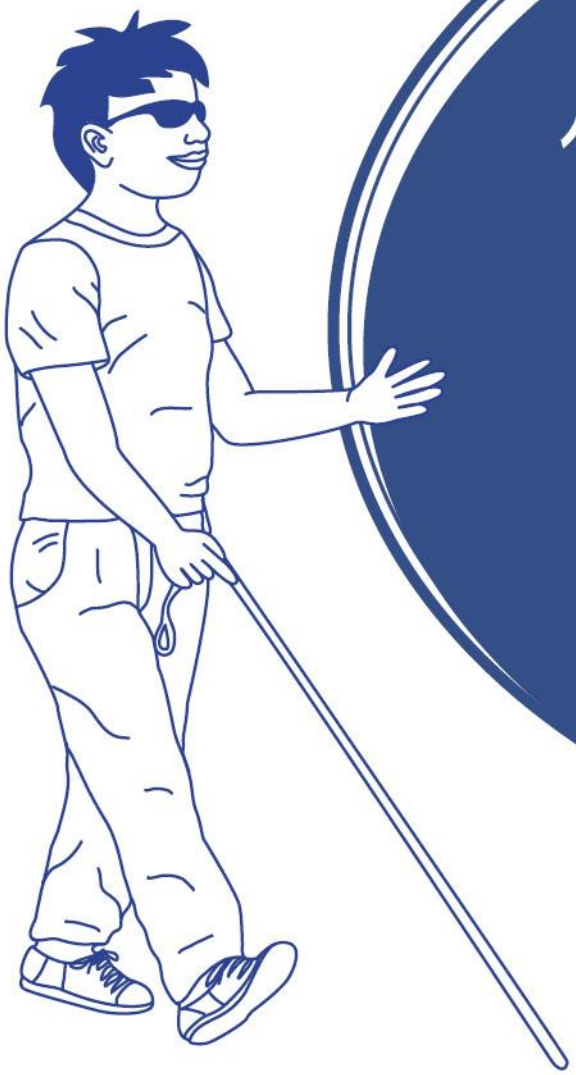
Teaching the Blind

Mathematics



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22 - 8 = 14

34 * 8 = 272

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Inclusion in Europe through Knowledge and Technology

Project no: KA201-2015-012

Teaching Math to Students who are Blind

Contents

Inclusion in Europe through knowledge and technology

Information on the fundamental principles practices, educational material and teaching aids used to teach various subjects to students with special needs are few and far between. In some cases, material has been prepared for internal use at specialized schools or in other closed environments. In other cases, knowledge has been passed from teacher to teacher as part of workplace training.

No systematic material on pedagogical principles, practices, educational material and teaching aids exist for areas such as teaching first language teaching, foreign language teaching, mathematics and music for the blind.

With this in mind, the goal of this European project is to further develop, implement and disseminate good practices in the area of inclusive education and learning technologies by delivering three primary components: *Teaching Guides*, Guide on g*ood practices Inclusive learning and Teaching* and *SMART E-learning objects*.

Teaching Guides

In completing the project, RoboBraille partners have created a series of twelve educational guides covering fundamental principles, practices, educational material and teaching aids covering first language teaching, foreign language teaching, mathematics and music for the blind, partially sighted and dyslexic.

Inclusion Guide on good practices Inclusive learning and Teaching

In support of this, the project has collected and collated information on good inclusion practices in five select areas (teacher skills, alternate media, support structures, preparation for inclusion and teaching environments) which are published in a catalogue of good practices.

SMART E-learning

Finally, the project will adapt a comprehensive set of educational material on the RoboBraille service prepared in the LLL LdV RoboBraille SMART project into a set of learning objects for popular e-learning platforms for web and tablet deployment.

For all materials produced by this project

Because the material covers teaching of students of various age, they are named students, learners, pupils and children. The material also reflects the different culture and level of inclusion practices of the project partners. The guide is not a substitute for formal training of teachers.

Introduction to this teaching guide

In most European educational systems, Mathematics is a compulsory subject in primary and secondary education. It is regularly presented in national examinations as a subject of assessment.

Regardless of whether the student will need Mathematics in his/her further studies or future career, Mathematics is still very useful as it forms and develops orderly, logical and investigative thinking, and helps to solve real problems encountered in everyday life.

Visual impairment involves great difficulty or even complete inability to get information from the surrounding environment visually. People with visual impairments use other senses as a compensation: tactile-kinesthetic (sense of touch), auditory (sense of hearing), gustatory (sense of taste), olfactory (sense of smell). Of all these, hearing and touching are crucial for the blind students to study Mathematics.

This guide aims at highlighting the difficulties in teaching Mathematics to students who are blind and offering realistic ways to overcome these difficulties, so that they can make progress in this subject at the same pace as students without visual impairment.

General objectives for the teaching of Maths

- Knowing and using the concepts, terminology and calculation procedures that are specific to Mathematics.
- Developing the abilities to explore / investigate and solve problems.
- Developing the capacity to communicate using mathematical language.
- Developing the interest and motivation for the study and application of Mathematics in various contexts.
- Forming the habit of resorting to mathematical concepts and methods in addressing everyday situations or solving practical problems.

Additional objectives

- Acquiring mathematical language.
- Recognizing different types of numbers (natural, integer, rational, real and complex).
- Training the skills in mathematical calculations (knowledge of algorithms, writing calculations on a Braille typewriter, developing mental calculations.
- Recognizing geometrical shapes and bodies by touch (tactile) and by description.
- Creating and developing the ability to imagine different spatial configurations (spatial orientation).

- Applying already learned mathematical concepts for solving common everyday problems.
- Acquiring the mathematical Braille code by assimilating the new symbols as the students' progress.
- Training students who are blind to use geometry tools set (ruler, set square, protractor, compasses).

Objectives for personal development through learning Math

- Developing focusing and attention, the sense of observation.
- Developing logical, open and creative thinking.
- Developing creativity, initiative, perseverance, independence of thought and action.
- Developing a critical and aesthetic sense.

Specialized pedagogies for teaching mathematics to blind students

The education of students who are blind is based on a set of special pedagogic principles. As a result, the didactic principles supporting the teaching of Mathematics to blind student**s** call for a special set of rules that guide and mark a functional sense of the educational process, ensuring the prerequisites of studying Mathematics by the students.

1. The principle of the scientific character of studying Mathematics through systematization and correctly structuring the information to be taught, as well as ensuring the continuous process of learning. This principle is based on the correctness and accuracy of the information given to the blind student supported by: school curriculum, textbooks, didactic means, use of abstract, formal mathematical language, and mathematical Braille code. Systematization and structuring the information must ensure the continuity of learning by making sure the information transmitted is logical and by integrating the students' knowledge in appropriate evolutive systems.
2. The principle of correlation between sensory and rational, between concrete and abstract in the teaching-learning process. According to this principle, any process of knowledge of the blind student relies primarily on perceptual act and, as a result, all blind students need concrete-intuitive support in understanding and assimilating new knowledge or information. Knowledge involves three stages:
    a. sensory-perceptual knowledge through direct contact with the surrounding reality and didactic material.
    b. the transition from concrete to abstract by developing the operations required in the process of thinking.
    c. the practical application of concepts, definitions, rules etc. - all these require exemplification.
3. The principle of a differential and individual approach when teaching math to a student who is blind. This principle requires the Math teacher to know and respect the individual characteristics of the student, as well as particularities related to age, personality and any specific psychological elements caused by impairment. Their knowledge is ensured through direct collaboration with the student, the support teacher and student's family. Subsequently, one should also consider the transfer of knowledge from simple to complex, from the particular to the general, from the known to the unknown, according to the comprehension of the student, by completing each stage of learning and maximizing the skills and the intellectual potential of the student.
4. The principle of integrating theory with practice, by providing sound knowledge, competence and skills. Studying Mathematics involves applying already acquired

knowledge into varied practical actions and use it for real situations in life. This situation relies on establishing a direct link between the level of knowledge and their application in various real-life contexts.

5. The principle of conscious and active participation of the students when studying Mathematics. According to this principle, the blind student must actively take part along with the other students in the classroom; be involved in the learning process and take it seriously, becoming a subject of self-training and self-development, as a result of their own intellectual and physical work.
6. The principle of ensuring the unity of instruction, education, compensation, recovery and/or rehabilitation. This principle states that every activity of learning must take into account, besides the instructional-educational component, also a compensatory and remedial component by training the functional psychological and physical resources of the students in their assimilation and development of the skills necessary for their adaptation and socio-professional integration.

Challenges relating to the disability/specific learning difficulty

Examples of difficulties faced by both teachers and students who are blind in the process of teaching-learning Mathematics:

Braille Writing

Braille is a linear and uniform writing as far as the size of the signs is concerned. In normal writing we can instantly see the position of certain elements of mathematical writing and their size (over, under, top left, top right, bottom right, the position in relation to square root sign, high, low, etc.). Position and size give the necessary information for the correct interpretation of the mathematical text. In Braille, the blind student does not have the same possibilities and needs special signs to tell them if it is superscript, subscript, a numerator or denominator, etc. This means more Braille signs to remember and use, lengthy expressions, some mathematical expressions more difficult to identify such as the numerators, denominators, expressions under the radical sign, difficulty in overviewing the whole exercise, especially if it is a longer exercise. Moreover, once a text has been written, students cannot go back to add Braille signs in it. Long-term memorizing the multitude of Braille signs specific to Mathematics is one of the difficulties faced by students who are blind. Some of the signs even use 3 or 4 Braille cells. Furthermore, in some cases there is the danger of confusion between different Braille signs.

Numerical Calculation

Calculations represent yet another difficult problem for blind students. A sighted student applies algorithms specific to each operation and does graphical layouts. For a blind student, these graphical layouts pose greater difficulties to achieve, requiring more exercise, a good memory, the ability to use a typewriter or cubarithm (a braille slate consisting of a box divided into square compartments into which cubes bearing on each face a number in braille dots may be placed in the usual pattern for performing arithmetical problems)

Drawing

In geometry, drawing is crucial. Almost every geometry problem requires a drawing. This helps tremendously to solve out the problem and very often, the solution is impossible without drawing. Drawing on a Braille typewriter is next to impossible. As a consequence, the Geometry as a school subject is hardly accessible to a blind student throughout primary and secondary education. Misunderstanding a number of lessons may lead to the conclusion that geometry is very difficult, quite incomprehensible for the student and ultimately any attempt to tackle this school subject may be abandoned. Understanding spatial configurations is also elusive for the blind student.

The Intuition Support

Understanding geometry appeals to our intuition, that is, everything we see around we usually take for granted. The surrounding things, which is so obvious for sighted people, are unclear for the blind. For example, the assumption that between 2 (two) distinct points there can pass only one line (Unique Line Assumption) is not very easy to understand for the blind student. Or, when comparing the classroom with a cuboid and talk about faces, edges, vertices, diagonals etc., for a student who has never seen nor touched the ceiling and does not know where the walls end… it will be very hard to understand.

Spatial Orientation

Typically, a sighted student can easily find their way when told "left-right" or "up-down". A blind student finds it difficult to find the "top-below" in a fraction or "left-right" in a longer exercise which can take more space than one line in a Braille sheet of paper. In addition, it is hard to focus when it comes to such notions as "middle, centre, inside, outside, up-down (top/below), left-right" in a 2D or a 3D geometric shape.

Time

A big concern in working with the blind is time. Blind students need many explanations, comparisons, taking repeated dictation to check the spelling, the use of specific teaching materials. All these operations take up a great deal of time out of the lesson, which means less time for applications.

If the student does not master the mathematical Braille writing very well, they will need more time than other students just to write what is dictated to them, moreover, they will have a number of mistakes, and will lag behind the others, possibly they will even give up writing entirely.

In case of a test, the blind students can find themselves in the situation of not having time to finish it.

Additionally, getting the necessary materials ready for the blind student uses up even more time for teachers to prepare the lessons.

Accessing Sources of Information

Blind students do not have a notebook and even if they are orderly and well-organized, and have a folder with Braille sheets of paper written in Braille during class, still it will be very difficult for them to find a lesson written a few weeks ago.

If they have a textbook: a typical Braille textbook of Mathematics is made up of 4-5 volumes, which makes it extremely difficult to find a particular lesson. Obviously, a page number in the Braille textbook does not correspond to the one in print.

There is no collection of mathematical exercises and problems in Braille. Additional exercises in mathematics books are very rare, even non-existent in some European countries.

Dependence on Others

Considering the above, it is clear that the blind student often is largely dependent on a sighted person, to read from the notebook, textbook or workbook or to dictate homework. In addition, the students who are blind need a sighted person to help them organize their own notes in Braille so that the blind students may be more effective in doing homework or additional tasks.

Dependence on the Braille Typewriter and Teaching Materials

Students who love Maths would want to do extra work as much as possible, outside the school programme. This way they are dependent not only on someone else to read to them and give dictation, but also on their Braille typewriter. Likewise, they are also dependent on the teaching (didactic) materials they have at school but may not have at home.

Ways to overcome the difficulties in the teaching-learning process

In the process of teaching-learning Mathematics with students who are blind several facts are fundamental:

- Verbalization.
- Teacher providing educational materials that will support an effective learning process.
- Heavy mental exercise by the student.

It should always be remembered that blind students lack visual perception, and there are only two kinds of information that support learning Mathematics: tactile-kinesthetic and auditory, which act as a compensation for the lack of vision. Blind people perceive shapes, sizes, volumes, spatial relationships using tactile-kinesthetic perception, which is achieved according to the cybernetic principle of "relevant information", with maximum value for identification, relying on the most important elements (corners/vertices, curves, edges, angles etc.) and on the basis of interoperable networking and conditioning between the tactile sensitivity and proprioceptive-kinesthetic sensitivity.

The Maths teacher's role is, after consulting with the support teacher, if available and preferably trained in special education, to carefully select the teaching materials to be used.

Rational and proper use of these materials by the blind involves giving more time of tactile-kinesthetic exploration in order to form an accurate perceptual picture of objects. The tactile-kinesthetic exploration process has a discontinuous progress, manifested through detachments, jumps, returns, repetitive forward movements to get to know some parts of the object, and then backward movements of return. The teacher or support teacher should insist that the blind student performs such activities as handling, observation, selection, analysis, synthesis, comparison, verbalization.

Any Maths teacher in mainstream education who has blind students in their class must know the specifics of the visual impairment and how to work with these students. Knowledge of Braille code is compulsory, also notions of access technologies should also be familiar, knowing that the support teacher often only has allocated a very short amount of time, and therefore insufficient.

Braille Writing

It is necessary that the person in charge with assisting the blind student in learing Mathematics (the Maths teacher, the support teacher, the parents or someone else) should master the mathematical Braille writing very well in order to understand the difficulties the blind students face. It is only in this way they will be able to help students write, understand and solve exercises correctly. Only then will they be able to dictate an exercise. Only then will they find ways to adapt certain calculations to Braille writing.

Mathematical Braille signs may be introduced gradually as students' progress along.
For the blind student to memorize the Braille signs, it is necessary that the teacher repeats them whenever and as many times as needed until the student really masters them.

Numeric Calculation

Some of the graphical layouts sighted students usually do for calculations are extremely difficult to achieve by the blind students. It is therefore necessary for the Maths teacher to adapt the layout for Braille writing.

For example, to compute the square root of the number 5184, a sighted student will only require 2 lines on a Braille sheet of paper, as follows:

Computing square root video

Additionally, the student can make use of the cubarithm or a specially designed calculator with speech function.

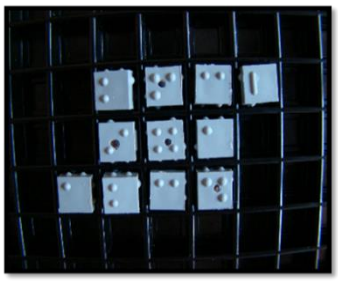


Figure 1: Cubarithm

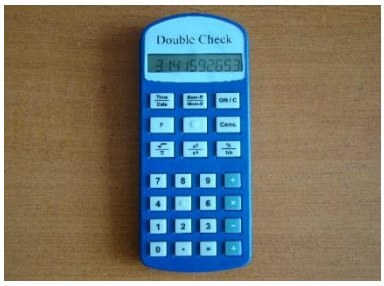


Figure 2: Calculator with Speech Function

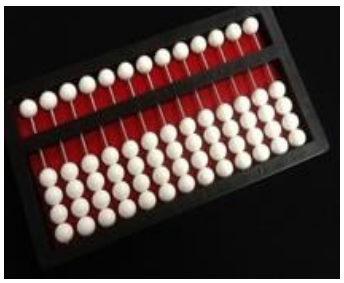


Figure 3: Abacus

Another way is to do repeated mental calculations, including some techniques of rapid calculation.

Examples of rapid calculation:

Step	Calculation to be per-formed	Mathematical Proof	Method of rapid mental calculation
1.	$7 \cdot 86$	Knowing that $86 = 80 + 6$ $7 \cdot 86 = 7 \cdot (80 + 6) = 7 \cdot 80 + 7 \cdot 6 =$ $= 560 + 42 = 602$	$7 \cdot 80 = 560$ $7 \cdot 6 = 42$ $560 + 42 = 602$
2.	$7 \cdot 863$	Knowing that $863 = 800 + 60 + 3$ $7 \cdot 863 = 7 \cdot (800 + 60 + 3) =$ $= 7 \cdot 800 + 7 \cdot 60 + 7 \cdot 3 =$ $= 5600 + 420 + 21 = 6041$	$7 \cdot 800 = 5600$ $7 \cdot 60 = 420$ $7 \cdot 3 = 21$ $5600 + 420 + 21 = 6041$
3.	$96 \cdot 12$	Knowing that $12 = 10 + 2$ $96 \cdot 12 = 96 \cdot (10 + 2) = 96 \cdot 10 + 96 \cdot 2 =$ $= 960 + 192 = 1152$	$96 \cdot 10 = 960$ $96 \cdot 2 = 192$ $960 + 192 = 1152$
4.	$264 \cdot 5$	Knowing that $5 = 10 : 2$. $264 \cdot 5 = 264 \cdot 10 : 2 = 2640 : 2 = 1320$	$264 \cdot 10 = 2640$ $2640 : 2 = 1320$
5.	$103 \cdot 97$	Use this formula: $(a + b)(a - b) = a^2 - b^2$ $103 \cdot 97 = (100 + 3)(100 - 3) = 100^2 - 3^2 =$ $=10000 - 9 = 9991$	$100^2 = 10000$ $3^2 = 9$ $10000 - 9 = 9991$
6.	103^2	Use this formula: $(a + b)^2 = a^2 + 2ab + b^2$ $103^2 = (100 + 3)^2 = 100^2 + 2 \cdot 100 \cdot 3 + 3^2 =$ $= 10000 + 600 + 9 = 10609$	$100^2 = 10000$ $2 \cdot 100 \cdot 3 = 600$ $3^2 = 9$ $10000 + 600 + 9 = 10609$
7.	97^2	Use this formula: $(a - b)^2 = a^2 - 2ab + b^2$ $97^2 = (100 - 3)^2 = 100^2 - 2 \cdot 100 \cdot 3 + 3^2 =$ $= 10000 - 600 + 9 = 9409$	$100^2 = 10000$ $2 \cdot 100 \cdot 3 = 600$ $3^2 = 9$ $10000 - 600 + 9 = 9409$
8.	35^2	Use this formula: $\overline{a5}^2 = \overline{xy25}$, unde $\overline{xy} = a \cdot (a+1)$ $\overline{a5}^2 = (10a+5)^2 = 100a^2 + 100a + 25 =$ $= 100a(a+1) + 25 = \overline{xy25}$, unde $\overline{xy} = a(a+1)$	$3 \cdot 4 = 12$ Add 25 to 12 Result: 1225

Drawing

For a blind student, the usual 2D drawings may be replaced with tactile drawings, flat shapes and geometric constructions. For this purpose, the following can be used:

- A Thermoform (it's an embossing drawing machine that prints on a special sheet using heat).
- Different geometry kits with tools specially adapted to the blind.
- The GEOMAG game (which contains magnetic segments that can be put together by means of metal balls, useful for building up geometric shapes)
- The Geoboard Kit (a wooden or plastic piece on which there are inserted metal rivets or bolts at certain distance, and the students use elastic strips to form out basic geometric shapes).
- Special plastic sheets on which, using the compasses or the Braille stylus, students draw the desired shape; however, the student must be permanently assisted by the teacher. The plastic foil is placed on a silicone mat or soft rubber on which the students plots the lines that will be raised out.
- A Braille printer
- A 3D printer that can output extremely useful geometric shapes that are great for Maths.

Examples:

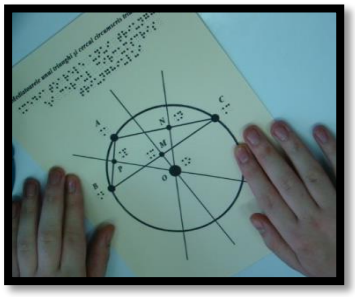


Figure 4: Geometry on swell-paper

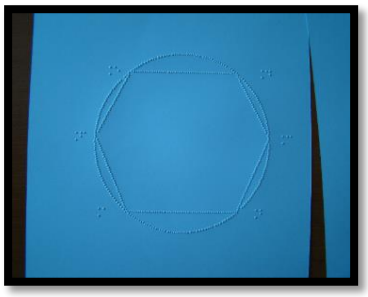


Figure 5: Drawings on Braille paper from a Braille printer using the "Tactile View" software

Figure 6: Plastic sheets

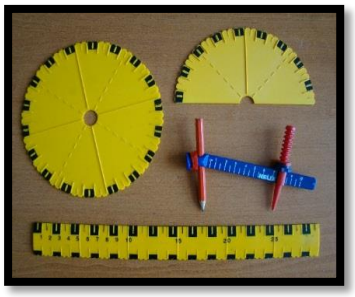


Figure 7: Geometry Kit tools for the blind

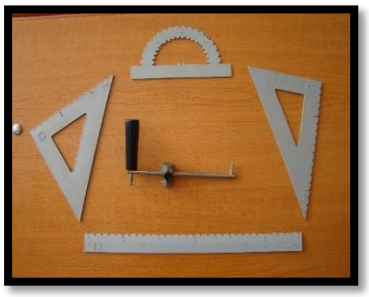


Figure 8: Geometry Kit shapes for the blind

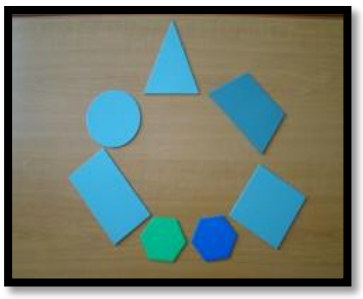


Figure 9: Geometry Kit shapes for the blind

Figure 10: Cone

Figure 11: Geometry Kit 3D: prism and cylinder

Links to math tools:

- Ruler
- Set square
- Protractor
- Compasses
- Development-of-pyramid-truncated-pyramid-pyramid
- Cone, axial section in cone, pyramid, transversal section in pyramid
- Two cones with coloured highlighted elements: base, radius, generatrix, height
- Lateral surface of a cone, the base of a cone and the development of the cone
- Development of a cone

More examples:

Figure 12: Geomag

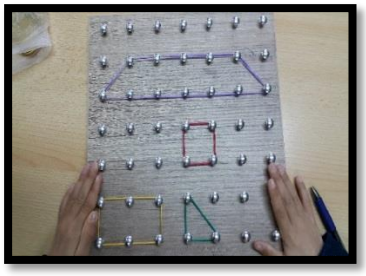


Figure 13: Geoboard

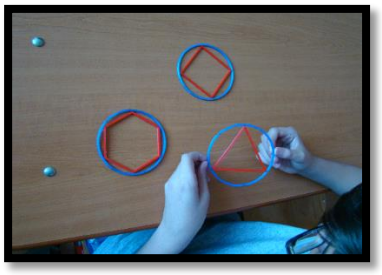


Figure 14: 3D printer shapes

For spatial configurations, 2D drawings are completely useless for a blind student. It is therefore strongly recommended that students use geometry kits and geometric 3D shapes which help them perceive the 3D configuration.

Students should permanently aim at forming in their mind the mental image of the studied geometric 3D shape. It is a process from the outside to the inside, from overall to detail.

Let's take, for example, the study of the pyramid: first, a closed pyramid (empty inside) is studied the tactile way (touched); then one side of it is removed so that the student is able to explore the remaining sides and actually go inside the pyramid; next, the student is given a pyramid only with edges; finally, other elements are gradually added: the height of the pyramid, the apothem of the pyramid, the apothem of the base of the pyramid, the radius of the circle circumscribed around the base of the pyramid. The resulting different types of triangles are then highlighted to the student.

- Hexagonal pyramid with some of the lateral faces removed
- Triangular prism with its elements: base, edges, height, apothem
- Cylinder with a part of its lateral surface removed

It is useful for the students to make heavy use of the surrounding environment in order to get a closer understanding of spatial geometry.

For instance, the classroom or a closet can be used as examples of prism or cuboid. These physical objects have pairs of parallel, concurrent or non-planar lines.

It is a good idea that the blind student should be taught and encouraged to use specific geometry tools.

- Pupil measuring the length of a rectangle using a special ruler for the blind

The Intuition Support

The intuition of the blind student can be dramatically boosted by permanent use of the didactic material in school or specially designed by the persons in charge of teaching the student.

As an example, exploring the surrounding environment can be really helpful.

For instance, to exemplify the Unique Line Assumption, the student may walk following a straight line (e.g., on a plank etc.) between two objects on the ground, in the schoolyard.

To understand the prism, the student may explore, both on the outside and on the inside, a cardboard box big enough so that the student can get inside of it, or even a low-ceiling classroom, for that purpose.

Spatial Orientation

The blind student's ability to find their way around is well formed and developed through practice. It is necessary that the family and other persons dealing with the student's education encourage the student to constantly do spatial orientation exercises: indoors, in school, open space as well as study various geometric shapes.

Time

Both the Maths and support teachers must be very familiar with the Braille mathematical writing in order to know exactly what and how to dictate to the blind student so that both confusion and time wasted in useless explanations can be avoided. The student's reading and writing speed in Braille should be as high as possible. To achieve this, the student must practise, write and read a lot in their spare time.

In case of a test, in order for the blind student to be able to keep up with the sighted students, without exceeding the time limit, the teacher must choose the topics accordingly. Otherwise, they will need to find a way to allow extra time to the blind student as opposed to the sighted ones. It is necessary that the blind student is given the exam topics written in Braille.

Accessing Sources of Information

One way to keep the notes may be the audio recording. The teacher can make it available to the student or it can even be recorded by the student themselves with the help notes taken in class.

If the student has a Braille Maths textbook, the teacher can show them the volume and page where the lesson is to be found.

To compensate for the lack of Braille written collections of exercises, the teacher can prepare sheets written in Braille with exercises and problems in accordance with the progress of the class at that point in time.

Dependence on others

Using the above suggested: audio recordings, Braille textbook, sheets with theoretical text and exercises written in Braille, can lead to the blind student being independent of other persons.

Dependence on the Braille Typewriter and Teaching Materials

The education system should provide the blind student, throughout the entire period of schooling, with a Braille typewriter. Likewise, the student should also have a personal Braille typewriter for use at home.

For the family, it is important to procure educational games such as Geomag, Lego etc.) to help the blind student to develop spatial representations.

A Description of suitable teaching methodologies practices

This chapter presents three examples of educational activities aimed at forming these concepts for students that are blind or partially sighted.

Activity Overview 1

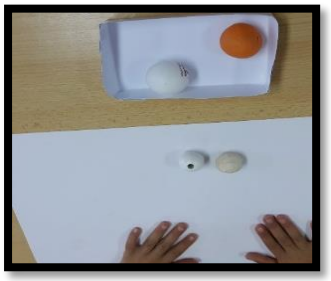
Occupational Therapy at preparatory school year:

6 learners take part in this activity: 3 are blind and 3 are partially sighted. Topic: "Compare them!"

Objective: Strengthening basic concepts: large, medium, small.

Activity overview: The learners sit at their tables in the classroom. After the presentation of the topic and the objective the learners begin to warm up their hands by means of specific fine motor exercises.

Plasticine clay is then handed out. The learners are given a ping-pong ball and are then asked to make a similar one out of plasticine. Then the original ball is compared against the new one: different material, different texture, different smell.



The learners are now given a smaller ball made of sponge (or any other material, different from the material of the previous balls). The learners will make small balls of the same size as the original.

The balls are then compared among each other. Next, all of the balls—small, medium-sized and big—are compared to one another. The originals are counted, then the ones made by the learner, and after that all the balls are counted together. After the learners have analysed and compared them all, the plasticine balls are sorted out and placed in three boxes: the big, medium-sized and small ones, accordingly.

This is an activity which can be carried out by both blind and partially sighted students. This activity helps consolidate the notions of BIG, MEDIUM SIZE and SMALL. The learners also practise counting. By touching and feeling different textures the tactile sense is stimulated. By smelling obviously, the sense of smelling improves. The activity takes around 30 minutes.

- Inclutech presentation 2016

Activity Overview 2

Cognitive stimulation

Occupational Therapy, Complex and integrated educational therapy for preparatory school year

6 learners take part in this activity: 3 are blind and 3 are partially sighted. Topic: "Compare them!"

Objectve: to form, develop and understand the concepts of LEFT, RIGHT, UP, DOWN

Activity overview: The teacher presents the topic and the objective, then makes a short description of the activity. Next, the learners revise the notions of laterality and spatial orientation—LEFT, RIGHT, UP, DOWN—in the big space (e.g., in the classroom) and in the small space (e.g., on the desk/table). The blind learners are given cubarithms, while the others are given square sheets of paper for Mathematics. On the cubarithm, the blind learners are asked to place the cubes with the dash on the right and fill in the top row. On the square sheets, the partially-sighted learners are required to write a dash in the right side of the top row squares.

The row below is filled in with the dash positioned on the left, on both the cubarithm and the square sheets.

The learners are required to fill in the bottom row with the dash on the bottom, then the row above with the dash at the top. Teacher talks to the learners about UP, DOWN, then checks the cubarithm and the sheets.

Now the learners will fill in the columns: first the 2 left columns, then 2 on the right. On the cubarithm learners place the cubes with one dot; on the sheets learners draw one dot in the middle of the squares along the columns. Teacher talks to the learners and checks the cubarithm and the sheets, insists on the notions of LEFT, RIGHT, then congratulates the learners whenever they properly solve the given tasks and use the correct terms.

This activity takes around 20 minutes. It is an activity of tactile stimulation for the blind learners, exercises for pre-Braille preparation, and for the partially sighted, understanding the terms correctly.

- Inclutech-presentation

Activity Overview 3

Communicating in Braille. Objective: Practising the mathematical language in Braille writing

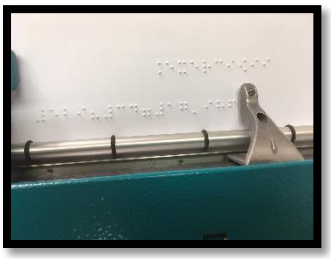
Materials: cubarithm, Braille typewriter, Braille sheets

Time: 30 minutes

Regarding the progress of a Maths class for students in the first school years, it should be remembered that the class has the length and structure of a usual Mathematics class. But in order that blind students to get to calculate independently on a cubarithm, it is necessary for these students to gain the proper abilities in this respect. So during the recuperative-compensatory activities, the following objectives are pursued:

- Knowing the rules of working with these instruments
- Proper and efficient handling of these tools in the learning process
- Training the skills for spatial orientation in a confined space (Braille plate, row / column, Braille box, Braille machine; cubarithm etc.)
- Proper knowledge of the rules of working with instruments specific to Mathematics;
- Developing the skills of properly and efficiently handling these tools in the learning process





What is important to remember is that the blind students share the same curriculum as their sighted peers.

Learning technologies for inclusive teaching of math to blind students

In the first school years the blind student gets acquainted to writing-reading Braille but it is also necessary that they start acquiring digital competences, such as using the PC, tablet, smartphone etc. through adapted means.

When the blind student is already digitally competent in part, he/she can use assistive technologies specific to the education process (teaching, learning, assessment).

For this purpose, they may make use of:

- Laptop / tablet with voice synthesis
- Braille display
- Laptop with speech function and Braille display
- Microsoft Word and Microsoft Equation
- Converters from print to Braille (RoboBraille, Math2Braille)
- Braille printer
- Braille Tablet

This way, notes may be taken during lessons with a smartphone, laptop or a tablet with voice synthesis using Microsoft Word and Microsoft Equation.

Learning can be carried out using voice synthesis, or a Braille display, or by converting files with print material to Braille code using a converter from print to Braille and finally a Braille printer.

The same methods can also be used in assessing the student, but also for creating teaching materials, worksheets or assessment tests.

However, if the use of a laptop with voice synthesis, a laptop with speech synthesis and Braille display and Microsoft Word – Microsoft Equation can be made from years 6 or 7 up, other technologies may be used by students in higher years, when blind students have become more familiar with those technologies (RoboBraille, Math2Braille).

Yet converters from print to Braille (RoboBraille, Math2Braille) and the Braille printer can also be used in lower classes with the teacher´s support.

Early acquisition necessary for the blind students to study Mathematics

Teaching Mathematics in primary school must be backed up by concrete, intuitive support.

The basic concepts should be presented to the students before they are taught abstract processes.

Some of these concepts are:

many-few	more-less	large-small
big-little	tall-short	long-short
far-near	top-bottom	under-over
upper-lower	part-whole	right-left
same-different	heavy-light	before-after
around	middle	half
equal	bigger	smaller
high	long	wide

The Maths teacher of a blind student must express orally everything on the board, should dictate in such a manner that the blind student can keep pace, must clearly explain and talk loud enough to cover the noise of the Braille typewriter.

It is very important for blind students to deal with a problem using multiple modalities: listen to it, write it, read it, and touch it using auxiliaries and, when possible, move his/her body and / or the auxiliary in the space around.

There is a continuous need for communication between the Maths teacher, the support teacher and the student's family.

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