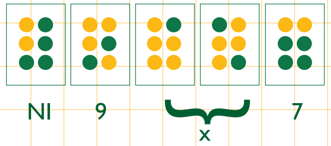
8 - 2



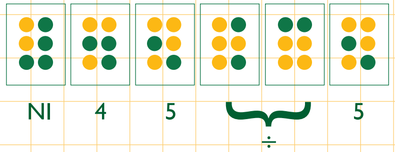
x > y



9 x 7



45 ÷ 5

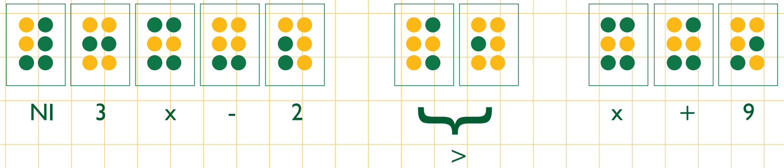


The sign for addition, subtraction, multiplication (cross), multiplication (dot) and division are operation signs. No space must be left either before or after them.

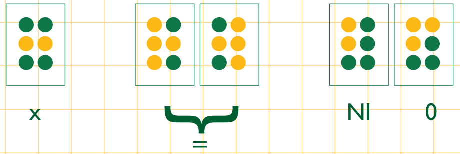
The signs for 'is equal to', 'is greater than' and 'is less than' are comparison signs. A space must be left both before and after them.

NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator

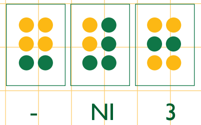
3x - 2 > x + 9



x = 0



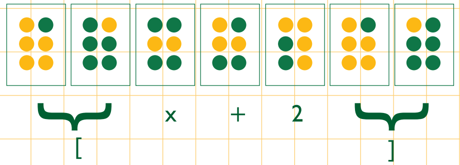
-3



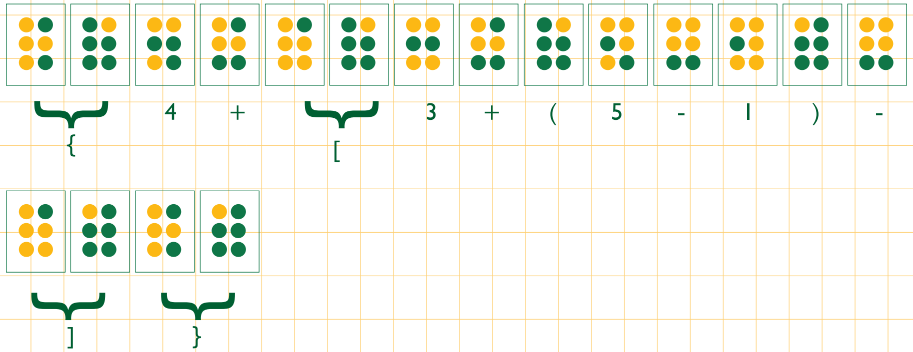
The numeric indicator is used after the subtraction sign which occurs at the beginning of a Braille line or which follows a space.

The signs for paranthesis must be used both for literary and mathematical purposes.
The signs for parenthesis in English Braille, however, are used to enclose literary ,matter on title pages.

[x + 2]



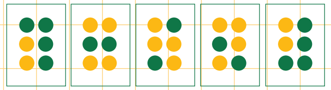
{ 4 + [3 + (5 -1)] }



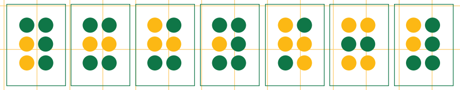
NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator
FI-o - Fraction Opening Indicator
FI-c - Fraction Closing Indicator
MFI-o - Mixed Fraction Opening Indicator
MFI-c - Mixed Fraction Closing Indicator
ELI - English Letter Indicator

A Simple fraction is one whose numerator and denominator contain no fraction.
The indicator for a simple fraction must not be used when the expressions on either side of the diagonal line appear in the same level and are of the same size and type.
Mixed number is an expression which begins with a numeral and is followed by a simple fraction whose numerator and denominator are both numerals.
A spatial arrangement is preferred when a fractional notation is to be introduced to the reader, particularly in the lower grades.

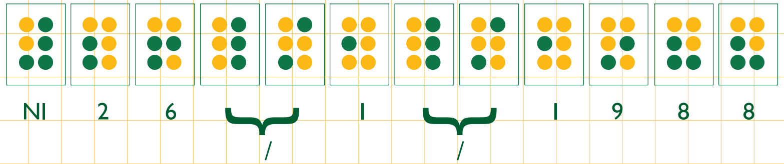
$\frac{3}{5}$



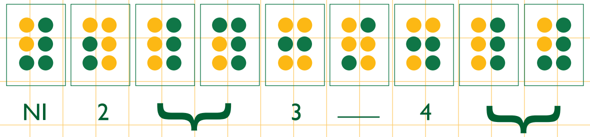
$\frac{x + y}{3}$



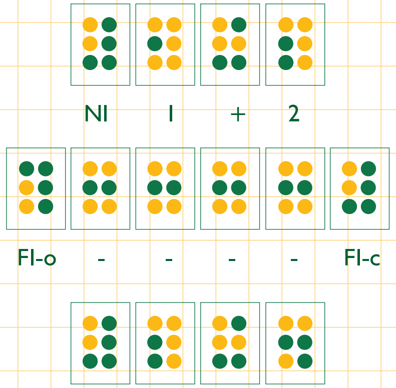
26/1/1988



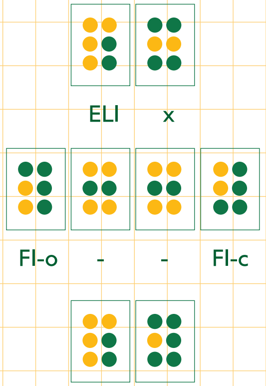
$2\frac{3}{4}$



$\frac{1 + 2}{2 + 4}$



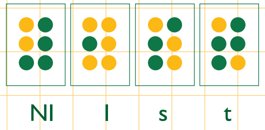
$\frac{x}{y}$



NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator
ELI - English Letter Indicator
CeLI - Capital English Letter Indicator

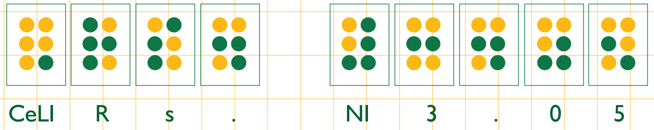
Units of currency, weight, length and capacity are generally expressed in the form of abbreviations. All these abbreviations must be represented in Braille as they appear in ink-print.
If the abbreviations consists of a single letter and is followed by a full stop, the English letter indicator must not be used before it.
A space must be left between an abbreviation and an operation sign.

1st

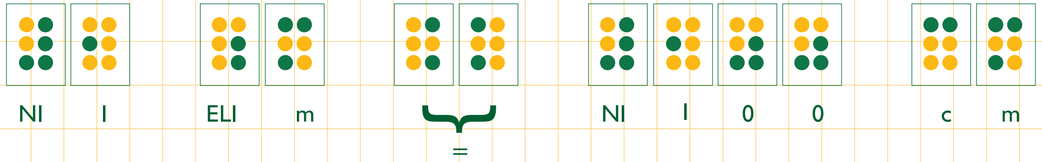


'st' must not be contracted

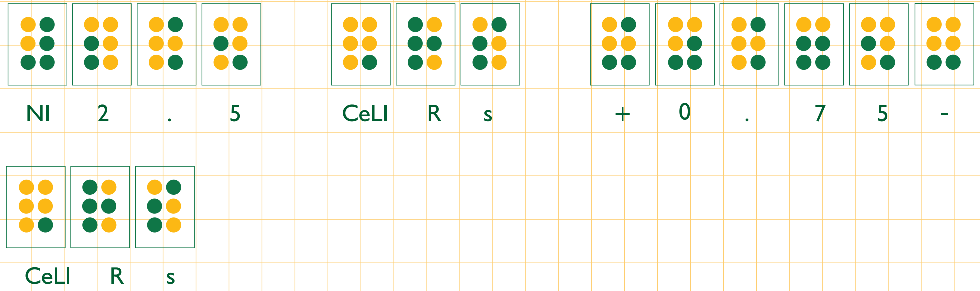
Rs. 3.05



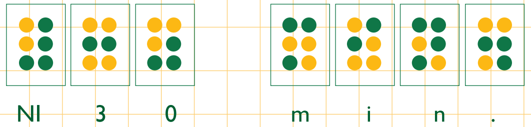
1 m = 100 cm



2.5 Rs + 0.75 Rs

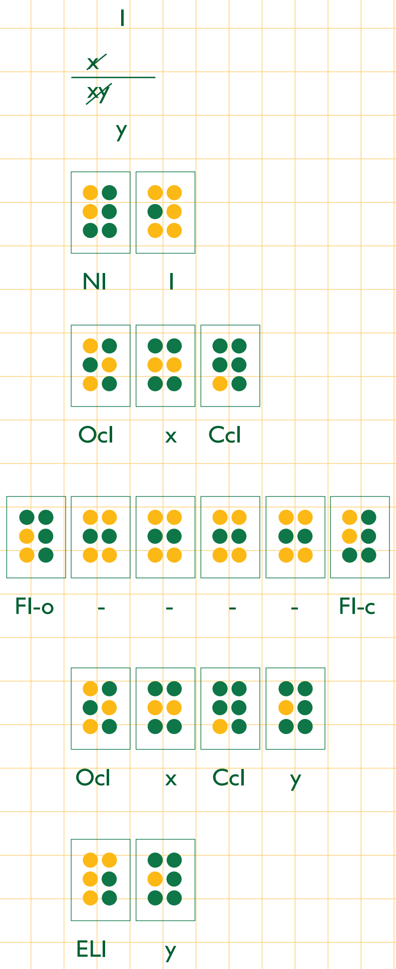


30 min.



NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator
FI-o - Fraction Opening Indicator
FI-c - Fraction Closing Indicator
MFI-o - Mixed Fraction Opening Indicator
MFI-c - Mixed Fraction Closing Indicator
ELI - English Letter Indicator
OcI - Opening Cancellation Indicator
CcI - Closing Cancellation Indicator
SI - Shape Indicator

The signs for brackets must be used both for literary and mathematical purposes. The signs for brackets in English Braille, however, are used to enclose literary-matter on title pages.

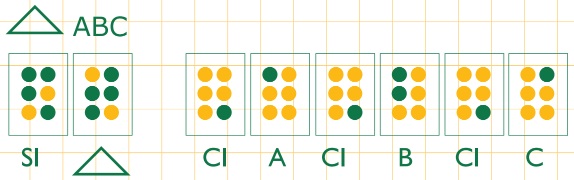


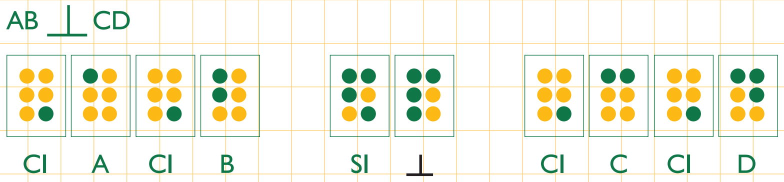
NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator
ELI - English Letter Indicator
OcI - Opening Cancellation Indicator
CcI - Closing Cancellation Indicator
SI - Shape Indicator

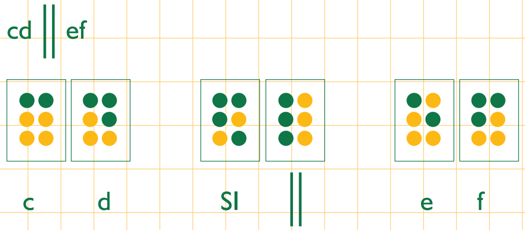
A shape is a sign which is a miniature picture or a diagram of an object.

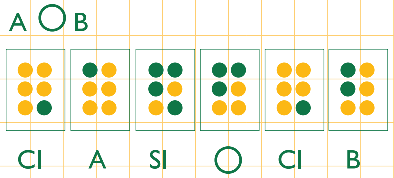
A sign of shape must be used only for the representation of the corresponding sign in ink-print. It must never be used for its name in word or phrase.
(a) A shape must be left between a shape sign and its identification, a letter, a sequence of letters or a number.
(b) Signs of shape which are either comparison signs or operation signs must be spaced accordingly.

A space must not be left between a Braille indicator and associated shape sign.







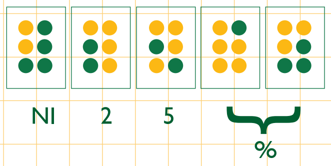


A space must not be left between a Braille indicator and associated shape sign

NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator
ELI - English Letter Indicator
OcI - Opening Cancellation Indicator
CcI - Closing Cancellation Indicator
SI - Shape Indicator

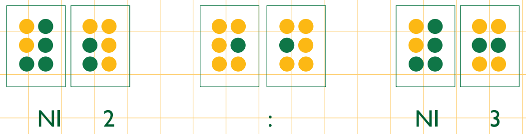
A combination of two or more signs appearing one below the other is called a vertically compounded sign. When the combination is represented in the same line one followed by other it is called horizontally compounded sign.
A compound sign must be regarded as one sign and must be represented in one Braille line only.

25%



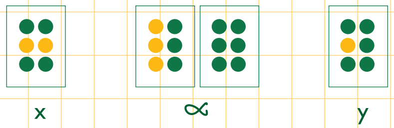
Percentage sign does not precede a space

2 : 3



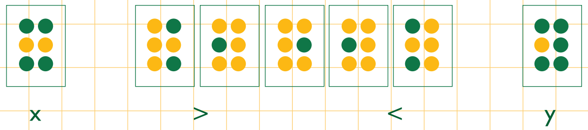
Ratio and proportion signs are compound signs. A space must be left before and after them.

$x \propto y$



Variation is a comparison sign

$x >< y$

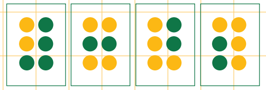


Illustrating Nemeth Code

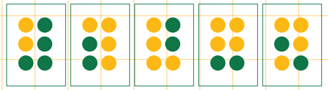
NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator
ELI - English Letter Indicator
OcI - Opening Cancellation Indicator
CcI - Closing Cancellation Indicator
SI - Shape Indicator

In an expression such as x^2, x is written in the normal line and 2 is written in the upper level, slightly on the right side. The level of x is called a base line level or reference level and the level of 2 is known as a superscript level.

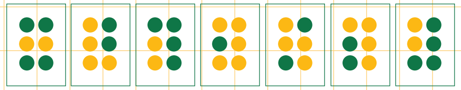
3^2



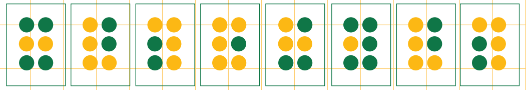
2^{-5}



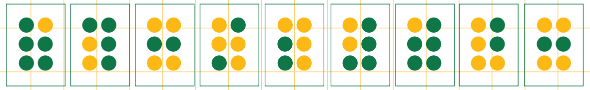
$\frac{1}{x^2}$



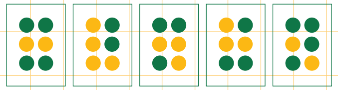
$X^2 + Y^2$



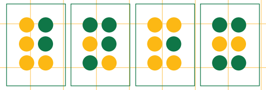
$(\frac{3}{2})^3$



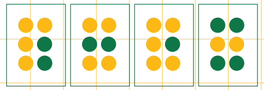
X^{m+n}



${}^{n}X$



${}_{3}X$



NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator
ELI - English Letter Indicator
Sup - Superscript
Sub - Subscript
Bs - Baseline
TI - Termination Indicator
RIiR - Radical Indicator index of Radical
firI - first Inner Radical end Indicator
ORfir - Order of Radical First Inner Radical End Indicator

When the square root sign has a vinculum (horizontal bar), follow the three step as given below:

(1) The radical sign

(2) The expression to which it applies

(3) The terminator indicator

Radicals with index other than 2 require a specific index. While transcribing, follow the steps as given below:

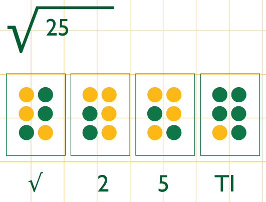
(1) The index-of-radical indicator.

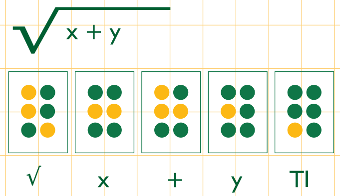
(2) The index of the radical

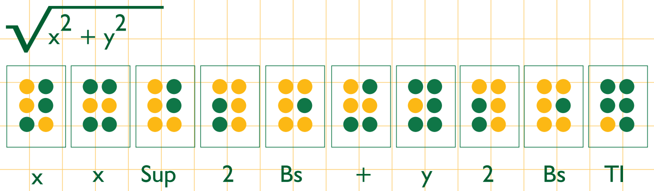
(3) The radical sign

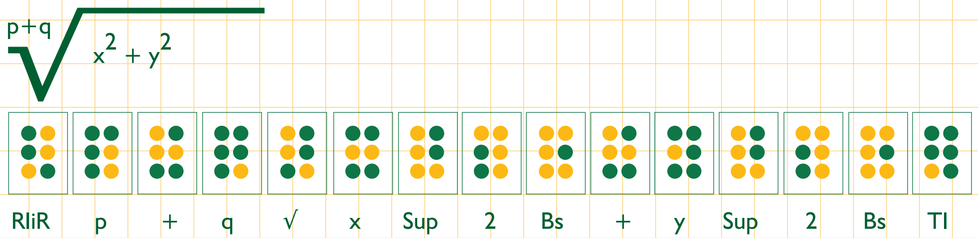
(4) The expression to which it applies.

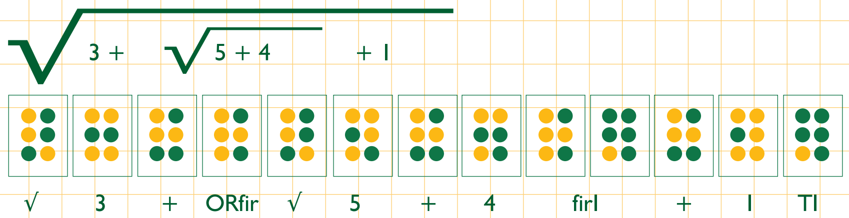
(5) The terminator indicator









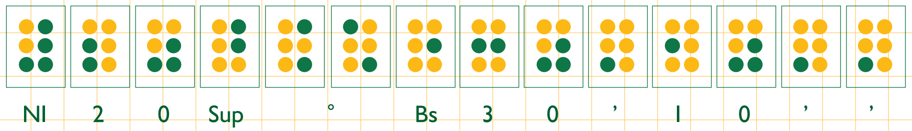


NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator
ELI - English Letter Indicator
Sup - Superscript
Sub - Subscript
Bs - Baseline

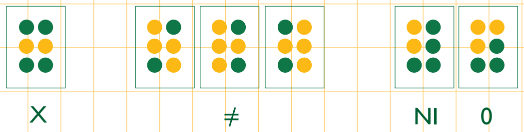
A comparison sign in negative by putting dots 3-4 before it without a space. In ink-print it is represented by a vertical stroke or by an oblique stroke in either direction.

Only a few negated comparison signs are mentioned in this chapter. Other such signs can be constructed in the similar manner.

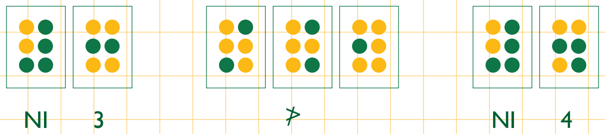
20° 30' 10"



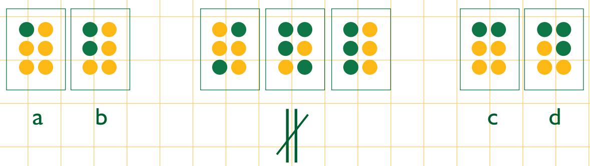
X ≠ 0



3 ≯ 4



ab ∦ cd



NI - Numeric Indicator
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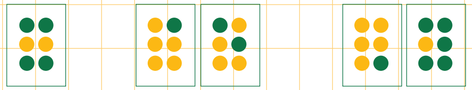
IIn - Italics Indicator
ELI - English Letter Indicator
Sup - Superscript
Sub - Subscript
Bs - Baseline

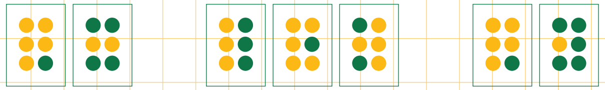
A sign for union and intersection are operation signs. A space must not be left before and after these signs.

The other signs are comparison signs. A space must be left before and after these signs.

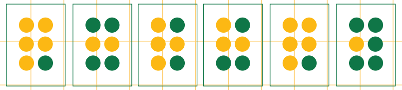
x ∈ Y



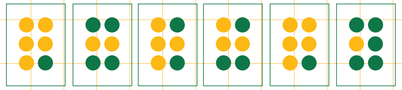
X ⊂ Y



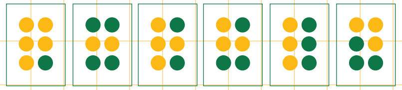
X ∪ Y



X ∩ Y



X = ø

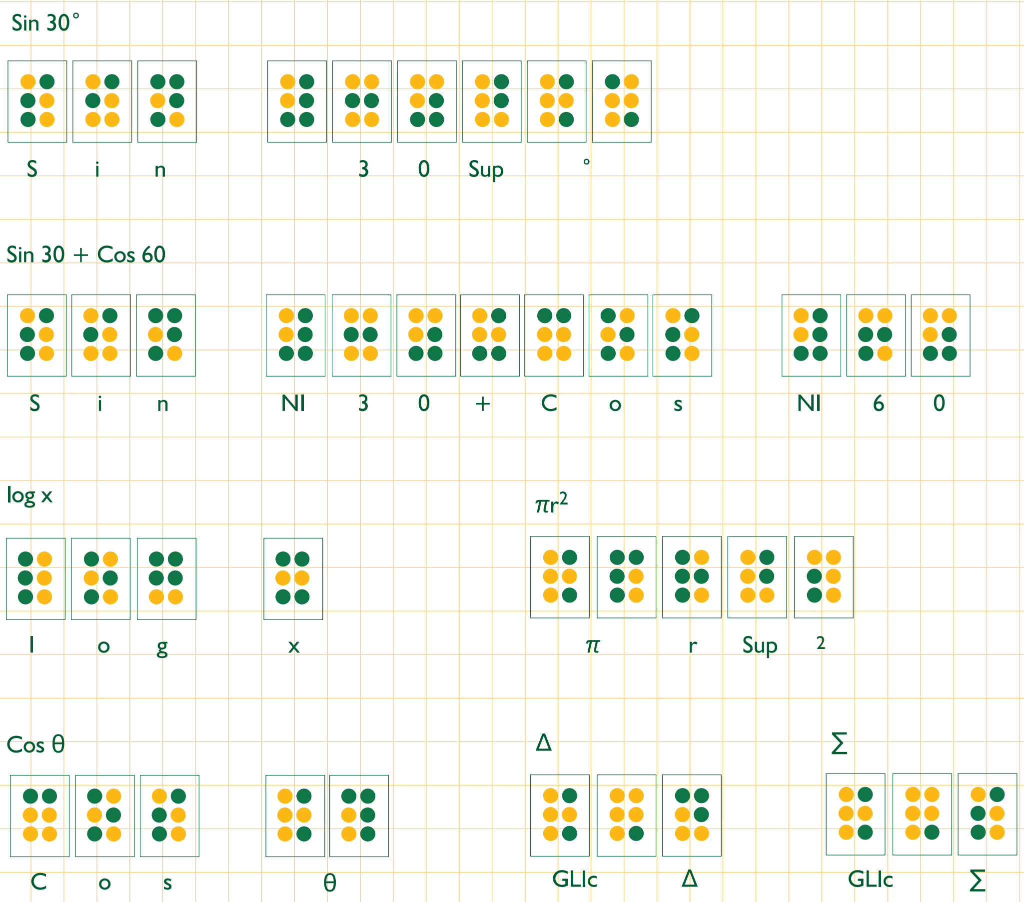


Illustrating Nemeth Code

NI - Numeric Indicator
PI - Punctuation Indicator
IIn - Italics Indicator
ELI - English Letter Indicator
Sup - Superscript
Sub - Subscript
Bs - Baseline
GLIc - Greek Letter Indicator Capital
GLIs - Greek Letter Indiactor Small

Trigonometric ratio and logarithm are functions. The function name and its abbreviation with or without a superscript is followed by a space.

When Greek letters occur in sequence, each Greek letter must be preceded by an appropriate indicator.



Contractions and Short-Form Words

(A) Contractions and short form words must not be used as part of a word, or abbreviations when it is in direct contact with it.

(i) Any mathematical sign or expression including the general omission sign and single letter.

(ii) Any comparison sign, even though there is a space between it and the word, part word or abbreviation.

(B) Contractions must not be used in abbreviated function names or unabbreviated function names, provided that the latter occurs in a mathematical context. In the following examples, words which are underlined must be written in grade I English Braille.

Examples

1) ten ? four = six (here ten and four cannot be contracted)

2) $\frac{\text{distance}}{\text{Time}}$ = rate (here distance and time cannot be contracted)

(C) The contraction for 'to', 'into' and 'by' must not be used before,

(i) Any mathematical sign or expression including the general omission sign and a single letter.

(ii) Any abbreviation which consists of one letter or a combination of letters corresponding to a short-form word.

(iii) Any Roman numeral, brackets, Reference Sign

(iv) A sequence of more than one letter in which each letter has a separate identity.

(v) Any abbreviated function names or unabbreviated function names, provided that the latter occurs in a mathematical context.

When the contraction for 'into' may not be used the contraction for 'in' may nevertheless be used in 'into' unless otherwise prohibited.

Examples

1) From a to z. (here 'to' cannot be contracted)

2) Divided by √3. (Here 'by' cannot be contracted)

(D) The one-cell whole word alphabet contractions for 'but', 'can',…,'you', 'as' and the one-cell lower-sign whole-word contraction for 'be', 'enough', 'were', 'his', 'in', 'was', whether capitalized, italicized, or neither, must not be used when these words are in direct contact with any bracket. The contractions, whole-word or part-word, for and', 'for', 'of', 'the', 'with', whether capitalized, italicized, or neither, must also not be used when in direct contact with any brackets. If any punctuation intervenes between a bracket and any contraction of the types mentioned above, the rule still applies. When this rule precludes the use of a contraction in one part of a word, no part of the word may be contracted.

(E) Contractions must not be used when they are likely to be mistaken for mathematical expressions.

(F) In the case where transition to another Braille line has been made, contraction must not be used if they could not have been used without the transition.

(G) In the case of an expression containing a hyphen or dash, only that portion between the hyphen or dash and the item with which direct contact is made is subject to the rules above.

Tools are helpful in carrying out and accomplishing a task. The visually impaired use several devices and tools that aid their learning and accessibility. Tools used to understand and aid in learning mathematics can be divided into three categories, writing tools (which also aid general writing of Braille, example Braille slate and Perkins brailler). The other category into which tools fall, are tools that help in calculation. Fine examples of it are the math board or Taylor's frame, abacus and the talking calculator. Some tools help in understanding basic shapes and assist in the making and understanding diagrams and graphs. Example, a geometry kit, mesh board, Pragna's sketching device etc. In recent times the computer has become a popular tool for higher mathematics. Screen reading software like JAWS help the visually impaired to use the computer independently. These devices and tools have made mathematics relatively accessible for the visually impaired.

In India there are two main institutions National Institute for Visually Handicapped (NIVH) and Worth Trust that manufacture assistive devices for the visually impaired. The devices range from educational devices, mobility devices, vocational devices, devices for daily living assistance, low-vision devices and entertainment devices.

The Braille Slate

A Braille slate is the oldest, most popular device to write Braille text. This tool was developed by Louis Braille. The Braille slate and stylus are considered equivalent to pen and paper for print-disabled people.

The slate

Upper sheet

The slate has two plastic or metal sheets hinged together. The upper sheet has Braille cell shaped holes, evenly spaced. Which ensures uniform spacing between lines and individual Braille characters. The curved shape of the cell also helps in embossing the right dot number.

Lower sheet

The Lower sheet has a template with evenly spaced indentions for the dots of braille cells that help in embossing; these indentions in the lower part ensure uniform height of the embossed dots. The Braille cell shaped hole on the upper sheet rests over the lower sheet in such a way that the two aid the writing of the dot combination in a Braille cell.

The paper is placed between the two sheets. With the help of a stylus the dots are embossed.

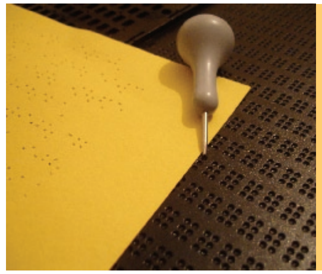
The stylus

The stylus is like a pen with a small, rounded point about the size of the tip of a ball-point pen at one end and a big plastic top on the other to grip the stylus. Tactile dots are made by pushing the pointed end of the stylus into the paper over the depressions and the paper bulges on its reverse side forming "dots." The top of the stylus comes in a variety of shapes that suit different holding styles of the user.

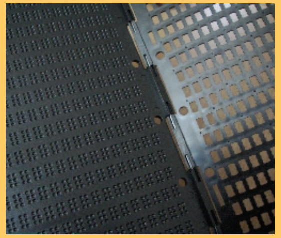
Writing with the slate

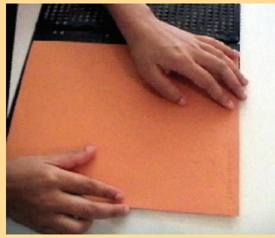
The user writes from right to left (backwards), so that the braille will be read from left to right when the braille paper is removed from the slate and turned over.

A Braille slate is the oldest and most popular device to writeBraille. This tool was developed by Louis Braille









Role of a slate and stylus in an education system of visually impaired

As mentioned earlier, the slate and stylus are an indispensable part of education for a visually impaired person. The importance of the tool can be compared to a pen or pencil for their sighted counterparts. It is the only writing tool for visually impaired, which is portable and convenient. This gives them the independence to document notes and expressions any time at any place.

Advantages

• Due to their portability, the slate and stylus are especially helpful for taking notes during lectures, for labeling things as file folders, cassettes etc…

• The device is inexpensive and easily accessible.

• Slates are very durable products and last for a fairly long duration.

• It is manual and does not rely on any kind of power or batteries..

• They come in a variety of sizes.

Limitation

• The Braille slate makes noise while embossing.

• The Braille slate writes in a mirror image format. This becomes very difficult to pick up for people who begin Braille very late.

• There is no immediate reference point to know what has been written.

• Opening the Braille slate and removing the paper each time to read is a very tedious method. Though the tool has the provision of grooves for the paper, the paper has a tendency of shifting. In this case it is difficult to place it back and continue writing. There is no way to correct your mistake immediately.

• While writing faster the stylus tends to hurt the users fingers.

Types of Braille slates

The three basic types of Braille slate which are available in India. They can be acquired in NIVH Dehra dun or Worth Trust, Katpadi.

These are the three types that are available in NIVH

• Wd-05 Braille Slate Small: Laminated top with 14 lines and 28 cells in each row with a stylus. It is very useful for beginners.

• WD-05 Braille Slate–large: Laminated top with 18 lines, 36 cells in each row with a stylus

WD-06 interpoint Braille Slate: Plastic make 27 lines and 30 cells in each row, in the size of A4, there is a provision for writing inter-point Braille with a stylus.

From Judy Dixon's Collection[1]

Limitations of the existing tool is discussed below in categories

Materials:

• Sturdy metals are heavy;

• Light metals bend easily;

• Light anodized metals generally have a slight texture which reduces writing speed and comfort;

• Many plastics become brittle;

• Some materials can contribute to slate noise; and

• Hard materials are slippery on writing surface.

• Materials should be selected and combined in such a way economy, comfort, and stability can be achieved.

[1]During my research I came across a collection of Braille slates by Judy Dixon's. Any one doing work in the Braille slates or manual writing device this website is a must visit. It has a user perspective and knowledge regarding the Braille slate. I have made a summary of what I have managed to gather from my research from this website. Judy Dixon's website: www.brailleslates.com, http://www.brailleslates.org/exhibit.htm





Examples

A solid brass front providing stability and allowing for smooth, fast writing and a lightweight aluminum back reduces the overall weight.

A light aluminum front and a plastic back.

There is a thin sheet of rubber on the underside of the back inserted for quieter writing.

The Hinges

Curled hinges are very expensive. In some slates the hinges have been riveted to the outside of the two plates and in some to the inside of the two plates. One of the slates shows a hinge made from a piece of sturdy tape with a very thin dowel rod in the center for stability. One of the slates has a curled hinge at the top of the slate. This eliminates the need for a precise size of paper for interpoint braille.

The Pins

Pins are meant for holding the paper in place and are placed on the inside of the bottom portion of the slate.

Problems with the pins

- Pins often require excessive dexterity to position correctly
- Pins are time-consuming to position
- Pins tear paper resulting in an untidy appearance

Thus they should be modified for utility and tidiness. For example some show a slightly raised frame around the perimeter of the bottom portion that holds the paper in a fixed position. Some slates do not use a pin altogether by permanently fusing the front and the back with an opening at one end into which a card can slide. In some slates there are hinged magnets mounted on the underside of the front portion at the top and bottom of this full-page slate. The magnets on the front allow the back portion to be swung away without disturbing the paper so that it can be read easily.

Line numbers

As seen in Indian Braille, line numbers play an important role in locating oneself on the board.

Movable Line Guide

One of the features in some Braille slates is a small bar across the front of the slate that is attached at one side and has a knob for grasping. The bar can be positioned at any line to keep track of the last line written.

Folding board

Some boards fold inwards and have slots for storing two slates and a stylus. The folded board is held closed with a magnet.

Perkins Brailler

Braillewriter or Perkin's Brailler is an equivalent to the typewriter. It can be both a manual and electronic device.

The Perkins Brailler was first produced in 1951 by David Abrahams, a woodworking teacher at the Perkins School for the Blind. The director of the Perkins School for the Blind, Gabriel Farrell, asked Abrahams to create an inexpensive and reliable machine which would allow students to write Braille easily. Farrell and Abrahams worked with Edward Waterhouse, who was a math teacher at Perkins, to create the design for the Brailler.

The Perkin's Brailler has six keys which correspond to the six dots of a Braille cell, a space bar, a backspace key and a line space key. Like a manual typewriter, it has two side knobs to insert paper through the machine and a carriage return lever above the keys. The rollers that hold and insert the paper have grooves designed which help avoid crushing the raised dots the Brailler creates.

Dot 1 is pressed with the index finger of the left hand, dot 2 with the middle finger and dot 3 with the ring finger. The index finger of the right hand is used to press dot 4, dot 5 is pressed by the middle finger and dot 6 with the ring finger. The spacebar, backspace key, and a line space key is operated with the right or left thumb as convenient.

The paper is inserted into the Perkins Brailler. To write the symbol required, the dot combination corresponding to the symbol or character is pressed simultaneously. For example, if you want to write the character 'y' then the keys corresponding to the dots 1,3,4,5 and 6 have to be pressed together at the same time, then the alphabet 'y' will get embossed on the inserted paper. At the end of the line a bell rings indicating that the carriage return lever needs to be changed.

Advantages

The most important advantage of the Perkin's Brailler is that the characters appear the same way that they are read. Writing Braille with Perkin's Brailler is fast.

Limitations

• Perkin's Brailler is an expensive tool which in the Indian context is not a viable and affordable tool for individuals.

• Perkin's Brailler is big and bulky and not easily portable.

• It is very noisy to type on the Perkin's Brailler and thus is not a very classroom friendly tool.

In India Perkin's Brailler is available at Worth Trust, Katpadi.

Tell a Touch

Like Perkin's Brailler there is a tool for the visually impaired who are also hearing impaired called "Tell a touch" it is a tool made by the American foundation for the blind. It consists of a typewriter in front behind which is a metal Braille cell which lifts the dot combination of the particular letter that is being pressed on the typewriter. By placing a finger, the hearing and visually impaired person recognizes the dot combination and thus understands. This instrument is also used in court rooms during cases involving visually and hearing impaired people.

The instrument is exhibited in Worth Trust, Katpadi and with permission will be shown.

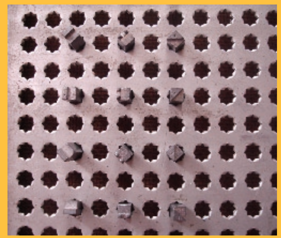
Math Board

Nicholus Sanderson had the idea for a board of this kind (see image on the right). James Taylor worked on the development of the board. The board has a star shaped grid where a visually impaired places pegs and arranges a mathematical problem and solves it like any sighted child does with paper and pencil. It is a tactile tool where a visually impaired student presents and executes the problem in its spatial arrangement thus providing a better understanding of simple arithmetical problems.

The Board

The Taylor's board is a rectangular box with an aluminum top which has holes (star shaped with 8 spokes) in a grid like structure of 18 rows with 25 cells or 25 rows with 25 cells depending on the size of the board, which accommodates pegs or the types which has four sharp edges.

Pegs or Types



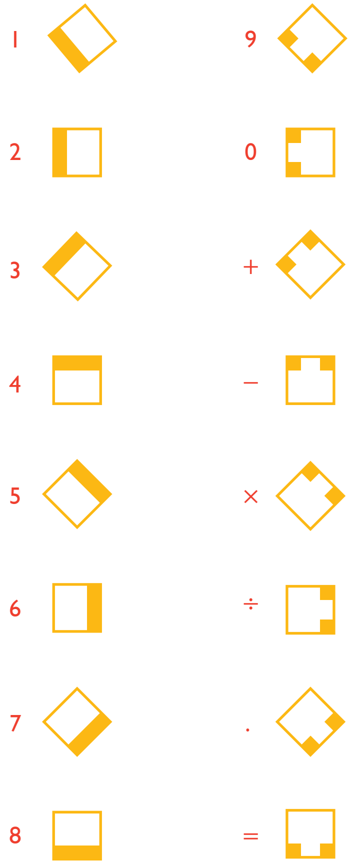
Pegs or types as they are called are made of metal and have embossing on either side of the cuboid. There are two types of pegs and together we have four sides with embossing which give 32 possible symbols. The pegs are inserted in the star shaped hole which has 8 spokes. These 8 spokes help in getting 8 different directions in which the pegs can be placed. The student feels the direction of the embossed shape and recognises the number or the symbol. Similarly he places a particular side of either of the two pegs to get the number he wishes to insert. The two different types of pegs or types are known as arithmetic and algebraic

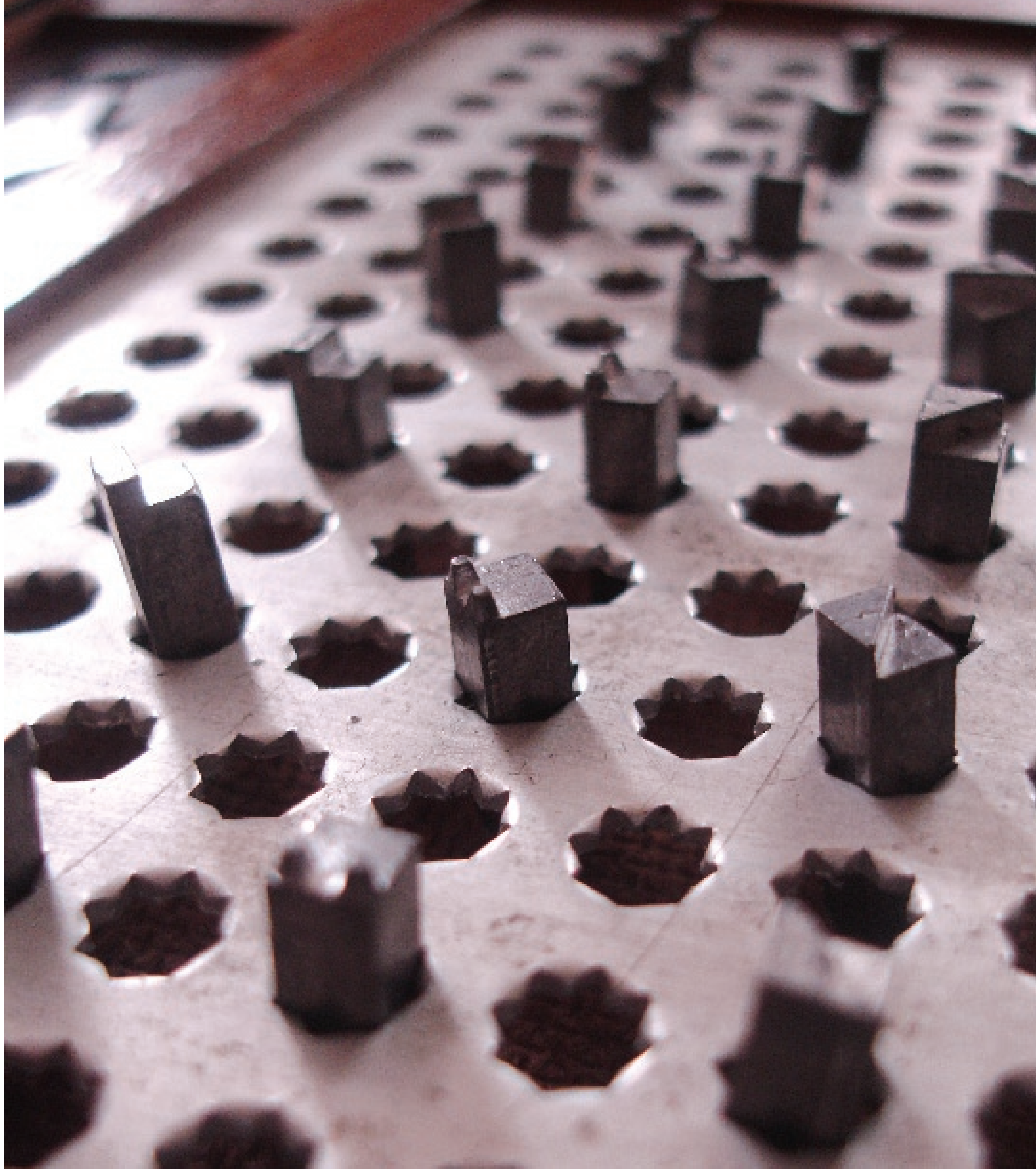
Arithmetic type Algebraic type

Arithmetic type

It is the most basic type since it denotes numbers and the basic operation signs like addition, subtraction, multiplication, division, decimal point and equals sign. One side of the peg has a line embossed on one side of the square. This line represents from digit 1 to 8 depending on the direction they are placed in. The other side of the same peg has two dots which represents digits 9 and 0 and some basic arithmetical operation like addition, subtraction, multiplication, division, decimal points and equals to symbol.

Diagram representing the symbols for the value in an Arithmetic Types

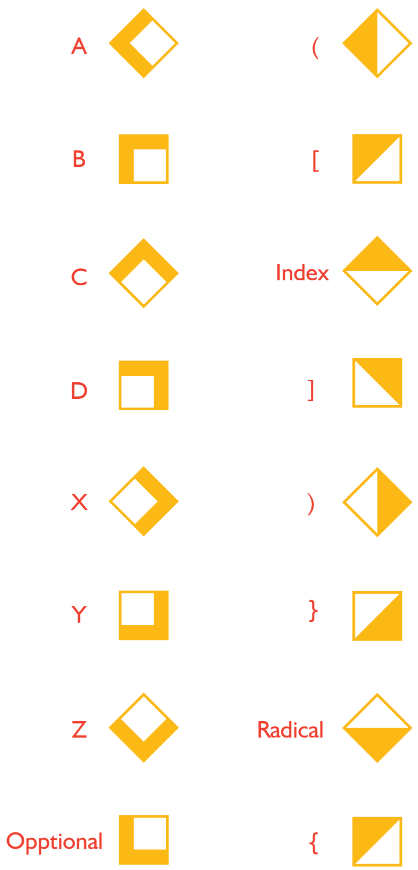




Algebraic type

This type represents a, b, c, d and x, y, z and an occasional value on the side which has a two line embossed on adjacent sides forming a right angle. The other side of this type which has a triangle embossed represents the three type of brackets round, square and curly in addition to this they also have a representation for radical and index.

Diagram representing the symbols for the value in an Algebraic Types



Advantages

It is very useful as it gives a spatial representation of a mathematical problem through tactile medium.

There is an immediate reference point to what is being written and therefore the student can instantaneously spot the mistake and correct it without much trouble.

Math board is very good for learning elementary and junior level mathematics.

Limitations

- The direction of the pegs are too bleak and are a problem for beginners.
- It takes a lot of time in fixing and uprooting the pegs
- All the notations are not covered in the math board. This gives a limitation of solving some problems.
- It is difficult to do longer problems as it really takes a lot of time and it has been observed that many times mid way through the problem the person has already mentally solved.
- If the board is new then the metal types are difficult to insert in the star shaped whole.
- The metal types dirty the finger and this can not be very good for young children who are using it at a very young age of 5 to 6 yrs.
- These pegs may get lost then it is difficult to acquire them.
- The pegs also become an added cost that they have to continuously bear.
- The two different types of pegs are not even compartmentalized in the math board it is difficult to find the right one to use which slows down work.
- The metal pegs are sharp and edged they may not be very friendly.
- Often when the math board is in a bag the pegs fall out of the side drawer which leads to further loss of these pegs.

• The plastic board is easier as it is lighter but may not be as durable as the metal one. Also over a period of time the holes and pegs tend to loosen making the pegs slip inside the board; which then make it difficult to remove them in the plastic board and impossible in the metal board, hindering work.

• There is no way one can document the sum that has been solved on the board. The only way is to use the Braille slate to rewrite the entire sum onto the paper ;a tedious, time consuming and strenuous task.

• Even when one has to practice one must either memorize the problem or write it down on a Braille slate then solve it on the board. After which the entire procedure is written back on Braille slate so as to cross-check it with the teacher.

With all it's limitation math board is undoubtedly one of the most popular tools on which to learn school level mathematics.

Math board is available in plastic and metal at NIVH, Dehra Dun and Worth Trust, Katapadi.

Abacus

Abacus is a simple instrument used to perform rapid arithmetic calculations. It consists of a frame holding vertically arranged rods on which beads slide up and down. These rods are divided by a horizontal bar into two sections.

The upper section

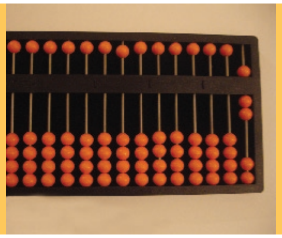
In the upper section each vertical column has 1 bead with the numeric value 5.

The lower section

In the lower section each vertical column has 4 beads each having a numeric value 1.

According to the instruction manual of Worth Trust an important note for the blind users.

Beads 1 to 4 are moved with the right thumb and the bead 5 is moved with the right forefinger. While values are thus being set or cleared in any one specific column with these fingers of the right hand, the identity of this column should be remembered by keeping the left forefinger on the next column on its left.



When one dot is brought down from the upper section and two dots are raised up from the lower section it denotes the number 7 (as seen in the photograph).

Learning with Abacus

Abacus is useful in abstract learning of mathematics through practical and tactile means. Concepts like place values, decimal system of numbers addition, subtraction, multiplication, division and fractions can be taught on abacus. However for a child to grasp all these concepts with ease it is advised that concepts of number and counting should first physically introduced by means of pebbles, blocks and fingers etc.

Abacus in the system of education is an individual preference. Some find it easy and some difficult. Therefore it is not a very extensively used tool among the visually impaired.

Talking Calculator

The Talking calculator is an important tool that gives auditory help to a visually impaired person to help her perform a difficult and lengthy calculation.

In a talking calculator both number and basic operations are spoken out when pressed and certain basic functions like the 'off' and 'on' button have a unique distinguishing sound and also a varying size. An important feature of a talking calculator is the repeat button. Repeat button repeats what is present on the screen. It also repeats the information in figures like one zero or the same in words like one hundred. A talking calculator is easy to handle and an efficient device. It is a regular device not adapted efficiently to suit the visually impaired.

Geometry kit

This geometry kit contains a ruler, compass, set squares and a protractor. With the help of these instruments and a spur wheel to emboss the lines, visually impaired children are taught to draw geometric shapes and diagrams.

Drawing with a geometry kit

The instrument with which a diagram is drawn is kept on Braille paper (140gsm board) which is kept over a rubber sheet to help better the quality of the embossed dots. Each of these instruments has embossed lines or circles to indicate measurements. To draw the diagram a spur wheel is used. These spur wheels come in a variety for different types.

Spur wheel is an instrument with a handle that assists the index finger and the hand for grip and a spiked radial that makes equidistant dots when moved over a surface with some pressure.

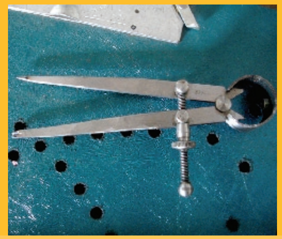
Some times the edges of the instruments are jagged evenly, this helps in producing emboss with a blunt pointed pen. However it prevents the user from placing accurate measurements.

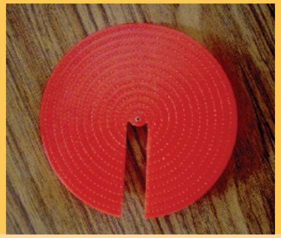
Mirror Construction

Like the Braille slate the user of a geometry kit also has to think of the mirror of the required diagram or a shape while he is drawing, as only then when the Braille paper is removed and turned over he will get the required diagram. For example to be able to draw a 130 degree obtuse triangle she has to draw a 50 degree acute angle then join it to a180degree angle. Only after he turns the paper will he get the required 130degree obtuse angle.

Role of a geometry kit in an education system of visually impaired

Geometry and other graphical diagrams are one of the most difficult parts of mathematical education for the visually impaired. In this light a geometry kit is certainly helpful but still not the easiest popular device or tool that may be used. It is very difficult to understand and execute a diagram. It is also very time consuming and provides very little precision.





Left: Geometry kit from Worth Trust
Above: Geometry kit from NIVH

Since the tool is difficult to handle, more than often a visually impaired child does not even execute the graphics on his own with these tools. With leeway from the government and also out of personal choice this tool and its related topics are not used by the visually impaired children.

Kinds of Geometry Kits

The two basic types of geometry kits that are available in India are :

One that can be acquired at Worth Trust, Katpadi is produced on the basis of international standards and design. They come in two different sizes big and small.

One that is available at NIVH Dehra Dun, is slightly different. It comes with a board with holes and a paper holder. It is also a little different in its functions.

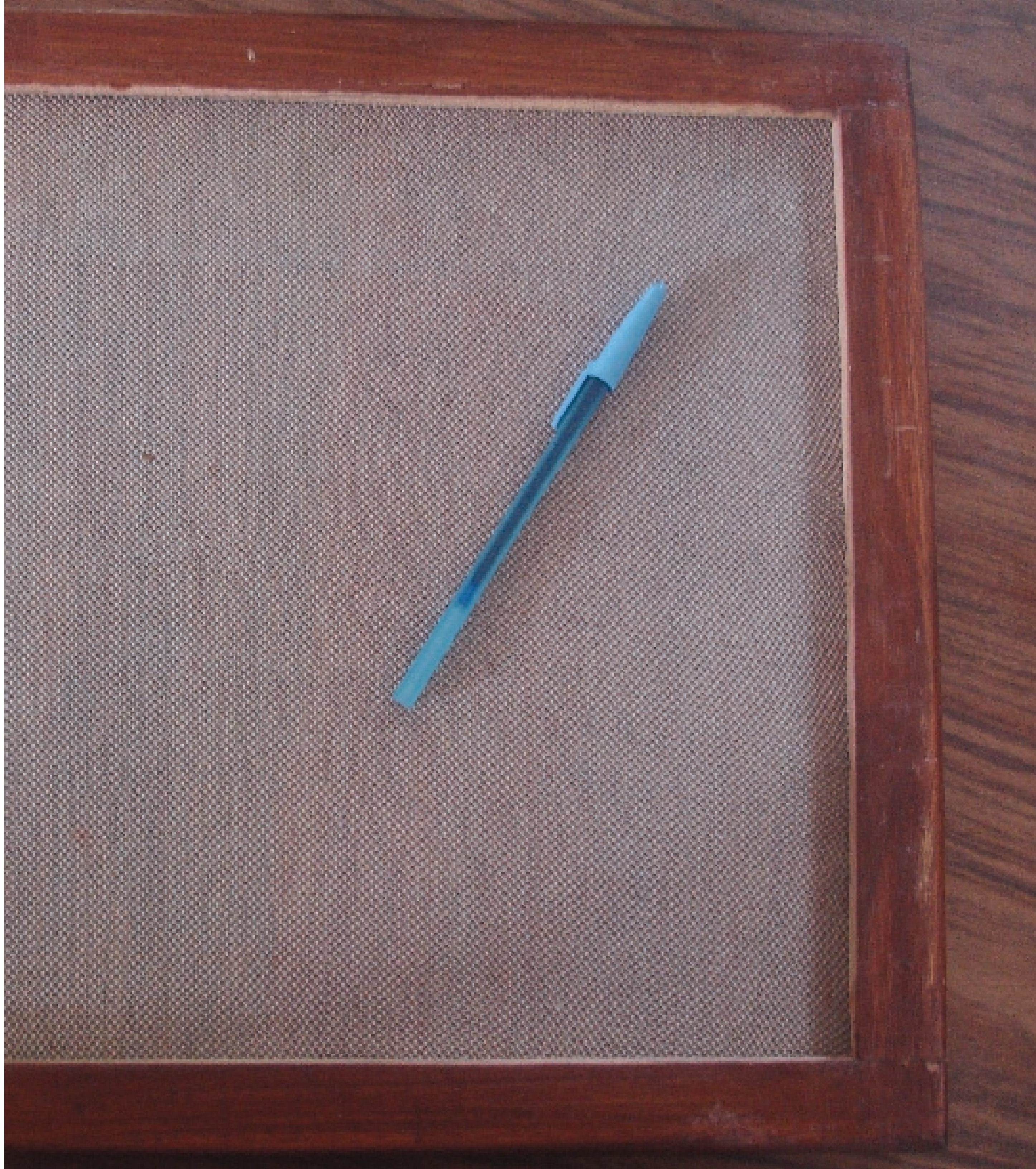
Study and development in this area

T. Robinson, a professor at Madras Christian College has done research on the mathematics education scenario (especially in Tamil Nadu) among the visually impaired. He has concentrated his study around the difficulties of geometry and other graphical diagrams, has worked on the development of a tool that will make their execution easy for visually impaired students. His article in the section of "Learning mathematics" is very insightful.

T. Robinson
Madras Christian College, Chennai - 600 059
robin.mcc@gmail.com

Mesh board

The mesh board was designed by Milan Dass from NIVH, Secundrabad. It is a simple drawing board made up of nylon net/wire mesh backed by a ply board. An ordinary ball-point pen is used to draw lines on ordinary paper.



The mesh board has a wooden base with a plastic mesh on the top. A paper is placed on top of the mesh board, when a slightly blunt tipped instrument is maneuvered over the paper a raised image is achieved on the other side. The image achieved is however the mirror of the one drawn (on the front). To rectify this drawback, a carbon sheet is used.

Under a plain sheet of paper a carbon paper is placed such that the inked side of the carbon paper is in contact with the back side of a plain sheet. On to the front of this plain sheet the required diagram is drawn.

Due to the inked side of the carbon sheet placed below; a mirror image of the drawing is attainted at the back side of the sheet. The carbon paper is now removed.

The mirror diagram is placed over the mesh board such that it faces upwards. The diagram is traced over by a sharp tool and the embossed diagram is achieved on the other side. What one gets is the raised reflection of the original picture as intended.

Another simple method for teachers is to make simple stencil/cut outs made up of cardboard, plastic etc would help in drawing the figures. This can also be given to the visually impaired child upon which he can draw figures independently. These stencils come in a variety of shapes and are provided to the teachers.

Advantages

The limitation of the paper size is resolved as the mesh board is inexpensive and can be easily manufactured at home. This tool can be used by a low vision child and a sighted teacher in order to explain the shapes. With the help of stencils even a visually impaired child can make an attempt.

Limiations

• The drawbacks being that the precise size and dimensions are hard to achieve with out the incorporation of various other instruments.

• It is difficult to draw curves, parabolas and circular diagrams.

Pressure Sensitive Thread

This material is used for sketching in tactile. The pressure sensitive thread is simple. Suitable quality of thread has to be selected to induce the prepared solution in order to obtain the desired stickiness and removable quality.

The users as perceived are visually impaired children, educators, volunteers and parents.

Since the thread is very flexible, versatile sketches are possible on any on any plain surface except oil based surfaces. It is a low cost product but should be used with precautions.

Pressure sensitive and mesh board are products of NIVH
Dr. Milian dass
N.I.V.H R.C
Manovikas Nagar
Secundrabad- 500009
Andhra Pradesh.
Ph: 040-27751838
milandass@yahoo.com

Pragna sketching device for the blind

This device was designed by a father of a child with low vision, in order to help the child understand shapes through a tactile medium.

It is made up of Velcro tapes pasted on a wooden board. A woolen thread is used on the Velcro. The thread sticks on the Velcro and gives the desired shape.

The structure of the object which stores the woolen thread is very similar to that of a writing pen. It has a spool on the top which consists of a woolen thread rolled onto it at one end on the top, and can be pulled out from the other end onto the board (the Velcro base). It works exactly like a pen except now the ink is replaced with a woolen thread.

The thread sticks onto the Velcro base, giving us the desired constructed shape. However, the convergent points of the design\shape have to be fixed onto to the board properly.

The tool is more of an explanatory tool that is used by teachers, in order to give them an understanding of a particular shape.

Advantages

The prime advantage of the tool, is that it is simple to understand and use without requiring a manual for the tutor.

Low cost and easy portability increases its accessibility, making it a popular tool for personal and institutional use.

Limitations

The basic drawback of the tool is that it can only draw continuous and basic shapes easily.

Discontinuous shapes and pictures cannot be drawn. For example, "X","K", "A", etc… In order to do so separate threads are needed.

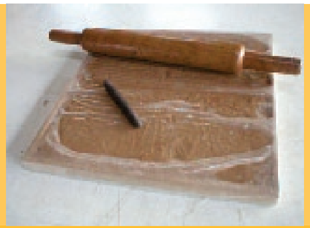
It is difficult to construct geometric shapes with particular dimensions.

Pragna sketching device is a product of

National Rehabilitation Engineering Institution
for Blind People's Association (India)
Formally known as:
Blind Men's Association
Vastrapur, Ahemdabad- 380015.
Gujarat
India
Phone: 91-79-6440082, 6442070.
E-mail: blind@adl.vsnl.net.in

Further Development

Avnish Priya Gautam a student of National Institute of Design Ahemdabad has done a project on redesigning of the Pragna's sketching device. Under are the details of the project and the persons contact.



Project brief

To redesign the existing sketching device for blinds "Pragna sketching device" to making it more comfortable to use.

Analysis, problem statement

There are few problems in the existing product stated below,

• The continuity if the thread cannot be broken. This creates problem to teach alphabets like "A" "E" etc and other geometric shapes, where the continuity on line has to be broken.

• The tactile feeling of Velcro is not that pleasing.

• The woolen thread is very difficult to wind back, once it comes out.

Experience regarding the user

During the project I visited the place called BPA "Blinds People Association" in Ahmedabad for the user study and testing. I also came to know that people with visual disability have a very strong sense of touch. They can feel very minor changes on the surface.

Important things which you kept in mind while redesigning

• Since this product is used to teach alphabets and geometric shapes to blind people, main thing which I considered.

• Surface difference has to be created, and in addition to it, it should be able to draw every alphabet and geometric shape, (there should not be a problem with continuity as with the Pragna sketching device). It should have good tactile feeling.

• It should be very easy to make.

• Low cost.

• When I was working on this project, I did an experiment, by covering my eyes for few hours and then trying to figure out things in my room.

• I felt that I became more conscious and alert in my other senses like hearing sense, touch...In spite of being very familiar with my room I

found difficulties in finding out things. It was then that I began to realise the importance of sight.

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JAWS (an acronym for Job Access With Speech)

A JAW is a screen reader for the visually impaired. Its purpose is to make Microsoft Windows accessible for the visually impaired user. It is an Interactive talking technology that makes it easy to access computers, its many software applications and the internet without any sighted assistance.

It provides the user with access to the information displayed on the screen using text-to-speech and allowing a comprehensive keyboard interaction with the computer. With the help of an internal software speech synthesizer and the computer's sound card, the information from the screen is read aloud. The technology accesses a wide variety of information and applications. It supports all Windows applications without the need for any special configurations. Most popular applications, like Microsoft Office, Corel WordPerfect Office, and IBM Lotus Notes, Adobe Acrobat Reader are easy to use with JAWS. It also helps in accessing Internet Explorer. JAWS or now Revised as JFW (Jaws For Windows) has undergone improvisation many times since it's first release in 1993.

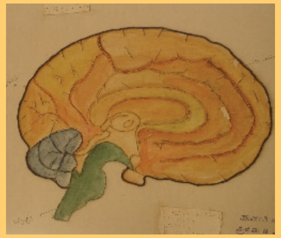
Advantages

• JAWS helps in making a visually impaired person independently use computers.

• It facilitates the use of software's and internet and thereby helping them move with the changing times and become competent at work

Limitations

• JAWS is not very useful at providing any diagrammatic and visual data on the screen. Thus it is difficult to access any visual heavy websites (flash based) and software's. It scans all unnecessary information before arriving at the one needed.



• Most importantly while doing mathematics JAWS is unable to read the mathematical symbol and also misinterprets many equations. For example Square root of sigma is square 1 x square y plus sigma y whole divided by. The screen reading software does not read the whole divided by but it only reads divided by.

JAWS is a product of Freedom Scientific

JAWS was introduced in 1989 by Ted Henter, who founded the Henter-Joyce Corporation. In April 2000, Freedom Scientific was formed by combining three companies: Blazie Engineering, Henter-Joyce and Arkenstone. Since then they have produced many assistive and adaptive technologies for individuals who are blind, or have low vision or learning disabilities. Their products include screen reading software for the blind, magnification software for those with low-vision, and other products for accessible scanning and reading, as well as Braille displays, note takers, and the world's leading accessible PDA for the blind.

www.freedomscientific.com

Tactile lines and dots

Tactile lines are used to indicate significant edges, lines, contours etc involved in the diagram. During my research I gathered some understanding, examples and ways of how diagrams were explained using tactile lines and surfaces.

• Diagrams are created using various textured surfaces, line, sand, paper, felt paper etc and sometimes textures are created by sticking twigs, threads, grains etc.
• One way with which tactile lines are created is through combinations of spur wheels and surfaces like rubber sheet, mesh board etc. The quality of the tactile line has to be very good. It has continuous dots and uniform so as they trail their finger along the line it gives them better stimulation for better sensation.
• To convey the information contained there is a necessity to give variation in the tactile lines using different textures, dots, thickness etc as finger tips have more nerve endings than in the palm.
• The tangible diagrams identifiable by the fingers are the essence of making the tactile lines.

• To differentiate between two objects, there needs to be a difference in texture or thickness.
• The dotted lines give enough stimuli while tracing over it verses the non dotted smooth lines.
• The nature of the picture and the stroke pattern - are important as the child tends to scan the picture using her palm.
• While teaching a diagrammatic concept it is important to give an orientation about the picture the nature of the line that may have curves, take sharp turns and the region of a picture that may have shade, dots etc,...
• According to Dr Robinson's research a progressive method (step-by-step) presentation is effective as the child develops the expression presented with his or her mental image. In his research he has given a step-wise tactile journey of geometrical theorems to students. This helps the student visualize better. He says that the "the progressive steps overlay the information on the mental map."
• For partially impaired students it is good to provide contrast in colors and to avoid patterns like checks or stripes, that can be visually confusing.

Learning Mathematics

Education systems

There are two systems of education for the visually disabled

• Integrated Education

• Blind Schools

Integrated Education

Integrated education system is a facility provided by the government where disabled children must not be denied the opportunity to study in a normal school. Hereby a visually impaired child finishes his education along with the sighted children in the same class. The school provides that child with all the help and assistance.

Advantages

• Visually impaired people who have studied in the integrated education system feel that it exposes them to the real world far more than the blind school would have.

• They feel that they attain a training to cope with the environment and how to communicate with it.

• The competitive atmosphere is also good for them to strive towards better results and success in life.

• They become more aware of the day-to-day changes in the world which helps them understand the choices they make and ways in which to achieve the desired goal.

• The broad outlook, excitement and competition pushes them towards their aim for better life.

Limitations

• The schools are not aware of the techniques and the advancements to provide the child with the adequate facilities as required by the visually impaired. Here by the child either goes to the nearby government or NGO's for assistance.

Integrated education system is a facility provided by the government where disabled children must not be denied the opportunity to study in a normal school.

• He may be excused with a lot of things which are sometimes taken as 'denied' by the visually impaired. For example, the teacher may not ask questions or when wrongly answered, the child may not be reprimanded as opposed to his sighted counterpart. This in some ways is considered as partial behavior and this also seeps into his peers making the visually impaired child feel different.

• Examinations are another problem; many times the institution does not know how to conduct an examination for the visually impaired. They may be asked to complete the paper at home and bring it the next day. Many times the paper is being dictated to the teacher in the staff room which does not allow them to concentrate. For instance some of them have to dictate to their scribes sitting in the middle of the school grounds, where everyone is playing and making noise. In this case it becomes difficult for the student as well as the scribe to concentrate.

During my research i met four people who studied in regular schools under the Inegrated Education Kameshwari, Mr. Kiran Kaja, Mr Satayamurthy and Mr Ramana. Below is a written interview with Mr Ramana

Q. What is your name and present nature of occupation?

A. My name is Ramana Polavarapu. I currently work for SAP Labs as a platinum developer (senior software engineer).

Q. What were the advantages of integrated education?

A. First of all, the disabled individual is not segregated from the main stream. Our dreams and aspirations do not stem from vacuum. What we would like to pursue as a career is engendered and influenced by the interactions with others. These interactions and the variety are much broader if the person partakes in the system of integrated education. As an additional side effect, there is a greater chance for the individual to enjoy more socially acceptable behavior.

Q. Were these subjects encouraged and what type of assistance was provided?

A. Not really. In fact, I felt that I was discouraged to pursue my career in these lines.

Q. What were the various disadvantages?

A. In general, the disabled individuals require special attention in several cases. Normal schools which provide integrated education may not be able to meet all the needs. However, all the educational institutions gradually learn to cope with the varied requirements.

Q. What were the teaching system and methodology used for math and science in the integrated schools?

A. In general, they do not follow any different policy to teach science and mathematics to the disabled individuals. Consequently, it becomes difficult for the persons with disabilities to do well in these subjects. In US, they provide note takers. As a result, life is somewhat easier for them in US.

Q. Were these subjects encouraged and what type of assistance was provided?

A. Not really. In fact, I felt that I was discouraged to pursue my career in these lines. Once again, I went to an educational institution in India roughly twenty years ago. The situation must have improved in these intervening years. However, in US, one does not feel discouraged at all if he or she wants to study science and mathematics.

Q. What facilities lack while doing mathematics in an integrated system of education?

A. As I have mentioned, we need special note takers. In addition to that, teachers need to be generally inclined to help the disabled individuals.

Q. What are the facilities would you encourage in an integrated system of education to make it a perfect system?

A. Every school should have a disabled students resources center. The persons who work in this center should be aware of the problems that disabled students face and the solutions to those problems. Computers should be introduced at a very early stage.

Q. What were advantages and disadvantages of memory as a tool to do problems in mathematics?

A. The advantage is that we need not rely on external tools. The idea is similar to playing chess blind-folded. The more you rely on external tools, the slower you will become in grasping the problem and attaining the solution for it. I do not see any disadvantages to this method except for the fact that one may ignore exploring some newer and more user friendly tools.

Q. What topics in mathematics are the most troublesome due to visual constraint?

A. The areas that involve graphs and pictures extensively like graph theory.

Q. What topics in mathematics are not dependent on any visual constraint?

A. Vision is always helpful in almost every branch of mathematics. For that matter, even outside mathematics, there is no perfect substitute for vision. Consequently, it is difficult to identify a branch of mathematics that does not require vision. If I were to come with one topic, I would say Number Theory.

Blind Schools

There are very few blind schools that provide education in mathematics beyond 7th standard and almost none which provide any mathematics and science education option at the pre university level. Most of the students for further studies join the normal colleges and institutions and with help of NGO's like Samarthanam try to complete it with a respectable percentage.

On their own, Blind schools struggle hard to give a decent education to their students. Most of the blind schools and NGO's are integrated with hostel facilities to help the visually impaired students who hail from the interiors of Karnataka. However due to lack of funds they have poor infrastructure. The Ramana Maharishi School for blind in Bangalore teaches Mathematics till class 10th. Another school that is trying hard to help its students give mathematics examination in 10th standard is Rakum School for Blind.

Advantages

• Education in the blind schools follows a step by step method to understand the concepts and training of the tools.

• The training of the tools goes in synchronization with the basic curriculum.

• Each of them is introduced at specific points of education as it's a system that understands the need of the visually impaired student.

• The teacher and the administration of the institution are trained and experienced to deal with a variety of situations and problems to help the child understand a educational concept.

There are very few blind schools that provide education in mathematics beyond 7th standard and almost none which provide any mathematics and science education option at the pre university level

Limitations

• The blind school make a child dependent on the institution which in itself does not last for a very long duration of his higher education.

• It does not expose the child to variety of situations. Hence limiting the scope for his or her innovative and creative thinking to look for solution and ways to understand and approach a problem.

• In schools for visually impaired the interaction of the students is limited to just the visually impaired.

• The variety of background and thought is missing; this does not help in widening the outlook and perception.

Education in mathematics from 1st standard to 10th standard

Mathematics as a subject is introduced to the children in the primary classes itself. It is a regular subject till the 7th standard, there after according to the state rule (as in many states this subject is optional to various other subjects like sociology political science history economics music etc…) this subject becomes optional.

The main tools used while learning math in school are the:

• Math board or Taylor's frame

• Nemeth Code

The students from standard 1st to 5th are restricted to do mathematics on Taylor's frame or the math board. They are briefly introduced to the nemeth code from 4th standard onwards. A regular use of the Nemeth code for mathematics begins only after 5th standard in the higher school. In the 7th standard the Nemeth code becomes compulsory.

The reason for delaying this process is that it is felt that the students in the younger classes get confused with the codes and hence are not able to learn. It is only when they are old enough to understand the distinction between the codes that's when they are taught Nemeth code. Besides the point that perhaps one has to teach Nemeth code as the math board becomes an inadequate tool to do mathematics of that higher level.

• However the math board is indispensable to studying mathematics, it may not be able to document but the math board as mentioned in the tools section has is own set of problems. The minute change of directions is perhaps the most confusing.

• Learning according to me is also repetitive, the students are asked to put the pegs representing the digit 1 some hundred times.

• As it was said by the teacher teaching math board, that some students are fast in picking up the math board but some of them often find it difficult to use and learn. They may write the correct symbol for 1 on the math board the first five times however the sixth time it could be wrong.

• He also said that some students who are good at the math board are not good with tables and visa versa. He could not understand the reason for this but he said he faced a problem regarding this scenario.

•First they are taught number and tables orally, then they are taught small numbers and big numbers, odd and even numbers, 1 to 500, simple addition, in pre school math board is started there are usually only 4 to 5 students. Tables are taught orally.

Initially it is difficult to understand the difference between line and dots. While doing numbers, they put I instead of 3 this is due to the slight direction change. Some students find it very difficult to learn the math board concept and some students however don't try. It is said that in a class of 20, around eleven of them find it difficult to use the math board.

The system of home assignments is that, whatever the teacher has taught them that day they are asked to practice it on their own and the next day the teacher will give them a problem in that regard .If the child is able to do it that means he has practiced at home. There are a lot of touch sensitive people among the visually impaired perhaps they are a minor on that score. But at the end of it all the math board pegs are difficult to understand for the young boys and girls.

One common comment that I heard from the entire teacher body is that mathematics is easy for all the students who are intelligent and not for those who are a bit slow.

The beginning of Braille code in higher classes is an interesting process that I learnt much later in my research. I had assumed that the Braille code is introduced to the children like the way it is written on the board how ever that is not the case at the primary level there are many devices that aid this initial learning.

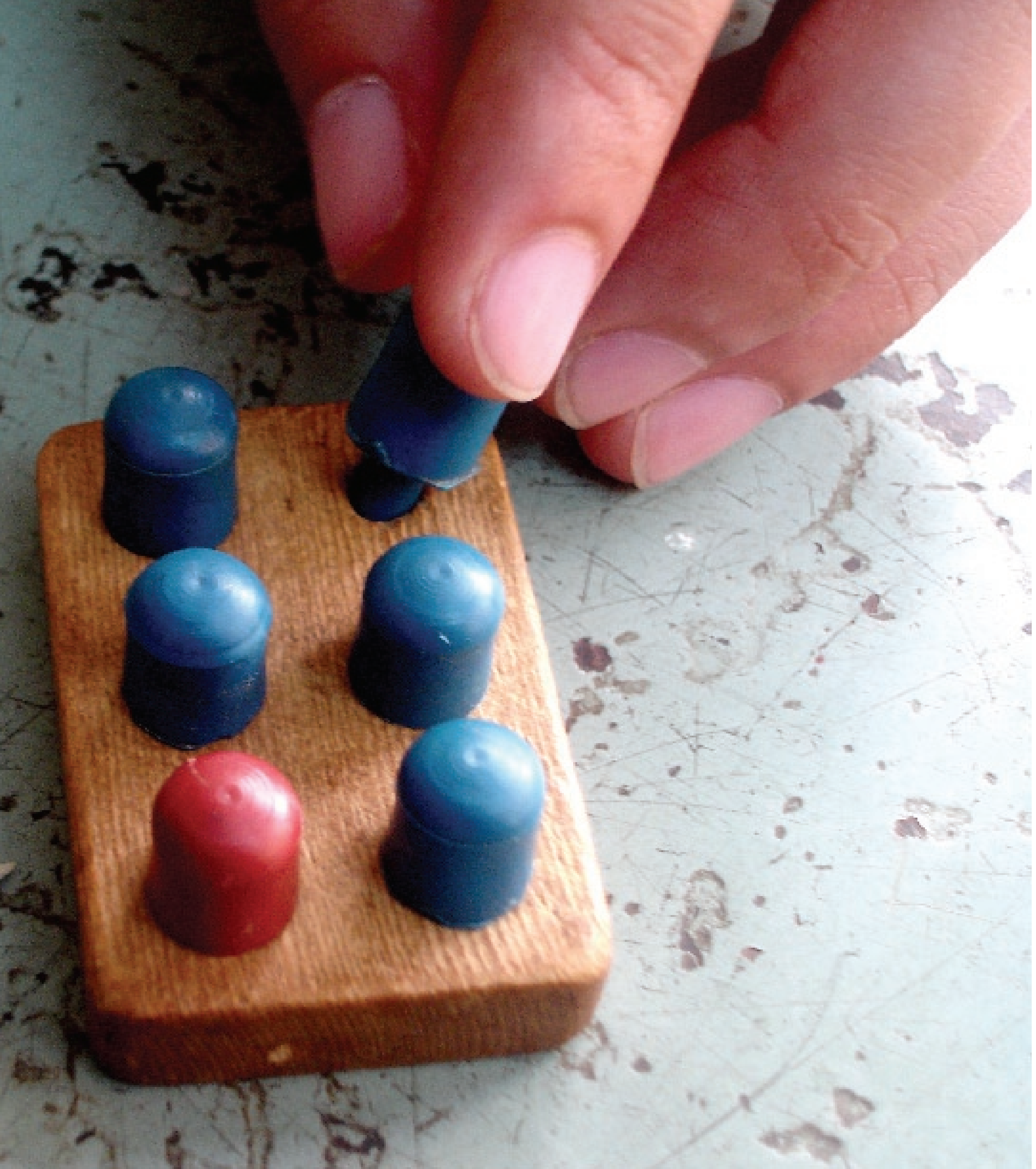
There are a few tools that are used which aid in their learning:

Marble board

• The marble board is an enlarged form of an debossed Braille cell in wood.

• This board is about 5"x 3" inches a rectangular palette, with evenly spaced dots in a Braille cell like a pattern of three horizontal rows and two vertical columns.

• Students' can learn the dot combination by placing the marbles in the correct depression. This way they put the marbles in the six depressions in the right formation for the required symbol.



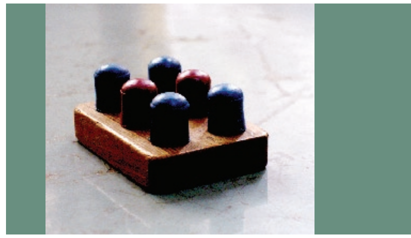
Peg Board

• The Peg board is a smaller version of the marble board.

• Its size would be 1" x 2" inches.

• In this tool the marbles are replaced by the plastic pegs that are inserted in the holes and they rise half an inch above the board even after being inserted.

The children are made to practice various alphabets in these assistive Braille tools. After the peg board they are introduced to the pin board. But by this point it is easy to take them to the final Braille slate.



Problems faced while studying mathematics

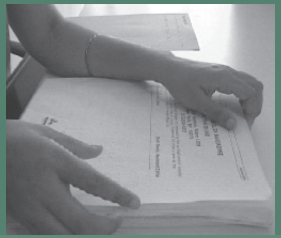
Attributes of Math as a problem

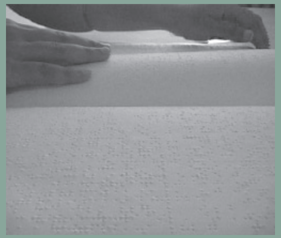
Mathematics is a non-linear subject. It is not written left to right or right to left. Be it geometry or numerical it is characteristically visual in nature. Mathematics involves a lot of juggling of numbers and variables from one side to the other plotting of graphs, drawing diagrams, and understanding of shapes, sizes, distance and spaces. Therefore mathematics becomes problematic in two ways one is on the end of conceptual understanding of mathematical idea the other is the execution of these concepts. There is a need for a great amount of attention and innovation to achieve a solution for both these problems for the visually impaired.

Mathematics is a non-linear subject. It is not written left to right or right to left

Poor tools

Unlike their sighted counterparts they lack the proper tools which make it easier for them to solve and document at the same time. The tools give no immediate reference to what has been written there thus making a visually impaired person rely heavily on memory. When there is an immediate tactile reference of the task as in case of the math board then the tool gives no means for documentation and in addition is extremely slow and time consuming. Lack of proper tools to do mathematics with swiftness and ease makes a visually impaired person rethink his interest.





Lack of books

Non-availability of textbooks and other reading material in Braille is a hard reality in the education system for the visually impaired. It is only recently that some books like Braille printed books and a few books in mathematics are available.

Problems of recording

The lack of books may get compensated by reference material given in form of notes but at times this also is not executed by the teachers. Therefore many times there are no reference notes given in mathematics. The recording tools like Braille slate and stylus do not allow an immediate reference to the written material. Whenever notes in Nemeth code are taken there are times that while writing fast a numeral may be jotted wrongly which leads to the wrong equation. Since it is not immediately recognized and corrected as it is not known what is written the task of writing and doing mathematics is not instantaneous.

Too many tools involved

The task of solving on the math board and then writing the procedure on the Braille slate is cumbersome. There are too many tools involved at the same time to do a particular equation. This may be time consuming and a mind boggling procedure. At this stage the student relies on their memory for quicker results and calculations. Some students may not have a good concentration and memory which deters the student to do mathematics. As mentioned before the lack of facilities and infrastructure also dissuades a student to pursue mathematics. Since most of them come from weak economical backgrounds they are unable to afford expensive education offered by integrated schools.

Lack of awareness

During my research I was told by the students that some of the notations are not available in Nemeth code but when I referred to the existing nemeth code the result was the opposite. Even though all the notations in the Nemeth code are available for a visually impaired person to do mathematics conveniently, the students are unaware of this. In some cases even the teachers. This results in

an understanding that the teachers themselves are not fluent with the tools and the codes. There is a lack of availability of trained and good teachers for the visually impaired.

I had also raised questions with the students and the teacher as to what do they think about the idea of visually impaired teachers teaching the visually impaired students. The analysis can be drawn on two ends that is:

- The visually impaired teacher can contribute in the methods to understand a concept much better as he/she is aware of the communication gap that a sighted person is likely to make.
- However he/she lacks the extra input that the sighted teacher can provide.
- Besides this the visually impaired teacher may not be able to make out the mistakes made by the students when they are at work. He needs to sit individually with each of them to check their work.

Outlook

When the system that you are in encourages you to move in one direction rather than another, it is easier to opt out of it due to the lack of confidence and an immature mind. They feel they can do other subjects where the application is much less and one can achieve far more through memory. Teachers, elders and parents also do not encourage the child to face their problems. They do not help them in making a right choice as one feels that they too doubt the child's ability to do these subjects. One can say that there is a conservative approach and newer techniques take a lot of time to be applied. Many times there is lack of awareness too, since most of them come from the socially and economically backward classes. Often parents of these children have a fatalistic view to the problem that is of a purely physical nature.

Employment

Very few people from the visually impaired have a mathematical background and an almost insignificant number are working in the applications related to mathematics. The past recent years have seen a rise in people from Commerce backgrounds. But according

Teachers, elders and parents also do not encourage the child to face their problems. They do not help them in make the leading you to wonder if they doubt the child's ability to do these subjects.

Visually impaired students who study Mathematics find topics related to Geometry, Trigonometry, Complex numbers, Binomial theorem, diagrams, columns, tables and graphs very difficult.

to Shanti Raghvan of Enable India, 98% of the people who come for employment help have done their B.A and quiet a few of them have done Economics and some come from the recent trend with diplomas in Public Relations.

Even the people who have done B.Com, B.E or MCA their overall basic aptitude is low in order for them to get a decent job in respective fields. This leads to unemployment and underemployment. The low aptitude has reasons; primarily lack of exposure. Even though they have studied their course material they are not equipped to handle real time jobs due to lack of exposure through real-life projects. A programmer finds it hard to code in the language; a student of B.Com is weak with her concepts in Accounting; Debit and Credit. The reason being that the systems of education allowed them to memorize their subject and pass the examination without giving them any practical knowledge.

Problems pertaining to the Diagrams

Efficiency in Braille is confined to words and symbols. Visually impaired students who study Mathematics find topics related to Geometry, Trigonometry, Complex numbers, Binomial theorem, diagrams, columns, tables and graphs very difficult. There are tactile diagrams available but these are expensive and not the most viable means, since they may be be available while studying or may not relate to that particular problem.

In this case these diagrams are mostly explained on palms however it is very hard to do anything precise on palms. There are tools available to draw diagrams but again these are very time consuming and can only be used by tutors.

Students attend normal colleges for higher studies where they are an insignificant number for the teacher to take the pains to pay them more personal attention. To make up for the loss they visit NGO's like Samarthnam and Enable India that help them. In these places they are connected to volunteers who help them in reading, scanning and editing their course material. NGO Institutions also prepare some tactile materials of their own to help in understanding some concepts

"According to Vishal, he just has to depend on his memory when he's taught to do the graphs on his hand and use them when necessary. He agrees he would be able to do it better if practiced regularly but he does not know how".

Normal colleges

The students who join normal colleges do face a lot of problems. Firstly, getting acceptance and to be understood amongst the other students. Communication skills are important according to them, that is expressing ideas fluently and at the right time. English is the language used for interaction in a normal class room. There are chances for hesitance, while interacting, due to the language barriers. They are upset due to the separate treatment and the attitude of the teachers. They want the teachers to initiate methods for an active participation for them in a class room. E.g: asking questions and discussing in the class itself. On contrary they feel hurt if they were not adequately reprimanded as a sighted student would have been when making the same mistake. Challenging one's memory to understand the visual parts since the teachers are not prepared to spare an extra minute.

According to Vishal and his other friends at Samarthanam, Calculation where steps and visuals are involved becomes difficult. The solution according to them is not very important, once the structure and the concept is learnt and understood it's easier to solve any sum. He usually gets his friends to write the steps on his hand while they read it aloud. Mr. Satyamurthi and Kameshwari depended on their parents and siblings for the same. Mr. Ramana and Kiran often sat with their friends at school and college and did joint studies.

Computer as a tool to do higher mathematics

Recently since the 90's there has been a prolific use of the computer among the visually impaired to study mathematics. Many professionals like Kiran, Rajni, Ramana and Satyamurthi heavily depend on them to do their work. Rajni feels that the computer helped her finish her CA education and thus elevated her hope and dreams to do better. Many students pursuing mathematics and subjects related to the same thing and take inspiration from the achievements of these professionals and learn the computer to do better in life. However the computer is not yet mathematics friendly and has its own set of drawbacks.

• The difficulty is that the symbols are not on the keypads.

• It's difficult placing the symbols on the screen.

• Many symbols are not even recognized by the screen reading software's.

• It is difficult to write in super-script and sub-scripts a simple 23 is written as 2 cube.

Even though the computer has its own problems, it certainly enables them to do various tasks. Also the computer is improving as time passes by. Everyone feels that the computer is the way of the future and it will help in emancipating the visually impaired.

Readers and volunteers as help

One of the main help that visually impaired receive is from the volunteers. NGO's and government supported institutions connect a visually impaired person and people who volunteer to help in the process of education. Volunteers can help a visually impaired in many ways like scanning text books, editing the scanned books, reading, explaining and practicing for the exams. Since math related topics are difficult to explain orally, lots of problems are encountered on the way. Also volunteers for mathematics are not easy to find as the subject requires expertise in it.

Mr Nanda Krishna a reader for a visually impaired has shared his experience in the following interview.

Q. What topic where you reading for the student?

A. The student wanted to learn Statistics.

Q. Can you state the process (as you know) of learning a subject like mathematics for a visually impaired person?

A. Mathematics is not a theoretical subject, so a lot of patience and a lot of practice is required to make them understand it. It will be difficult to explain the symbols, or manual calculations, and with a subject like statistics it will be much more difficult. So initially I had to explain the concepts with real life situations, and making him note down all the numbers, made him add up and used to correct whenever he does something wrong. I had to explain the symbols on hand, and what they signify. I had to revisit the whole problem set to explain him the problem. The best part was, the student whom I was teaching was very quick in understanding the concepts, which made it easier for me. I did meet a few volunteers who were asking how to tell the visually impaired about the colors, or explain the things around. Since Math's has to do with numbers and symbols, it is the basics that will take quite some time to explain but coming to the problems. It was more like letting them do it and help in verifying the results.

Q. What all did you experience in the process? (As in what we take for granted has to be communicated in different ways for the listener to not misinterpret the symbol or equation)

A. The person I was teaching was preparing for his 12th class exams, there were a few topics which I thought he would be knowing, and the general symbols and their use. All the things have to be revised. But it was a lot better, and I myself came to know a lot of things from the doubts which he was asking.

Q. What topics did he find difficult to understand and execute?

A. Statistics has got to do with seeing the numbers and calculating. So it would be difficult for anyone to remember all the numbers. The main difficulty lies there. Rest of the calculations was pretty simple. Whenever a new concept comes, I had to explain with the real life situations, which I thought made his job a little easier.

Q. What topics did he find difficult to understand and execute?

A. Statistics has got to do with seeing the numbers and calculating. So it would be difficult for anyone to remember all the numbers. The main difficulty lies there.

Q. What all where the sections he could do easily? Did you find any gaps in the methodology of reading out a subject like mathematics for comprehension and understanding? (Problems you faced while explaining a topic problems he faced in understanding some topics)

A. When it came to making him understand the concepts it was fun, I used to ask about his incidents and link it with those situations. This would make it easier to understand.

Q. What in your view limits a visually impaired person from doing mathematics with ease?

A. Limitations are always present but after seeing the determination and the focus they have, it made me believe that except for a few situations, they can handle things like any other person. Few limitations such as remembering the whole set of numbers or practicing the problems on their own which makes them better etc. were few limitations which make it a little difficult. But with the modern technology, those few limitations can be easily overcome.

Q. From your own end would you like to add any point that the questions didn't cover?

A.You can see the interest which they have in learning and understanding the subject, listening to our every detail, trying to understand from them. It surely is fun to sit and read with them, understand with them and enjoy with them.

Oral mathematics

Oral learning is very common among the visually impaired. Mediums like the recorder and volunteers are one of the most common mediums and are important to orally transmit the educational material. Visually impaired are usually dependent on people around them like family, friends etc…or sometimes volunteers to dictate problems in mathematics for them to practice or to understand certain concepts. They face a lot of difficulties during their exams. During the examination their paper is often read out to them and they have to mentally solve it

and then dictate the answer to the person who writes it for them, who is also called as a **Scribe**. This sort of dependency hinders the ease of learning especially for subjects like science and mathematics, because reading can lead to misinterpretation of symbols and equations. Since audio alone cannot provide the conceptual framework needed to solve mathematical and scientific problems, visually impaired students have often been excused from taking courses that require manipulation of graphic or symbolic information. It takes away their control of their time, space and the material they wish to learn. During the examinations they are often left to the mercy of the scribe and on the assumption that what they are dictating is being written correctly. The existing computer reading software is very basic and is not compatible to do mathematical equations with ease. It is often unable to even decipher many basic symbols.

Mathspeak is a project that was initiated by a company by name gh,LLc which is established on the vision of providing access to Mathematics and Science textbooks for students with Print Disabilities (a term used for all those who find it hard to access the print). With the help of the Indiana Department of Commerce and grant from Indiana 21st Century Research and Technology Fund which was awarded to gh, LLC in the Summer of 2004 to develop MathSpeak™.

Project Overview[1]

This project is significant as the first attempt by an organization to adapt core science and mathematics curricula into the ANSI/NISO Digital Talking Book format for use by all print disabled students. Additionally, this is the first effort to incorporate MathSpeak™ into DTB's and the DAISY/NISO DTB standard.

There is a strong need for better math and science education among print disabled students. Currently, secondary school age students are in a large part unable to receive accessible instructional materials in mathematics and science. The natural result of this lack of materials is a general deficit in knowledge and skills and in math and science by students who are print disabled. This lack of accessible instructional materials has unfairly limited students who are print disabled in that they

[1]The Project Overview, The Fundamental Problems of Spoken Mathematics and Examples of mathspeak which have been taken from the website of mathspeak. www.gh-mathspeak.com

often lack the opportunity to study math and science. Because of a lack of access to science and math instructional materials the print disabled are ultimately unable to seek employment in the growing high tech job sector. If print disabled individuals have an equal opportunity to study mathematics and science, many new career opportunities will be opened up to this class of individuals that were previously not viable options.

The ultimate goal of this project is to provide print disabled students an opportunity to learn mathematics and science. To further this goal, gh is developing a module for the gh PLAYER™ capable of interpreting MathSpeak™ and rendering both visually and aurally the information encoded therein. This MathSpeak™-compliant software player will be a key commercialization outcome of the project. Although the MathSpeak™ specification itself is intended to be an open specification, there are some aspects of this project which are proprietary, including the gh PLAYER™ itself, which has unique parsing and rendering features so as to make a viable and competitive commercial product.

Additionally, by working with Dr. Nemeth, gh is continuing to refine and codify the MathSpeak™ specification, incorporating the use of both VoiceXML and MathML in the execution of the desired outcome. The eventual result will be a robust specification for spoken math, which will be introduced as a potential addition into both the National File Format standards for K-12 Instructional Materials, and both the ANSI/NISO and DAISY specifications for Digital Talking Books. gh is also committed to is making MathSpeak™ available as an open specification for anyone to build from.

The cornerstone technology of the project is the gh PLAYER™. The gh PLAYER™ integrates six types of accessible media - e-Braille, e-Large Print, Digital Talking Books, Foreign Language, Captioning, and Sign Language - allowing a broad range of people access to information sources from textbooks and publications to training manuals.

Although the gh PLAYER™ technology and the DTB media type have already been developed by gh, there is an incomplete portion of the ANSI/NISO and DAISY 3.0 standards that limits the utility of these solutions. This incompleteness is that Math and Science information is not currently addressed as part of the DTB solution. gh has developed, in conjunction with Dr. Abraham Nemeth, a technological solution for

voicing mathematical and scientific information called MathSpeak™. This work is an extension of the basic MathSpeak™ grammar and lexicon originally developed by Dr. Nemeth for use by a human reader. The basic principle of MathSpeak™ is that print mathematics can be rendered aurally in parallel with both the print and Braille versions of the text. The sample books and test converted for this project demonstrate the ease of use and power of the MathSpeak™ standard.

In sum, gh is working hard to ensure a bright future for students with print disabilities. By developing new technological solutions for the aural rendering of math, gh hopes to provide better access to math and science for students with disabilities. Over the course of this ongoing research project gh has had the opportunity to work with numerous students and to witness positive impact on the lives of disabled students - an impact that will hopefully carry forth for years yet to come.

The Fundamental Problem of Spoken Mathematics

General Description of MathSpeak™

Access to Math and Science information is a real problem for students with print disabilities (disabilities that prevent them from normal reading of the printed page). Students with print disabilities have a very hard time understanding the complex math equations that typically occur in Math and Science textbooks by just listening to someone read the math to them. This is mainly because of the lack of a standard for spoken mathematics, and also the traditional problems associated with reliance on a human assistant. This is a problem that can affect the ability of students from grade school through graduate school to learn. The gh MathSpeak™ technology solves this problem by combining a solid standard for spoken mathematics with high-quality computer synthesized speech. This allows the student to work by themselves at their own space and retain ownership of the ideas learned. The two facets of the gh MathSpeak™ solution are the standard itself, and the computer synthesis for the production of audio renderings.

The MathSpeak™ Standard

The MathSpeak™ standard itself is very powerful since it is based on the fundamental principles of the Nemeth Braille Code for the Mathematics and Sciences, the current standard for encoding mathematics into Braille. This code, developed by Dr. Abraham Nemeth, a gh employee, allows a student superior access to mathematics by conveying the information unambiguously and concisely using a special grammar and lexicon unique to mathematics. Dr. Nemeth has mapped the advantages of the Braille code over into a special spoken language for mathematics called MathSpeak. It is this language that gh is currently developing from theory to practice.

The power of the MathSpeak standard can best be understood by a simple example of the root problem. Consider the following simple mathematical equation as it would likely be read by a human reader.

x equals a OVER B plus 1.

When visualizing this equation, there are actually two possible meanings (or visual renderings) for this one voicing, as shown below:

- Rendering A:

$$x = \frac{a}{B} + 1$$

- Rendering B:

$$x = \frac{a}{B+1}$$

Which is the correct version? For a print-disabled student taking a test, the answer is crucial. Unfortunately, current techniques for the human production of audio for math are rife with these kinds of ambiguities, in addition to being of inconsistent quality, expensive, and time-consuming to make. The reality of everyday life as a print-disabled Math and Science students is that most materials are not available in alternative format and hence human assistants must be constantly employed, which creates a drain on both time and money for both the student and the school.

MathSpeak offers a precise, perfectly consistent version of the above equation each and every time the student listens to it

x equals BEGIN FRACTION a OVER CAPITAL b END FRACTION plus 1.

There are special reserved words in MathSpeak that are used to indicate to the listener what the actual semantic meaning of the equation is meant to be. The above MathSpeak snippet can be interpreted (or visually rendered) in only one, unambiguous way:

- Rendering A: $x = \frac{a}{B} + 1$

Note that both the proper contents of the fraction and the fact that the denominator is a capital (as opposed to lowercase) variable are indicated by the use of MathSpeak. This is but one of the many advantages to the use of an automatically generated, systematic standard.

Although some of the initial groundwork for MathSpeak has been done by Dr. Nemeth and gh, much remains to do in order for a complete and consistent system to emerge. The initial work of Dr. Nemeth represented techniques to convey only the most common mathematical situations (such as fractions, radicals, super- and sub-scripts) and does not account for more advanced constructs. This extension of lexicon must be completed. This lexicon must be studied as to the effectiveness with the computer-generated speech currently used by gh, especially for issues such as pronunciation, clarity, and differentiation. In addition, some linguistic analysis is needed to ground the specification in a solid theoretical framework, including the precise definition of the grammatical rules to be used. All of the above work must be encompassed in an XML framework in order to allow automatic generation of the audio and in order to fit into gh's standard production processes. Finally, extensive testing and user feedback is the only true method to measure the efficacy and utility of the product.

Examples of Mathspeak

Without Semantic Interpretation, MathSpeak speaks the symbols as they appear and cannot deduce their meaning. For example, the cross-sign can be either cross-multiplication or cross-product, so MathSpeak will just say "cross." Since it is sometimes ambiguous whether a comma is a delimiter or a comma within a number, numbers are spelled out except for the highest level of Semantic Interpretation.

Example 1

3+4x2--2=3+8+2=13

Verbose semantics - 3 plus 4 times 2 minus negative 2 equals 3 plus 8 plus 2 equals 13

For most fractions, the beginning is indicated with “start fraction”, the horizontal line is indicated with “over”, and the end of the fraction is indicated by “end fraction”. For the semantic interpretation, most numeric fractions are spoken as they are in natural speech. Also if a number is followed by a numeric fraction, the word “and” is spoken in between.

Example 2 $\frac{x}{y}$

Verbose semantics - StartFraction x Over y EndFraction

Example 3 $\frac{x}{y} + a = \frac{x + ay}{y}$

Verbose semantics - StartFraction x Over y EndFraction plus a equals StartFraction x plus a y Over y EndFraction

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Government rules and Scribe

The National Constitution states that there should be no discrimination on the basis of disabilities. The responsibility of development of the disabled is given to the state and each state has the right to make its own disability laws to empower the disabled.

Constitution and Disability

The Preamble, the Directive Principles of State Policy and the Fundamental Rights enshrined in the Constitution, envisage a very positive role for the State towards its disadvantaged citizens.

Article 41 declares that , ‘The State shall, within the limits of its economic capacity and development make effective provision for securing the right to work, to education and to public assistance in cases of unemployment, old age, sickness and disablement.’

Article 46 lays down an obligation on the State ‘(T)o promote with special care the educational and economic interests of the weaker sections of the people, … and … protect them from social injustice and all forms of exploitation.’

The duties of the state for the education for the disabled.

The appropriate Governments and the local authorities shall:

(a) Ensure that every child with a disability has access to free education in an appropriate environment till he attains the age of eighteen years.

(b) Endeavour to promote the integration of students with disabilities in the normal schools.

(c) Promote setting up of special schools in Government and private sectors for those in need of special education, in such a manner that children with disabilities living in any part of the country have access to such schools.

(d) Endeavour to equip the special schools for children with disabilities with vocational training facilities.

The appropriate Governments and the local authorities shall by notification make schemes for

(a) Conducting part-time classes in respect of children with disabilities who having completed education up to class fifth and could not continue their studies on a whole-time basis.

(b) Conducting special part-time classes to provide functional literacy for children in the age group of sixteen and above.

(c) Imparting non-formal education by utilizing the available manpower in rural areas after giving them appropriate orientation.

(d) Imparting education through open schools or open universities.

(e) Conducting classes and discussions through interactive electronics or other media.

(f) Providing every child with disabilities, free of cost special books and equipments needed for his/her education.

The appropriate Governments shall initiate or cause to be initiated research by official and non-governmental agencies for the purpose of designing and developing new assistive devices, teaching aids, special teaching materials or such other items as are necessary to give a child with disability equal opportunities in education.

The appropriate Governments shall set up adequate number of teachers' training institutions and assist the national institutes and other voluntary organizations to develop teachers' training programmes specializing in disabilities so that requisite trained manpower is available for special schools and integrated schools for children with disabilities.

Without prejudice to the foregoing provisions, (The appropriate Governments shall by notification prepare a comprehensive education scheme which shall make Provision for

(a) Transport facilities to the children with disabilities or in the alternative financial incentives to parents or guardians to enable their children with disabilities to attend schools.

(b) The removal of architectural barriers from schools, colleges or other institution, imparting vocational and professional training;

(c) The supply of books, uniforms and other materials to children with disabilities attending school.

(d) The grant of scholarships to students with disabilities.

(e) Setting up of appropriate forums for the addressal of grievances of parents, regarding the placement of their children with disabilities.

(f) Suitable modification in the examination system to eliminate purely mathematical questions for the benefit of blind students and students with low vision.

(g) Restructuring of curriculum for the benefit of children with disabilities.

(h) Restructuring the curriculum for benefit of students with hearing impairment to facilitate them to take only one language as part of their curriculum.

All educational institutions shall provide or cause to be provided amanuensis (scribes) to blind students and students with or low vision.

Problem Scenario

It has been observed that due to the difference in the rules for education through out the country, people with disabilities find it a challenge when they pursue education in different states. Lack of common rules across the nation creates irregularity and confusion among the students.

Kameshwari says that she had done her education in mathematics till class 9th from Delhi, however in class 10th when she shifted to Nagpur, Maharashtra she found no school that would provide her with similar education and even though she studied mathematics in class tenth she had to give the examination for class 7th as there was no provision for the other under the laws of that state. Further difficulties that she faced while giving that exam was that she was meant to answer the paper in the manner of a class seventh standard student (that is step by step) othewise she would 'lose marks'.

Lack of common rules across the nation creates irregularity and confusion among the students.

Examination

For the purpose of examinations a visually impaired student has been provided with the facility to choose a scribe who does the following tasks

• He reads out questions .

• He takes dictation that is the answer.

• He assists while doing the calculations making diagrams for the visually impaired in the case of mathematical problems. (The scribes cannot calculate for the visually impaired, they will just help them in doing it by dictating the data to them.)

Scribe

The eligibility of the scribe is as follows:

1. The candidate has to arrange his own Scribe at his own cost.

2. The academic qualification of the Scribe should be one grade lower than the eligibility criteria stipulated for the posts.

3. The Scribe should be from an academic stream different from that of the candidate.

4. The Scribe should possess 60% or less marks in his own academic stream.

5. Both the candidate as well as the Scribe will have to give a suitable undertaking, confirming that the Scribe fulfils all the stipulated eligibility criteria as mentioned above. Further, in case it later transpires that he did not fulfill any of the laid down eligibility criteria or suppressed material facts, the candidature of the applicant will stand cancelled, irrespective of the result of the written examination.

6. Such candidates who use a Scribe shall be eligible for an extra time of 20 minutes for every hour of the examination.

The Scribe should be from an academic stream different from that of the candidate.

Problems of the Scribe

The Scribe becomes one of the main problems in the education of blind. As one can see from the eligibility rules above the qualification of the scribe has to be very poor. In this scenario the student while dictating may be misinterpreted, mainly in the diagrams and flow charts. Also when a scribe reads to the student he may not read the correct signs especially in the case of sigma (summation and standard sigma). All of this leads to a big problem. Again since the qualification of the scribe has to be lower he may not be aware of all the terminology and signs which he may write incorrectly. The students are fully dependent and have to trust the scribe to write and read correctly. Scribes should have to have a decent handwriting, good communicating skills and a lot of patience since they ask many questions and would want them to repeat the text many times.

There is another problem, the rules of the eligibility are not mentioned and clearly stated. The visually impaired person faces great difficulty in procuring and submitting the document of the scribe for which the acceptance by the university opens only few days before the actual exam. This administrative requirement at the last moment wastes a lot of time of the student which could be spent studying.

Braille in Governance

In India the Right to Information Act has been published in Braille. Also there has been a launch of Braille Electricity Bill for the visually impaired consumers, in Mumbai.

Mathematics Education of Visually Impaired

Article from T. Robinson

Introduction

Learning mathematics is considered to be difficult even for the sighted children. It is thought to be a subject involving with abstract entities having little resemblance to real objects which one handles in life. Yet the application of even simplest mathematical operations and results are numerous. Teaching mathematics should be viewed as a process of comprehending structures which organize the experiences of a child through the different developmental stages. The difficulties faced by visually impaired students in learning mathematics, can be attributed partly to visual impairment but to a great extent to the inappropriate teaching methods and non-availability of appropriate resource materials. In this article the survey conducted among the teachers of the special school for the visually impaired and the various difficulties imbibed in teaching and learning of mathematics is discussed.

Mathematics education in special schools

At present, the situation of teaching Mathematics and Science subjects is done up to high school level only. There has not been development of resource materials for the higher secondary or collegiate level for these Science subjects nor enough trained resource persons. The teaching of mathematics at special schools is not satisfactory while comparing the same with integrated education setup. According to the study done by Advani (1989) approximately 1,27,000 visually impaired children of 5–14 age group needed educational facilities. A study by Punani. B (1994) says that not more than 10% of the visually impaired children have an opportunity of going to special school or regular school. There are 243 special schools for the visually impaired now in the country as per the directory of the Rehabilitation Council of India (RCI). The curriculum followed in these schools is the same as prescribed for sighted children. Most of the schools in north India have exempted the visually impaired students from studying Mathematics after VIII standard (i.e. upper primary). Students are allowed to take one language or music in stead of Mathematics. In certain schools, some portions of Mathematics is omitted due to non-availability of adapted text material. And the special aids and equipments are not appropriate to the special needs of the learner. There are cases too where the entire syllabus of Mathematics is covered with tools such as Taylor frame, Abacus, Geometry kit, Braille Mathematics Code and text books transcribed in Braille format. As the teaching and learning of the same content in tactile and Braille format takes more time, the teachers are forced to cover the syllabus and the total understanding of the mathematical concepts by students is missed. This prevents the proper understanding of Mathematics and when the students join the mainstream later they find it difficult to cope up with the rest of the students.

The Biwako millennium framework (2002) advocates an inclusive, barrier free and rights based society for the persons with disabilities. A good mathematics curriculum must posses carefully chosen objectives that stress a balance among cognitive, affective and psychomotor domains as part of the instructional strategies. The possibility of visually impaired students learning mathematics is often questioned by highlighting some of the areas in mathematics that demand vision. There are various factors that contribute to the learning of mathematics. It is also very important on the part of teachers to adopt various approaches when teaching mathematics to them. Hence the success of mathematics education depends on two aspects – namely good teaching from teachers side and good learning from students side. According to Mani (1992), the key factors considered important for effective learning of mathematics by children with visual impairment among others:

1. Selection and teaching of suitable mathematics Braille codes
2. Adaptation of text material to students with visual impairment
3. Teaching of mathematical devices such as Abacus, Geometry kit etc.,
4. Provision of appropriate mathematics text material
5. Preparation and usage of appropriate teaching aids
6. Provision of simulating experiences, creation of situational approaches etc.,

Research studies reveal that student achievement is strongly influenced by the teacher's level of expertise. An expert teacher's student performs 40 % better than students of an ill prepared teacher (Ramesh, 2006). In any teaching learning process the teacher is an indispensable entity, which can not be substituted. A teacher to be effective in teaching mathematics to students with visual impairment needs to be abreast with:

1. Effective teaching methodologies
2. Use of mathematical devices such as Abacus etc.,
3. Mathematical Braille code

India
MYSORE
Asia
Asia
SAMSUNG

4. Suitable adaptation techniques without affecting the learning outcomes

5. Preparation and effective usage of teaching and learning material

6. Technology aiding mathematics education.

In addition, the teacher needs to be updating his knowledge with developments that take place in teaching strategies. Incorporating creativity in the act of teaching makes the learning of abstract concepts better and enjoyable to the students.

Details of the survey conducted are available with the Mr. T. Robinson; however, the analysis is presented below.

Survey done in the special schools

All the schools had residential facility and teachers to students' ratio were within 1:8. Five schools had the basic facilities of Perkins brailler, Braille embosser, Computer, Thermoform heater, Tape recorders and Braille text books whereas the other five lacked the Braille embossing, tactile production by Thermoform heater and computer facilities. The government aided schools seemed to have better infrastructure facilities. All the schools had reported about the regular medical checkups and eye care camps to their students with the assistance of N.G.O s and medical doctors. Eight schools mentioned the support services given to their students reading and recording of study materials and scribing during examinations. The student volunteers from nearby colleges and retired people of the local town were volunteering with their services. All the schools are offering sports and extra curricular activities to the students. Vocational courses were offered in seven of the schools. The course included vocal and musical instruments training, weaving, chair caning, basket making etc. On the issue of inclusive education, five of the heads favored the need for it whereas three were pessimistic about the success of it and two declined to make any comment. On the issue of mathematics and science education for the visually impaired, seven heads lamented about the difficulty of teaching these subjects with the existing resource materials. They mentioned that the content of the syllabus in these subjects were advanced and heavy for the visually

impaired students and also commented on the lack of proper teaching techniques for the higher classes.

Observation from the survey with Mathematics teachers

The questionnaires were sent to all the 19 schools for which the permission was obtained. Twenty nine teachers from fourteen of the schools gave their responses (74% of representations from the schools). Of them 15 were visually impaired teachers. Of the total of 29 teachers 15 were from government schools and 14 were from government aided schools. The teachers handled classes of primary, secondary, upper primary and high school level mathematics. For the purpose of study the questions were grouped into two – focusing on upper primary and high school level. There was balanced response from teachers handling up to 7th standard and 8th – 10th standard. There were 15 responses for the former and 14 for the later. Of all the teachers 25 teachers (86%) had under gone pre service or in-service training. In the remaining four, two were new recruits. There were 23 teachers having more than 10 years of teaching experience. On the familiarity of the tools used in general, 75% or more were familiar with Braille, Perkins Brailler, usage of embossed pictures and wooden models. The least familiarity was with usage of closed circuit TV, Screen reading and magnification software and usage of swell paper. In the case of familiarity with mathematical devices, 28 of 29 were familiar with Taylor frame whereas 19 were familiar with Braille mathematics code and geometry kit. Talking calculator was the least popular kit to them as 3 out of all the 29 were familiar. The table 3.10 gives the list of all tools and the number of teachers familiar with them. The question 10 of the questionnaire had 17 sub-divisions. The questions had the option of difficulty level felt by the teachers in teaching. The questions were based on expressing the notations (Taylor frame code, Braille mathematics code), expressions (polynomials, arithmetic), pictures (basic, specific), properties of trigonometric shapes (triangles, quadrilaterals), (geometric constructions), graphs (linear, quadratic), simple and compound interest and diagrams(bar diagram, Histogram). The five options given to express the difficulty level of teaching were very easy (ve), easy (e), moderate (ok), difficult (d) and very difficult (vd). For the analysis the ve and e were clubbed as 'easy' and the d and vd were clubbed as 'difficult'. Hence there were three levels of difficulty as 'easy', 'moderate' and 'difficult'.

For some questions the teachers who did not handle the concerned mathematics topic did not respond.

It is found that teaching of mathematical notations using Taylor frame was easier than using Braille mathematics code. The teaching of algebraic expressions and polynomials were difficult while compared with teaching arithmetic operations and algebraic expressions. Though teaching rational and irrational numbers were difficult it was comparatively easier. Teaching properties of triangles were very difficult. Teaching quadratic curves were more difficult than teaching linear graphs though both were difficult. Geometric constructions were the most difficult especially with constructions of parallelograms, rhombus and concurrent points in a triangle. Teaching of bar diagrams and histograms were found to be difficult.

On the specific difficulties encountered in teaching mathematics among upper primary classes (6th, 7th and 8th standards) the most number of teachers (19) reported their difficulty in geometrical concepts which involved quadrilaterals, rhombus, symmetry etc. Sixteen teachers expressed their difficulty in algebraic expressions, inequalities and identities. Nine teachers mentioned their difficulties in expressing real, rational and irrational numbers.

On the specific difficulties encountered in teaching mathematics among secondary classes (9th and 10th standards) the most number of teachers (7) reported their difficulty in practical geometry (graph of linear and quadratic curves) and theoretical geometry (especially point of concurrency and theorem proving).

On the question of 'other difficulties ', most number of teachers (19) lamented on the lack of sufficient text and resource materials on the mathematic topics while 18 teachers reported the difficulty in lack of proper teaching devices to the specific topics in mathematics and 16 teachers reported the lack of devices with the students is an added disadvantage for the students. Many teachers agreed on the quantum of syllabus being heavy to the students and finishing the syllabus on time and making all the mathematic concepts understandable with out proper resource materials and assistive tools is an impossible task.

The widely used tools such as Taylor frame, mesh board and spur wheel were designed for elementary level of mathematics and have inherent

limitations while teaching of higher level of mathematics. Some of the difficulty in teaching geometry and trigonometry notions are attributed to the limitations of the tools used. Though each tool has a specific usage and purpose they are limited while teaching certain mathematical concepts. The Taylor frame can be used for plotting of grid points but not for continuous curves. The drawing of curves or teaching of continuity, differentiability etc in calculus is beyond the scope of Taylor frame. While making embossed curves by mesh board or by spur wheel on a sheet of paper the embossing or raised line is created on the reverse of the paper. This tool is very handy for the teacher but it has its difficulty to make pictures of precise measurements. Due to the reversal nature of pictures being produced, it seems difficult for a visually impaired student to make use of it.

Hence it is identified that the most difficult topic of teaching is geometry and trigonometry as far as the syllabus of upper primary and high school mathematics. In particular, the geometrical constructions under practical geometry and theorem proving & axiom verification in trigonometry are identified as very difficult concepts. The identified difficulties are attributed to the lack of proper resource materials on teaching on these concepts and lack of proper tools for the students' part to understand.

TEACHING MATHEMATICS AS A BLIND PERSON

By Abraham Nemeth, Ph.D.
The Text of a Presentation to the
Mathematical Association of America
Orlando, Florida
January 10, 1996

Good afternoon! Well, clearly this is an undergraduate class. Had everyone written that greeting down in his notebook, I would have concluded that this is a graduate class. To understand how a blind person can successfully teach mathematics, I must take you back to my early childhood. I was born congenitally blind and thus have no personal memory of the world of sight. I grew up, surrounded by love, in an extended family with two parents, four grandparents, and lots of uncles, aunts, and cousins. My father would take me by the hand as a little boy and would keep up a constant conversation to keep me in touch with my environment. “Right now we are walking west,” he would say, “and as soon as we make a left turn, we will be walking south.” He would ask me to take note of the direction of traffic flow on the street along which we were walking, and would explain to me that when we got to the next street, the traffic would be flowing in the opposite direction. He would apprise me of the names of all the cross streets along our route of travel. He would lead me from home to our usual destinations always by a different route so that I would develop a mind’s-eye map of the neighborhood in which we lived. He would let me feel the metal lettering on mailboxes, police and fire call boxes; he would let me play with building blocks with large embossed letters; he would let me assemble large rubber stamps with raised letters; he would let me feel the neon tubing on the front of store windows so that I could learn the shapes of fancy script letters.

My mother would send me on errands. She would give me a list of four or five grocery items to bring home. But she was safe -- the grocery store was just around the corner with no streets to cross, and the grocer was my grandfather. I had good memory training by remembering grocery lists, and good training in mental arithmetic by adding up a few small numbers and figuring out the right change.

I attended the regular New York City Public School System during my grade school and high school years. In these schools, there was one room called a resource room staffed by a teacher trained in blindness skills. I attended regular classes with my sighted friends for such subjects as geography, history, arithmetic, and spelling, but when the subject was art or penmanship, I returned to the resource room where the teacher taught me braille, typing, and other skills of blindness. I was a competent typist by the age of nine.

I was always interested in mathematics, even in elementary school. But when I entered Brooklyn College, I heeded the advice of my counselors who told me that a field like psychology was much more realistic for a blind person than mathematics. Accordingly, I followed their advice and in due course received an M.A. degree in psychology from Columbia University. But I couldn’t get math out of my system. As an undergraduate, I took all the math courses that my schedule would allow. Even after I was married, I took math courses at Brooklyn

College in the evening until there were no more math courses in the catalog to take. Meanwhile, having no success in finding employment in my field of psychology, I supported myself and my wife by taking one unskilled job after another during the day. One day, my wife asked me if I wouldn’t rather be an unemployed mathematician than an unemployed psychologist. So I gave up my daytime job and enrolled at Columbia University as a candidate for the Ph.D. degree in mathematics; my wife went to work.

In 1946, men were coming home from the War in large numbers. At Brooklyn College, hundreds of men were registering for the second semester of calculus, having taken and passed the first semester before being distracted by the War. I leave it to you to guess how much of that first semester they remembered a War later. They needed help. A special workshop was set up for that purpose. A large classroom was set aside with blackboards all around except for where the windows were. Each student, with a book in his hand, was assigned a blackboard panel on which to set down as much of his calculus problem as he could do. Many blackboard panels were blank. A corps of volunteers circulated among these men helping them to complete the problem. I was one of the volunteers. I would ask the student to read me his current problem from the book. Then I would ask him to read as much of the solution as he had managed to write on the board. After analyzing the problem and discussing the next step, I picked up a piece of chalk and wrote the next (sometimes it was the first) mathematical expression. My father’s training in acquiring the skill of writing and printing came in handy. Unknown to me, the department chairman who was supervising this workshop was watching me with interest. One Friday night, I received a telegram from the department chairman telling me in telegraphic style that one of his staffers had become ill, that he would be out for the rest of the semester, and would I take his classes until he was able to return? That weekend, I scurried around, found the relevant textbooks, and boned up on all the material I would have to teach the following Monday evening, and that’s how my career as a math teacher was launched.

Meanwhile, as the mathematical concepts, and therefore the notation, became increasingly intricate, I found that the braille techniques for expressing mathematical notation were either inadequate or non-existent -- just as my counselors warned me. Little by little, however, I began to improvise new braille techniques to make it possible for me to write down all the notation that was buzzing around in my head. My mother's early training in sending me to the grocery store was excellent, but there was a limit to one's mental capacity. Finally, I settled on a braille system that was both consistent and served my needs. One day, a colleague who was a nuclear physicist and who was blind asked me if I had a table of integrals. I told him that I had one, but that it was written in a private braille code that he would not be able to read. Would I brief him on the code, he implored; he needed the table of integrals desperately. Within a half hour, he was having no difficulty reading the table of integrals with all its fractions, radicals, superscripts, Greek letters, and all the other arcane notation involved. Impressed, he asked me to write up a short expository paper of how the code worked, highlighting its underlying principles. I complied, but the result was not as short as he had wished. Nevertheless, he invited me to present my code before the braille standard-setting body of the time, and after about a week of testing; the code was adopted as the standard mathematics code in the United States and was thereafter known as the Nemeth Braille Code for Mathematics and the Sciences. It subsequently went through several revisions, each one extending the capabilities of the previous one. Meanwhile, the Code was adopted in Canada and in New Zealand. Several years ago it was translated into French for use in the French-Canadian provinces of Canada. Today there are tens of thousands of Braille volumes in the Nemeth Code. Braille transcribers who study the Nemeth Code, who pass a qualifying test, and who submit a manuscript to demonstrate their proficiency are certified in it by the Library of Congress. The two major volunteer organizations with a combined membership approaching five thousand routinely conduct Nemeth Code workshops at their national and regional meetings, and they routinely publish Nemeth Code information in the skills columns of their respective publications.

Let me now consider how a blind person receives his mathematical training. Many people who are legally blind still have varying degrees of residual vision. Many of them can use ordinary print effectively. These are not the people I have in mind, unless the prognosis of their eye condition is poor, in which case they should learn braille early. Still others, while they can use print to some extent, require special lighting, need to assume a special posture for reading, are limited to the length of time they can read, etc. People in this category are also

better off learning braille. It is the braille users that I have in mind. By far, the best results are obtained when the blind student has in braille the same math textbook that his class is using. This is not always possible due to frequent changes in textbooks. Also, different school districts and different colleges use different textbooks for the same subject. Failing this ideal, the second best solution is to have in braille an earlier edition of the textbook if available. A third useful alternative is a parallel textbook which covers the same subject, if the previous two alternatives are not available. Some educators believe that modern technology is the solution. They believe that an audiocassette or a computer can be just as effective as braille. This is a mistaken view. The educators who promote it either do not know braille or are too lazy to learn it. Just suppose you are listening to a math text on an audio tape, and the reader suggests that you consult formula (17b) on page 46. First of all, you can't be certain that page 46 is on the cassette you are currently using. Even if it is, imagine fast-forwarding or rewinding the tape with no easy clue as to how close to page 46 you are. There are some techniques that make such a search easier, like tone-indexing, whereby you can hear a page boundary when in fast-forward or in rewind mode, but otherwise such a signal is inaudible in play mode. Nevertheless, the search is clumsy at best. If you are lucky enough to find the formula in question, you must then return to the place at which it was referenced. I hope you have the mathematical content well in mind while you are doing all this fiddling with your electronic device.

I can't imagine taking notes in a math class other than in braille. It is a mistake to record the whole lecture and then listen to the recording later. First of all, it takes just as long to replay the lecture as to listen to the original. Second, the available time for study does not permit such a leisurely approach.

How does a blind student take a test? There are many formats, but I will describe the one I used as a student. At the beginning of the semester, earlier if possible, I would make an appointment with my professor and discuss with him the accommodations I would need as a student in his course. One of the issues I discussed with him was that of taking tests. I suggested that, at the time of the test, we find an empty classroom or office space. Either he or his TA would dictate the questions to me as I wrote them in braille on my braille writer. This would be done about 15 or 20 minutes before the scheduled test time. I would work out the test in braille on my braille writer, using blank braille paper I brought with me. When finished, I would put my worked-out test into an envelope that I also brought with me and, at the end of the test, hand it either to the professor or to his TA. The only extra time I needed was the time to copy the questions into braille. Some professors wanted me to read what I had written to them personally; some asked me to read my answers to his TA for grading; some wanted me to read my answers to another professor. Some professors proposed giving me the test orally. I always discouraged this approach; it may convey my understanding of the basic concepts, or lack thereof, but an oral test does not reveal any skill I have in manipulating mathematical expressions. This manipulative skill is carefully nurtured and cultivated from the earliest grades, and it should pay off when performing a substantial differentiation or integration or in solving a differential equation. This manipulation cannot be done efficiently during an oral test.

Now let me jump ahead to the time a blind person, trained as a mathematician, is seeking employment. His resume should contain a short section about his blindness and the alternative techniques he uses to achieve the same result as his sighted colleagues. But this description should not overwhelm the remainder of the resume. In all other respects, his resume should conform to what is expected of any other job applicant.

Our blind job applicant is now being interviewed. He should answer all questions forthrightly and pointedly. However, he should also be alert to the type of question which explicitly asks one thing and implicitly asks another. When I was interviewed for my entry level position at the University of Detroit, I was asked if I had been to downtown Detroit and what impression did I have of that experience. I realized that my interviewer was not interested in a tourist's perspective of downtown Detroit. What he really wanted was information about my ability to be mobile an travel about independently. I began by telling him that my first impression of downtown Detroit was that it was not unlike the King's Highway shopping center in Brooklyn, by which I intended to convey the idea that the problems in getting around in downtown Detroit were not overwhelming and that they were well within my ability to cope with them. I then elaborated, but not at great length, on my ability to travel comfortably around New York City, somewhat larger than Detroit, by using its bus and subway systems effectively.

Our blind job seeker has now been offered a job and has accepted it. He must now consider the issue of classroom conduct and devise strategies for each of its several aspects.

Let me first consider the issue of classroom decorum. This is almost always the very first question with which an interviewer is concerned. The answer is simple. Gain the respect of your students early. A teacher who has the respect of his students experiences very few problems in classroom decorum. The one or two would-be trouble-makers are quickly subdued by the law-abiding majority. If a teacher does not have the respect of his students, it doesn't matter if he is blind or has a thousand eyes with 20/20 vision in each one; he is going to encounter disciplinary problems.

The next issue is handling the blackboard. As I indicated earlier, my father's patience and foresight made me comfortable in the skill of writing, and this skill has stood me in good stead during my working years and beyond. What remained was to acquire a disciplined approach to writing coherent straight lines. I used my anatomy as a guide. On a blank panel, the first line would be written at the level of my forehead, the next line at the level of my nose, the next at the level of my mouth, the next at the level of my chin, the next at the level of my neck, the next at the level of my chest, etc. When one panel was filled, I would move to the next panel and proceed in the same manner. I erased the board just as systematically. Frequently, a student in the first row would volunteer to erase the board and it became his full-time job for the duration of the course. Sometimes two front-row students took turns.

I encouraged my students to ask questions and otherwise participate in classroom discussions. Since hand-raising was ineffective in my case, I made it clear that it was not uncouth to interrupt me at the end of a sentence. I suggested that the interruption be in the form of calling out the student's own name. Calling out my name gave me no new information; I already knew who I was. But calling out the student's own name allowed me to know the identity of the speaker and possibly to recognize his voice on subsequent occasions.

Let me tell you how I handled my lecture notes. I will do so by means of describing a typical situation. I was teaching a class in Fourier analysis. I had prepared my lecture by writing the pertinent formulas in braille on 5 by 8 cards, one formula to a card, in the order in which those formulas would arise in the course of the lecture. I assembled a small file of about 12 or 15 cards which I put into my left-hand jacket pocket. As the lecture got under way and I approached the first formula, I nonchalantly reached my left hand into my jacket pocket and with the right hand wrote the formula on the board that my left hand was reading. As I proceeded to deliver the expository connective information leading up to the next formula, I would casually remove the top card from the file; place it at the back of the file, thereby exposing the next formula. I put the updated file back into my jacket pocket where the next formula was ready for me to read with my left hand and write with my right hand at the appropriate time. I proceeded in this manner to deliver a coherent lecture. My students were impressed. They agreed that only a genius could put all those formulas on the board, with all the integrals, limits, and summations in proper order. Since the statute of limitations has run out, I hereby admit that I never did anything to disillusion them.

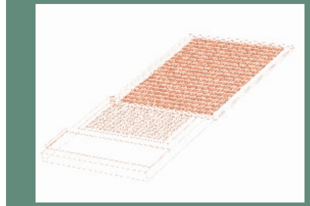
Finally, I would like to stress the importance of full participation in departmental activities and in the university community itself.

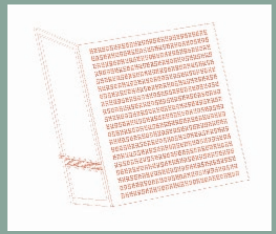
The premise of my presentation is that a blind person who is adequately trained in his field and who has mastered the skills of blindness can function as competently and as productively as anyone else as a mathematics teacher, and that his blindness need not be an obstacle in choosing that career, as it was in my case. My career was delayed at least five or six years because of the advice I received from my counselors, and I hope that my experience will be of benefit to other blind people who seek mathematics teaching as an honorable and achievable goal.

Thank you.

A Kind of a solution

The most urgent need of the hour is the revision of the tools used by the visually impaired. There is dire need for innovation and incremental design regarding these tools. To achieve this goal people who are interested have to communicate, interact and discuss. Regionalization of ideas and innovations only leads to stagnation and repetition. This also limits the scope of invention.





Another point of concern is that mathematics is a subject that has taken shape over years and years of change and invention of newer concepts and means of representing these concepts. The limitation of math is not that it is a non-linear subject and that there is no other better way in which that same concept can be written. It is important to think of fresh way to represent these concepts such that it becomes accessible to a visually impaired without much trouble and also relive the stress on his memory. It may take time but it is not an idea worth disregarding.

Invention of a new tools or a script all together is debatable and until one is invented and tested nothing much can be said. Besides adaptability is the key issue of a script which may take years. Incrementing over the existing design of tools and script is safer, faster and more feasible an idea considering the existing infrastructure.

The Braille slate being the most important of all tools should be constructed in such a way that one can see the solutions of the mirror writing. This can probably be done by embossing the dot of the cell on the lower sheet. Thus the stylus will also have to be made up of such a material that will aid the embossing of the dot on the paper.

The upper sheet of the Braille slate should be made in such a way that it helps in feeling the dots punched. That way any mistake would be detected sooner. For this I suggest that there should be a single line of cells that can be used for punching which can be movable.

A simple idea of keeping the paper in place while opening the braille slate in the middle of writing is to have clips on the upper sheet which can be clipped to the paper before starting.

An auditory tool can be developed such that it can read what is being written by the visually impaired on the slate. This would help in detecting the mistake immediately, reading what has been written and thus help a visually impaired person get an immediate reference to what he or she has written.

The interaction with the visually impaired and the workshop during my research yielded the ideas of combining the Braille slate, Taylor's frame and geometry tools. This can also be detachable. This is an interesting possibility that can be explored.

The workshop also suggested that the tools can incorporate a rough work sections.

The Taylor's frame can be developed in such a way that it can document what has been written.

In Process

While incrementing or reinventing the tools it is important to look at context. Perkin's Brailler and computer besides being a non portable product they are also very expensive and non manual. Which is my prime concern when I look at the fact that most of the visually impaired population comes from the developing and underdeveloped countries where purchasing power and power to bear the cost of regular maintenance is weak. There by it is important to be conscious while designing that they solve the problem but it remains basic, manual and inexpensive.

Also it is important that the material used should keep the real users that are the children in mind. If metals and plastics or any other materials are being used they should be made in such a way that they enhance the tactile sense and simultaneously are not difficult, harmful or dangerous to handle.

Few Thought

Due to my lack of knowledge and background I am not in a position to comment on the system of education and it's failing but some thoughts that have developed.

There is a need for uniform education system for visually impaired that can bring homogeneity. Even though there is thoughtfulness in the provision of the options to do subjects like mathematics and science. The idea needs to be reconsidered in terms of its long term

disadvantages and limitations. Also under the provisions the options and course material provided needs to be paid attention as the material of study belongs to a higher understanding attained after the completion of 10th and not intended for the level of an eighth standard student.

• An Idea much debatable is that should there be a difference in teaching methodologies, structure of institutions, system of education and structuring of the syllabus for visually impaired. Well personally I support the difference the reason being that in both cases the receiving senses are very different and so will be the perceptions. This difference in perception is what the education system for the visually impaired has to be responsive to. The foundation of the proposal lies in the research that will aid a better understanding and help in execution.

• There is a need for awareness and counseling with respect to health education and professions that can be provided to the visually impaired children and their parents. Many times the lack of awareness leads to negligence and loss of important years in their growth.

• The options provided for vocational training are not lucrative and does not help in a good standard of self maintenance.

• It was mutually felt that communication, presentation and other important social skills are important and such programs must be encouraged and developed.

• An interesting field of research would be of various professional opportunities in various sectors for visually impaired. These opportunities should be such that the visually impaired people add to the production rather than compete with their sighted counterparts. Opportunities where their expertise and know how will act as a unique and valuable input. An instance of such an idea is employment of visual and hearing impaired people as coffee tasters. In this example their keen senses became an asset to the company.

There is a need for awareness and counseling with respect to health education and professions that can be provided to the visually impaired children and their parents.

CONCLUSION

My role was that of a collector and a documenter of facts and data. After some months of collecting, understanding and exploring ideas I started to weigh upon them. Where upon I concluded the obvious that

- Yes, mathematics is a difficult subject for visually impaired.
- The content and attributes of the subject itself can be difficult to be imagined and executed by the visually impaired.
- But none of my research ever told me that the problem or the impossibility lay in the user's disability and the subject in concern.

Man as a human being has constraints, a simple instance that can elucidate this. Man as a human being has no ability to fly or swim across oceans therefore crossing oceans and discovering beyond was a problem but not only did he invent means to cross the ocean, he also invented means to cross planets and explore outer space. The reason this was possible , because he never saw his disability to fly or to swim across oceans as a disability. There was a challenge there as there is here.

Who will provide the solution?

I wonder, in whose hand lies the solution to the problem?

The answer is BOTH - the visually impaired and the sighted.

This idea germinated derivation from the analysis of the existing solutions where the inventors of both kinds (the visualy impaired and sighted) have overlooked certain aspects while designing.

Braille as a tool was discovered by Louis Braille who was visually impaired. He saw the potential and discovered a solution. The reason was simple; he knew the users need. He knew the constraints of the user he had also realized the alternatives for those constraints to which Hauy had only partly succeeded. The problems with Haüy's embossed letter were that it didn't go beyond reading and to device means for easy writing. It became limited to what was generally perceived as a mean of attaining literacy and basic education. However, the use of dots as a tool to code language and script was not the original idea of Louis Braille too.

It came from Charles Barbier's night writing technique. What struck me was that even though Louis Braille was struggling within the realm of problem and finding possible solutions, he could never discover the solution on his own.

Similarly when we look at Braille slate and the stylus verses the Perkin's Brailler. Again one is produced by the visually impaired (Braille slate) and the other by his sighted counterpart (Perkins Brailler). Perkins Brailler attempts to solve the most prominent problem of mirror writing and immediate cross checking that does not exist in the Braille slate. Again it is not the most appropriate solution as it not very portable tool.

Somewhere I realized that the two extreme user groups working solitarily on their own are always leaving gaps while coming up with solutions; advantages of one becomes the drawbacks of the other. This made me wonder what would happen if the two were to come together to produce the final product. In order to test this notion, I conducted a small workshop and observed the interaction between the visually impaired and the non-visually impaired. I noticed an increased enthusiasm between the two groups and also that ones visual experience lent to the others user experience. Where by interesting viewpoints and observation were made together. Both the groups agreed that such interaction must be increased.

As mentioned in the previous chapter, I have tried my level best in offering possible solutions for the problems faced. There is still a along way to go to achieve actual working solutions but I hope some of the ideas listed will work as triggers and will be taken forward

Further scope

This project is meant as a data collection bank, a means by which I am sharing my research material; all that I have gathered from it so that it may connect people to further resources. Due to lack of knowledge and time I thought this the most appropriate medium in which to share the information. Ideally, it would have been the World Wide Web. That is where I envision the most interaction of all who are interested in a project of this nature.

Ideally, it would have been the World Wide Web. This is where I envision the most interaction of all who are interested in a project of this nature.

The difference in the two mediums as I see it are as follows:

- It will be a site where individuals will be allowed to add and update the ongoing topics being researched.
- It will link to other websites.
- Provide a link to individuals and institutions who are working and using the information.
- The audience of the site will add to the content and become part of the content themselves.

The main aim of the website can be to

- Inform
- Trigger
- Share

Where by this resource bank will act as a starting point for new research ideas and queries.

- It will act as a platform that will connect existing developers and researchers.
- Help institutions to keep themselves abreast of the current state of affairs and perhaps allowing to them to contribute to the Research.
- It will also inform non-academics interested in the subject.

People and Places

“Don’t ask what the world needs. Ask what makes you come alive, and go do it.
Because what the world needs are people who have come alive.”
Howard Thurman

Institutions

NATIONAL INSTITUTE FOR THE VISUALLY HANDICAPPED
(Ministry of Social Justice &
Empowerment, Govt. of India.)
116, Rajpur Road,
Dehradun (U.A.)-248 001, India.
Phone: +91-0135-2744979,2744387 (PBX) 2744491 .
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NATIONAL ASSOCIATION FOR BLIND
It is spread all over India with a wide network of 18 State & 65 Dist. It started with it’s first branch in Mumbai in 1952.
National Association for the Blind, India,

Department of Employment, 2nd floor,
11/12, Khan Abdul Gaffar Khan Road
Worli Seaface, Mumbai - 400 025
Phone: +91-22-498 8134
Fax: +91-22-493 2539
Email: nabin@bom3.vsnl.net.in
www.nabindia.org

NATIONAL ASSOCIATION FOR THE BLIND KARNATAKA
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4,Rehabilitation Cmplx
Jeevan Bhima Nagar - Pin: 560075
Tel.: 25281590,25289939,25281439,
Mobile.: 9844080787,9448394118

SAMARTHANAM TRUST FOR THE DISABLED
(Contact Person: Paul Muddha/annamma)
11, Villa Suchitha
1st Crs, 17th A Mn Rd, 2nd Phase
Nr Woodys
Jp Nagar - 560078
Tel: 26591488,26592999,
Mobile: 9448689053

ENABLE INDIA
Ms. Shanti Raghavan
12, 8th block KHB colony
Brahma Kumari Rd
Near Mangal Kalyan Mantapa
Koromangla-95
080- 41101390
080-25714842
Mobile- 9845313919
Website:www.enable-india.org

MITRA JYOTHI CHARITABLE TRUST
Ms. Madhu Singhal
Mitra Jyothi is a talking library
M-137, 9th A Main,lic Colony,11th Sector, Opp To Bank of India Jeevan
Bhima Nagar - 560075
Tel: 25288504,25289040,25255558,
Mobile: 9448019737

SRI RAMANAMAHARISHI ACADEMIC SCHOOL FOR BLIND
CA-1B, 3rd Cross, 3rd Phase
JP Nagar - 560078
Tel: 26588045, 26580325, 26581076, 65616693
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SC Rd, Nehru Nagar
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Tel: 23369703, 65609053

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421/1, Sri Krishna Temple Rd,1st Stage
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She is a retired head of the education department in Mysore University. She has developed a Padmani counting board for both sighted and visually impaired.
One of her students Laxami Stayanarayan has a done her thesis project in the error analysis of the visually impaired in mathematics this document is not yet published but will soon be available in Mysore university.

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Braille Press in India

Central Braille Press
National Institute for the Visually
Handicapped
116, Rajpur Road
Dehradun 248001

Sri Ramakrishna Mission Vidhyalaya
College of Education
Coimbatore (Tamil Nadu)

All India Confederation of the Blind
Braille Bhawan
(Near Rajiv Gandhi Cancer Hospital)
Sector V Rohini
Delhi – 1100085

Govt. Braille Press
Tifra Police Line Road
Bilaspur 495 223 (Chattisgarh)

Regional Braille Press
Govt. High Secondary School for the Blind
Poonamallee
Chennai 6000 56 (Tamil Nadu)

Government Braille Press
Govt. Blind School
Tilak Nagar Sayaji Rao Road
Mysore (Karnataka)

Braille Press
Govt. Institute for the Blind
Jamalpur Ludhiana (Punjab

Govt. Braille Press
Near Govt. Blind School Vaishshta
Guwahati (Assam)

Braille Press
National Association for the Blind
11 Khan Abdul Gaffar Khan Road
Worli Surface
Mumbai (Maharashtra)

National Federation for the Blind
Braille Press
Near Atamshudi Ashram
Delhi Raod
Bahadurgarh (Harayana)

Blind People Association
Dr. Vikram Sarabhai Road
Vastrapur
Ahmedabad (Gujarat)

Kerala Federation for the Blind
Kunuukuzhi
Trivendrum Kerala

LKC Sri Jagdamba Andh Vidyalaya
Hanumangarh Road
Sri Ganganagar (Rajasthan)

Red Cross School for the Blind
City Hospital Road
Behrampur 760 001

Christian Foundation for the Blind India
Braille Press
2 Officers Lane GST Road
Pallavaram Chennai

The Poona Blind Men's Association
Technical Training Centre
109 Dr. Helen Keller Road
Ramtekdi Hadapsar
Pune – 411 012

The Regional Braille Press
Ramakrishna Mission Blind Boy's Academy
Narendrapur 743 508
24 Paraganas West Bengal

Manufacturing Units

There are two basic institutions known to me that provide tools and devices for visually impaired these are

- National Institute for Visually Handicapped, Dehradun, Uttranchal (NIVH)
- Worth Trust, Katpadi, Tamil Nadu.(WT)

National Institute of Visually Handicapped is one of the chief institutes for the development of visually impaired in India.
It is an autonomous body under the Ministry of Social Justice and Empowerment, Government of India. The services of the Institute are extended to other parts of the country by opening a Regional Centre at Chennai and Regional Chapters at Secunderabad and Kolkata. In addition, District Disability Rehabilitation Centers are also established at Dharamshala, Haridwar, Almora, Tehri-Garhwal, Gaya and Sangrur which cater to all types of disabilities.
It is engaged in human resource development, research and development, and designing delivery of model and tools for rehabilitation services, extension and out reach services. It is also

engaged in production of Braille / Audio books and assistive devices for the visually impaired.

Writing tools that are available at NIVH are Inter-point Braille Slate, Braille Slate (Large and Small) Inter line Braille writing device. Made of pre laminated particle board and guide made of G.I. sheet. There are easy to carry slate called Pocket Frame. With these slates there are varieties of styluses stylus plastic, safety stylus, bull head stylus, concave head stylus.

Computational devices like Taylor frame come in two sizes Taylor frame 18 rows with 25 cells, aluminum top with side box for types and 25 rows with 25 cells, aluminum top with side box for types. Taylor frame is also available in plastic. Separate Arithmetic/Algebra Type can be bought along with this these also come both in metal and plastic. Abacus is another famous computational tool available for the visually impaired.

There is a separate geometry kit for the visually impaired it is an up ward tactile geometry drawing device. Made of wooden frame, rubber base, aluminum and plastic drawing instruments.

Teaching aid devices like is tactile diagram set are available. It consists of drawing of geometric shapes and figures, physics drawing, biology (digestive system, respiratory system etc.), solar system and geographical maps of India, etc. Each set consists of 135 pieces and is made of plastic.

Other Recreational tools available are
Chess Board
Draught Board
Peg Board
Playing Cards
Puzzle
Cricket Ball
Cross Puzzle
Peg-in-Puzzle
Centre Peg Board
Bat

Assistive and mobility devises available are
Folding Stick
Long Cane
Signature Guide (Aluminium)
Signature Guide (Plastic)
Stand Type Magnifier
Magnifier Spectacle
Short Hand Machine
Needle Threader
Spool-for-Shorthand Machine
Paper-Roll
Hand Held illuminate Asphertic Spectacle
Measuring tap
Braille Scale (12")
Braille Scale (6")
Measuring Tape

Exact price list of the device is available at NIVH can be seen at this website
www.nivh.org
http://www.nivh.org/braille_appliance/braille.asp
NATIONAL INSTITUTE FOR THE VISUALLY HANDICAPPED
(Ministry of Social Justice & Empowerment, Govt. of India.)
116, Rajpur Road, Dehradun (U.A.) - 248 001, India.
Phone: +91-0135-2744979,2744387 (PBX) 2744491 .
Fax: +910135-2748147.
E-mail: nivh@sancharnet.in, director@nivh.org

Worth trust

The worth trust run on the self-sustained module whereby not accepting any sorts of charity for its activities in social development of various types of disabilities.

With its head quarters at Katpadi (near Vellore, Tamil Nadu) Worth trust operates production centers in Katpadi, Pondicherry and Tiruchirapalli. These centers are equipped with machinery to produce variety of components in metal and plastics which are supplied to major industries in the automobile, sanitary ware, electronics and household goods services. 100% profits earned from this production is then used it's parallel activities of technical and vocational training centers for disabled boys and girls and a schools for children with hearing and speech impairments which prepares them for integration into regular schools. It also provides aids to persons with disabilities in villages through its Rural Outreach Programme and provides them with guidance and counseling. Worth trust works with Vidya Virkshah, Chennai, on innovation and design of products and tools for various disabilities.

Also worth trust has a Brailler unit that assembles and exports the world famous Perkins Brailler. Tools available at worth trust are PERKINS BRAILLER Standard Model. GEOMETRY SET in Plastic available here is slightly different from that at NIVH. It is available in two sizes standard and large. It contains a set of 30o & 45o Set squares, Compass, Scale(30 Cms.) & Protractor. Other learning devices are. Worth trust also has the Braille slates and Taylor frames.
Other tools are
VASANTHA CUBE BRAILLE LETTER FORMING – Plastic
NATESAN BLOCK BRAILLE WORD FORMING – Plastic
BRAILLE WORD FORMING BLOCK – Plastic
ENGLISH ALPHABET TRAINER PLATE – Plastic
WORD BUILDING EDUCATIONAL KIT – Plastic
DOMINOES DOUBLE SIX
ERASER made of Plastic for use with PERKINS BRAILLER (big and small)
For more details and price list one can contact
www.worthtrust.org
For exact price list http://www.worthtrust.org.in/aidsfortheblind.htm
Direct mailing address
WORTH Braillers ,
48, New Thiruvalam Road, Katpadi - 632 007, Tamilnadu, India.
Tel.: 0416 - 2242739 / 2243739 / 2246728 ; Fax : 0416 - 2243939
Email : worth@md3.vsnl.net.in / worthbraillers@sancharnet.in

Internet

International websites

New York Institute for Special Education
www.nyise.org

Mathspeak
www.gh-mathspeak.com

American Foundation for the Blind
www.afb.org

Dotless Braille
www.dotlessbraille.org

International Braille Research Center
www.braille.org

Blind Readers
www.blindreaders.info

International Council on English Braille (ICEB)
www.iceb.org

Perkins School for Blind
www.perkins.pvt

National Federation for Blind
www.nfb.org

Unified 8 Dot Braille Code
www.unifiedbraillecode.com

History of Braille
www.brailler.com/braillehx.htm

Royal National Institute of the Blind
www.rnib.org

Texas School for Blind and Visually Impaired
www.tsbvi.edu

Braille for Various Scripts
http://homepages.cwi.nl/~dik/english/codes/braille.html

Duxbury System Inc.
www.duxburysystems.com

A brief historical overview of tactile and auditory aids for visually impaired mathematics educators and students
www.rit.edu/~easi/itd/itdv03n1/article2.htm

Indian Websites

National Association for Blind
www.nabindia.org

National Institute for the Visually Handicapped
www.nivh.org

Worth trust
www.worthtrust.org

Disability India
www.disabilityindia.org

Blind Foundation for India
www.blindfoundation.org

Blind People's Association (India)
www.bpaindia.org

National Institute of Rehabilitation Training & Research, Orissa.
www.nirtar.nic.in

Ministry of Social Justice and Empowerment
www.socialjustice.nic

International Council for Education of People with Visually Impairment
www.icevi.org

Acharya
http://acharya.iitm.ac.

Directory by Government of India: Policy and Welfare Schemes
www.webelmediatronics.in

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