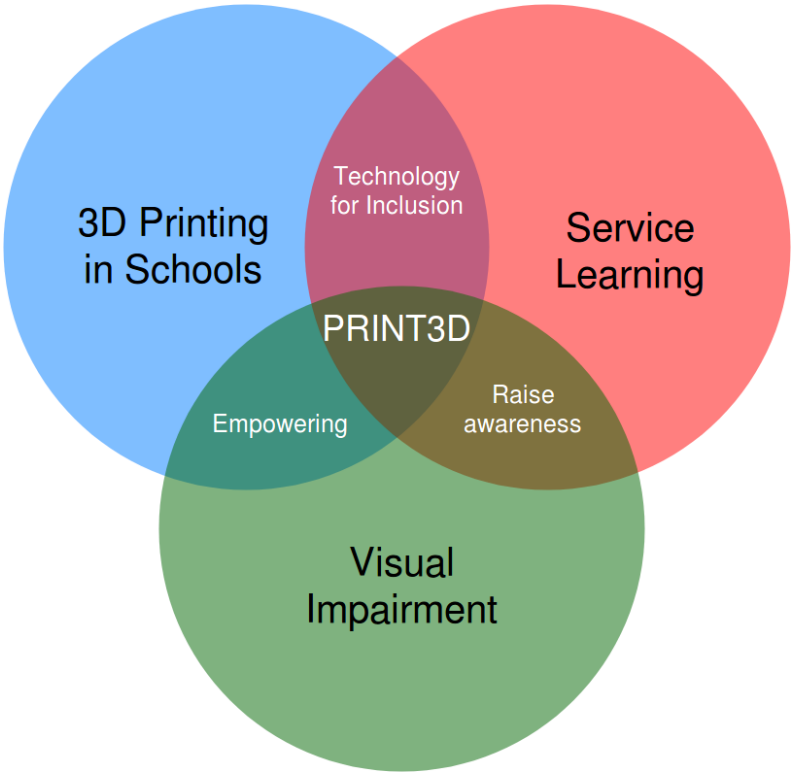
PRINT3D

Co-funded by the
Erasmus+ Programme
of the European Union

Promoting inclusion through educational 3D – printing



Students' handbook

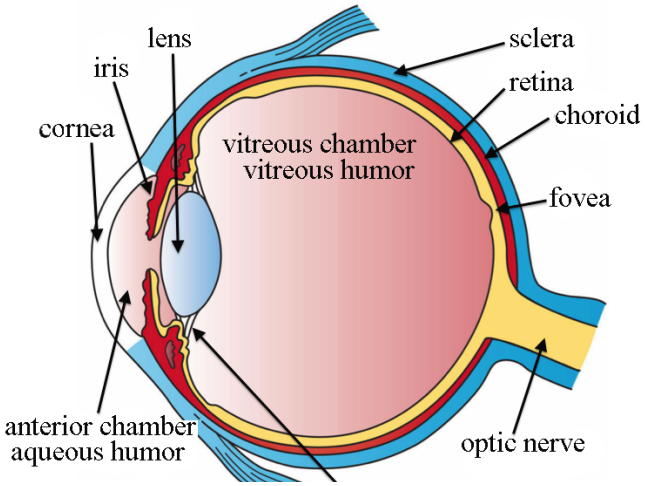
Chapter 1:
Visual impairments and blindness

The visual system is composed of t**hree different segments** which contribute to the reception and process of visual information:

Peripheral segment (the receptor): the eye and two parts of the optic nerve. Its role is to capture visual information and forward it to the brain through the optic nerve and visual pathways, for interpretation.

Intermediary segment (sensory pathways): the other two parts of the optic nerve and optic pathways. Its role is to transfer visual information to the visual centre of the brain.

Central segment (brain centre) the occipital cortex in the brain. Its role is to process visual information. It is connected to other centres of the brain which are also responsible for interpretation of visual information such movement, visual scenes, shapes, letters, faces and facial expressions, spatial positions etc.

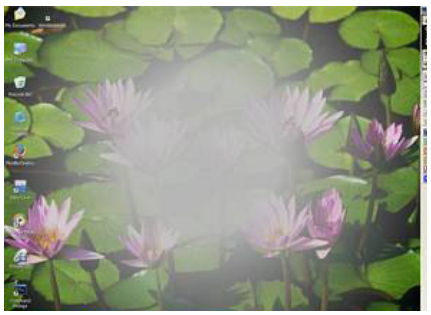


Common eye diseases

Visual dysfunctions may be the result of different eyes diseases. The most common eye diseases that could affect the visual functions in people, the activity and participation to different kind of activities are as follows:

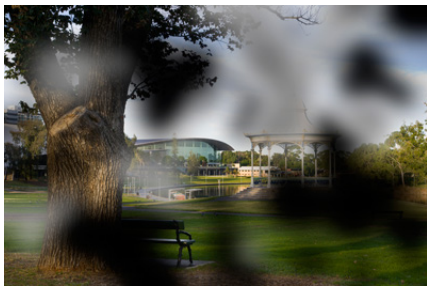
- **Eye injuries:** accidents mostly cause injury of the cornea.
- **Amblyopia**: impaired vision in one eye also known as "lazy eye."
- **Cataract**: clouding in eye preventing light from easily passing through the lens. Symptoms include cloudy or blurry vision, difficulty in seeing in the dark and in bright lights.
- Diabetic **retinopathy:** damaged blood vessels in the retina causing impaired vision.
- **Glaucoma:** raised pressure within the eyes causes damages on the optic nerve.
- Age related **macular degeneration**: a progressive loss of the visual acuity due to damage to the macula that is the most sensitive part of the retina.
- **Retinitis Pigmentosa (RP)**: genetic degenerative disorders of the eye, may eventually lead to "tunnel vision.".
- **Eye cancer:** retinoblastoma is the most common eye cancer in children.

Glaucoma (RP)

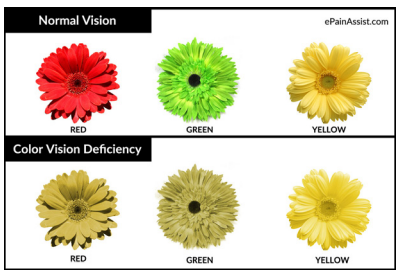


Cataracts - cloudy vision

Diabetic retinopathy



Diabetic retinopathy



Normal vision vs.
Colour Vision Deficiency

Colour vision defects: colour deficiency on its own is not considered to be a vision impairment, but it often accompanies and compounds other visual difficulties. The extent of a colour vision loss varies between individuals, are likely to involve difficulty in distinguishing detail in pictures, maps and diagrams.

The white cane
is an international sign for the blind and visually impaired. Primarily it aids its user to scan their surroundings of obstacles or landmarks.

Presentation of different type of visual impairment

Visually impaired

Visually impaired is a term used to describe people who have some functional vision. It includes people with relatively minor visual difficulties as well as those sometimes described as having low vision.

Blind

Blind is a term used to describe people who cannot use their vision for reading and writing and rely instead on tactile sense. Some can read text in Braille. Blindness may vary from residual vision to having the sensation of light or being completely blind.

Interesting facts:
We see with our brain and not with our eyes
The eye functions like a camera. The image is captured by the eye and sent back into the small area called retina. And the fascinating thing is that before the image being interpreted by the brain it is projected upside down into the retina in the back of the eye.
It is important to have sharp vision and good ability of accommodation in order to see three-dimensionally, to have binocular vision and have a depth perception – to be able to appreciate how far objects are in relation to one's position.
Children are colour blind at birth
Around 80% of our memories are produced by what we see
More than half of the brain is dedicated to the processes of vision
Eyes can process 36,000 pieces of information in a single hour
The eye muscles are the most active muscles of the human body

Videos:
Braille Literacy Facing Record Low Turns to Tech (Associated Press).
MOLBED Modular Low cost Braille Electronic Display.
Braille Touch Tablet and typing in Braille.

Further information:
- **101 amazing eye facts**
- For ideas of optical activities and testing some optical illusion of the visual system you can visit the site **Optics4 Children**
- National Eye Institute (NEI) on the subpage "NEI for Kids" provides you videos, cool eye tricks, glossary and more. **Here is one page that especially focuses on the biology of the eye**
- **20-20-20 rule:** For people spending a lot of their time in front of a TV or computer screen, it is worth talking about the 20-20-20 rule and instilling exercises as something to do at least once during every computer lesson.

Exercises/Activities

– Explore the environment while visually impaired.
Try walking in small and big spaces – in the classroom, outside classroom in the corridors, walk around the school, using different simulation glasses and/or a blindfold (simulating complete blindness). Students can be divided into groups of two, where one will wear the glasses and the other will guide his/her fellow student to walk safely in the space, give them directions where to walk and protect from possible accidents/incidents. Discuss observation made with the class afterwards. Simple and affordable simulation glasses can be made by adding different materials like plastic, bubble wrap, black paper, or cellophane to disposable safety eyewear/glasses. Glue one or more layers of plastic of cellophane on the lenses of glasses, cut the black paper like the shape of the lenses of glasses and make holes in different part of it in the middle, cut a half of the lens.

Exercise A - Touching different objects
Use a blindfold
The teacher will select different objects with different textures and ask you the following questions:
• How is it to touch the material? Is it hard, soft, smooth, cold, warm, etc.?
• Does it have any form like round, square, triangular?
• Does the material have a smell? What does it smell like?
• Does the material make any sound when you touch it?
Discuss your experience with your classmates and teacher.

Exercise B - Creating a map
Create a map of an area, e.g. the school hallway, the school grounds, the route to a selected location. Use something that can be felt by hand, like by gluing yarn to a paper, using paper with different texture, making raised lines by drawing on the opposite side of the paper (with a soft underlay) Let your classmate figure out how to use the map. This exercise is possible to work collaboratively with the visual arts teacher.

Exercise C - Touching different objects, part 2.
Use a blindfold
Students in the classroom are divided into groups of two. One is the observer and the other one is the student who will experience different objects. Use a blindfold for the student who will experience and objects. Select different objects with different textures like soft, rough, hard, small, big, cold, warm. The observer students will give one object at the time to the student with the blindfold and try to note all observation during the activity about the experience of the student with the blindfold.

Educational material

In recent years technology has enhanced learning experiences for all children. The increasing accessibility of tablets and smart phones means that blind and partially sighted students are now able to use them directly rather than having to learn to use special software or different equipment. Many students who use braille also learn early to touch-type and use electronic books. Visually impaired people can enlarge the text on the screen or use screen readers and speech synthesizer to read the text.

Equipment and software available to visually impaired people:

- **Screen reader:** software that makes text accessible for blind and visually impaired people by reading like speech synthesizers or Braille devices.
- **Braille display i**s a tactile reader that connects to a PC and allows tactile access to braille texts.
- **Braille embosser** is an impact printer that renders text as tactile braille cells.
- **Screen Magnifier:** software that interfaces with a computer's graphical output to present enlarged screen content. It provides the possibility of enlarging forms, books, photos etc.
- **Speech synthesizer** is the artificial production of human speech, and a synthesizer is a computer system that can read text out loud.
- **3D printer:** can be useful to illustrate or explain to the blind, e.g. the layout of a building.

Accessible teaching materials:

- Electronic books/digital text provides electronic content that is presented on a computer or another device.
- Large print is generally defined as 16-18 point or larger font size
- Braille
- Tactile books
- Swell-form tactile graphics

Braille

It is a tactile system of reading and writing used by blind and visually impaired people who cannot access print materials. Braille is made up of raised dot patterns for letters of the print alphabet. Braille is read with the fingers from left to right and is perceived with the movement of the hands in a steady and fast motion across the dots.

Blind people can read everything that appears on a computer screen with special braille terminals/displays, which are connected to computers. This makes it possible for them to learn without needing to print hard copies. That way, the braille follows the technology because it increases the potential for blind people to use computers to seek information in a technologically advanced modern society.

Take care of your eyes

Don't smoke

People who smoke are 3-4 times more likely to acquire various types of eye diseases.

Eat healthy and exercise

Eat food that's rich in vitamins. Obesity, sedentariness and high blood pressure are risk factors that can cause eye diseases.

See a doctor if your eyes or vision changes

If your eyes are bothering you or something is changing, go see an ophthalmologist.

Use sunglasses with at least 98% protection from ultraviolet rays of the sun.

Many eye injuries can be prevented, wear safety glasses when you are using tools, working with chemicals or playing sports that require them.

Make sure your hands are clean before touching your eyes. Especially if you're putting in or taking out contact lenses.

Braille Technology

Braille Displays: A device with rows of pins controlled by a computer that move up or down to display, in braille, the characters that appear on the computer screen.
Electronic Braille Notetakers: portable devices with braille keyboards
Braille Printers (Embossers): devices connected to a computer that emboss braille onto thick paper
Braille writers: a mechanical braille writer that works a little bit like a typewriter.

The braille writing system was created by Louis Braille in 1829, who had himself lost his sight as a result of a childhood accident.

Louis Braille - link to a video about the inventor of braille writing.

Tactile pictures

People with vision impairment cannot use their sight to learn about colours, shapes, objects at home, facial expressions, illustrations, so they have to rely on other strategies to access information within the environment, depending on the severity of visual impairment, their age or additional disabilities. When someone can see only part of an object or area at a time, it impacts the way they understand the object. There are some methods that can make the information more accessible to blind and visually impaired people, such as tactile sensitivity, tactile books, tactile graphics.

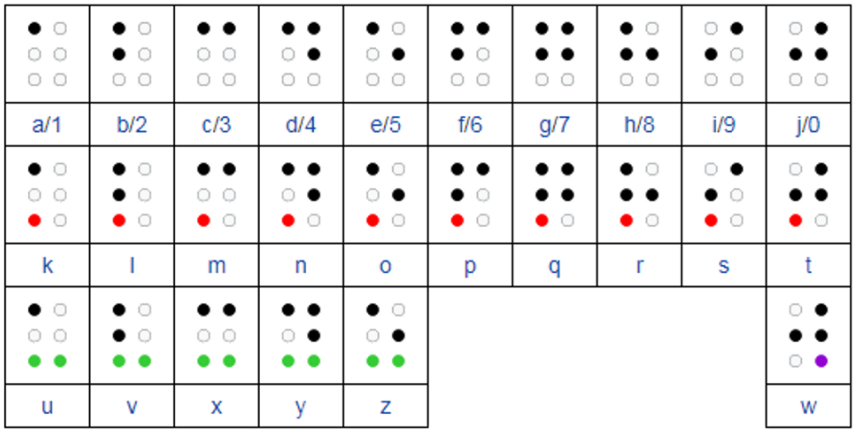
Tactile sensitivity

Tactile books are colourful picture books which contain pictures for a child to touch. Bright colours and clear colour contrasts benefit a reader with low vision. Different materials also stimulate other senses. In addition to pictures, the books have text in both black-print and braille.

Tactile graphics are not, however, exact replicas of the original, nor are they good for fine detail and representing very large graphics.

Around 80-90 % of all information about the environment is coming through the eyes.

Touch is a critical sense for the blind and visually impaired for connecting and understanding the world. Touch gives information not only about the characteristics of objects such as shape, size and texture, but also on the functional aspects of objects such as the possibility that they can be used as tools.



The first ten letters of the alphabet, a–j, use the upper four dot positions: (black dots in the table below).
The next ten letters, k–t, are identical to a–j, respectively, apart from the addition of a dot at position 3 (red dots in the table) :
The next ten letters are the same again, but with dots also at positions both 3 and 6 (green dots). Here **w** *was left out as not being a part of the official French alphabet at the time of Braille's life.*

The translation from real object to tactile picture can be a complex process. That is why it is good to keep the following things in mind:

· explore first real objects

• transfer the known objects in three-dimensional graphics

• transfer object within tactile pictures in books by using different textures and fabrics

• transfer real objects in tactile graphics.

Focus Blue 14 Braille display

The best tactile books use a variety of contrasting textures and real objects. They have a small amount of text and use very simple illustrations with every aspect accessible by touch. The objects used in a tactile book are meant to represent real things and are often made of the same or similar material so that when the child touches the object it feels the same or like touching the real thing that the story is about, such as soft fabric or synthetic fur to represent a dog in a story.

Swell-form tactile graphics are a form of graphics created in a swell machine using a special swell touch paper. It is possible to create tactile maps, diagrams, text and graphics (mathematical tables - charts - scientific material). Graphics are printed directly onto a swell touch paper and run through a swell form graphics machine. As it goes through this machine, the heat reacts with the black ink and causes it to "swell" or puff up, creating the tactile image. Instead of using a printer or copier, a user can also draw directly onto this paper using a special black marker.

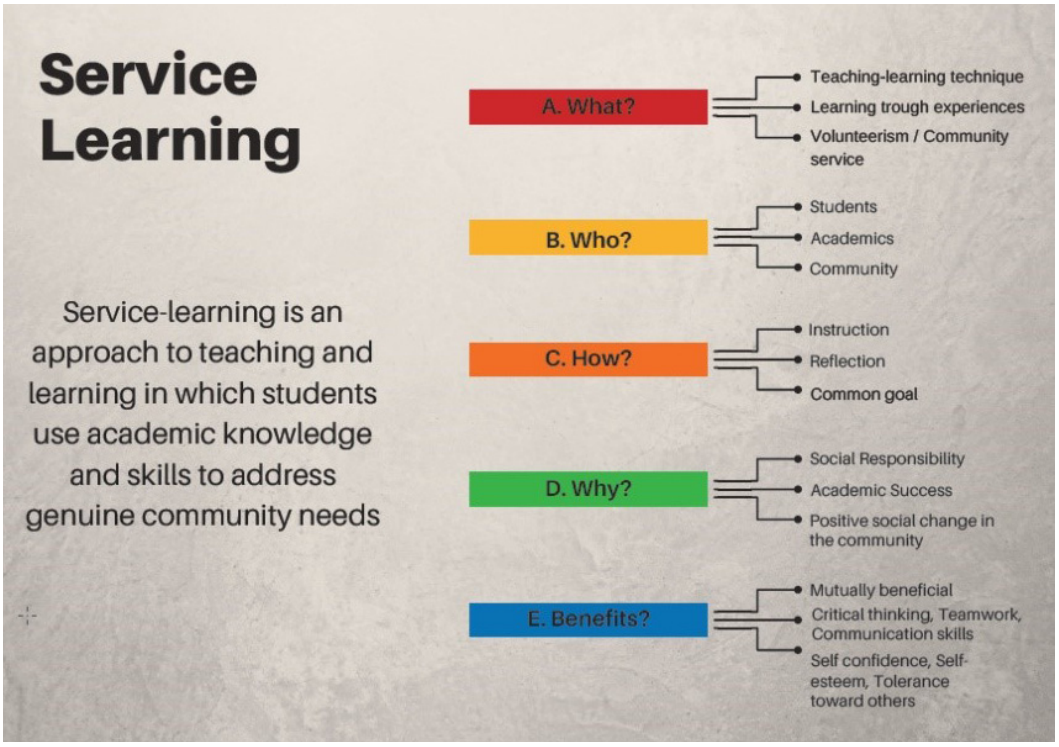
Perkins Braille Writer

Chapter 2: Service Learning

Service learning is a learning-teaching method in which students use academic skills and knowledge to address genuine community needs. It can be used in a program or curriculum that seeks to promote student's learning through experience.

Benefits of service learning:

- Students learn in a real-world situation.
- Brings together students, academics and community
- It encourages critical thinking, teamwork and self-confidence
- Service learning is a collaboration between students, teachers and society partners and mutually benefit through shared learning



Video:
Stages of Service Learning
Service-learning students in Hong Kong identify a problem among blind and visually impaired bowlers, and explain the process towards a solution.

Exercises/Activities

Think of 3-5 important places or places of interest in your area/country that should be accessible / more accessible to the blind or visually impaired (could be an airport, a historical site, a museum, an official building). How are they already accessible (if they are), and what could be improved?

Ideas for questions to ask: Is the place easy and safe to navigate for people with little or no vision? Does it have information written in braille or large letters, or audio guides? Should it have?

Service learning experience in Iceland

Making tactile books for blind children

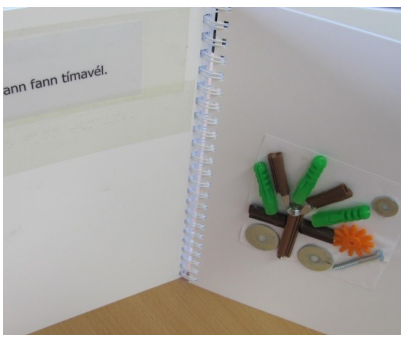
The National Institute for the Blind and Visually Impaired in Iceland lead a seminar for a class of 9-year-old students in Lindaskóli Elementary School in 2010, and again in 2011. The service-learning project centred around making tactile books that would benefit blind and visually impaired children and be at the same time a teaching and learning method that the students would benefit from. The students got a blank hardcover book and all kinds of textiles and material and were asked to follow specific instructions to make a simple story and then make a tactile book around the story. The students participate actively in the whole process, from deciding on the topic for the book, helping to collect and gather the items to illustrate it, telling the story, and putting it all together.

In the beginning of this process the students met a blind girl who showed them how she reads a tactile book. They were able to ask her questions and get a feel for how a blind person uses senses other than their sight to read a book.

Guidelines for the project

The students had to follow specific guidelines:

- Braille print in a normal size, 1,5 line spacing.
- The text is on the left side of the book, and pictures on the right side.
- Do not make the story too long (the book should not be longer than 5-6 pages).
- The printed (regular) text is put at the top of the page, then the braille print on top of it (embossed on see-through laminate).
- Pictures should be simplified and give the reader a good oversight. The picture should represent something told in the story. When making the tactile picture you need to make it so that the reader can use other senses (sense of touch, sense of smell esc.) than sight to "see" and experience the picture and in that way understand the story.
- Front cover: The name of the story on top, name of the author, name of the illustrator (who made the tactile picture), publisher.
- Page number at the bottom of every page.
- The books are bound by large spirals/coils; the front-page cover is made of thick paper in colour. The inside pages are made of strong paper.

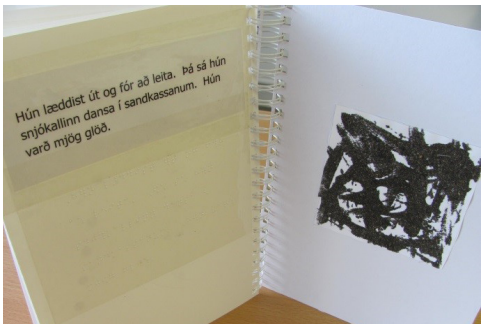


After the project - Reflection

After having completed the service-learning project the students were asked to reflect on their experience in making tactile books for the blind.

They all agreed that the project had been fun and enlightening. Few had ever known a blind person and the project made them open their eyes to the fact that we all do not "see" things in the same way. There are other senses we can use to read and the students themselves enjoyed reading the tactile books using only their sense of touch, sense of smell and so on.

This service-learning project was seen as very successful; the student learned to be more open-minded, learned to make something for someone else's benefit and the visually impaired and blind children who got the new tactile books were also very satisfied with them. In fact, some of the books that the students made are still in use by blind and visually impaired children.



The students of Lindarskóli, with their teachers.

Chapter 3: 3D printing

3D printing is a process of making three-dimensional solid objects from a digital file. A 3D model is either created from the ground up with 3D modelling software. There are several ways to 3D print. Some methods use melting or softening material to extrude layers, layer by layer.

- All these technologies are additive, differing mainly in the way layers are built to create an object.
- 3D printing enables you to produce complex (functional) shapes using less material than traditional manufacturing methods.

3D printing can be useful to illustrate or explain many things to the blind or visually impaired, that most people would otherwise rely on their eyesight to understand better. It may be the layout of a building or an apartment, different types of architecture, archaeological items, geography, or 2D illustrations and artwork.

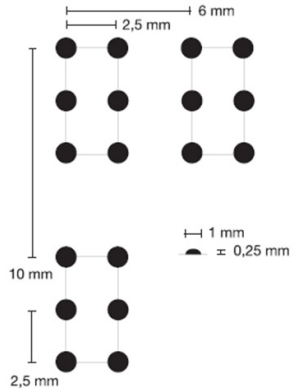
Tactile pictures and 3D models need to be simple because the visually impaired do not have the same overview as sighted people but must read one part at a time and then put them together in their mind to realize the big picture. Too many small details will not help the understanding.

The Tactile Museum in Athens, Greece, has a number of replicas of ancient pieces of art and history for students to touch and feel, where the original artefacts would be securely stored in a glass box. Among their items is the enigmatic Phaistos Disc from the Minoan Bronze age, which is covered on both sides with a spiral of stamped symbols, and a cylinder showing examples of geometric patterns on the surface of vessels, the originals dating back to around 700 B.C.

4th Primary School of Pefkis The group at the Tactile museum.

There are several techniques and materials to choose from if you want something 3D printed. The most common method for home use and small-scale manufacture is called Fused Filament Fabrication (FFF) or Fused Deposition Modelling (FDM). With this technology, the objects are printed out layer by layer with molten plastic (filament) which is fed from a large coil through a moving, heated printer extruder head. Imagine one tiny computer-controlled glue gun.

ONCE Typhlological Museum for the Blind (built in 1992) offers exhibits of typhlological material which can be felt through the sense of touch. It houses a collection of scale models of well-known monuments both international and national. The models shown are for instance the Eiffel Tower in Paris, the Sagrada Familia in Barcelona, the Colosseum in Rome, the Taj Mahal Palace in India and many more. The museum has been designed to promote and bring culture closer to those who are blind and visually impaired. It also retraces the history of Braille and other accessible writing systems that have been used in teaching blind people through the ages.



Le Petit Prince by Eva Sbaraini.

Videos:

Snapshots from visit to the ONCE museum (Erasmus+ 3D printing.)

Blind man guessing 3D-printed objects of oversized things

Introduction to 3D printing

3D printing FreeCAD - Making dice step by step

Follow these instructions to create a dice using the FreeCAD software.

1. File → New
2. Go to **Start** on the top of the tool bar and select **Part** to create items.
3. Select **Create a cube** that is a picture of a yellow dice on the top of the toolbar.
4. You can change the perspective of the cube high on the toolbar by selecting one of the green dice, for example axonometric view.
5. You can right-click on the background and select **Navigation styles** and select **Blender** then you can rotate the cube on all sides without changing the real size.
6. Under the **Labels & Attributes** to the left, are the things we have already designed. We already have a cube design. When **Cube** is pressed, the dice lights up and below on the screen to the left the dice shows the cube properties. There you can set and change the dice properties.
7. At the bottom left corner is **View and Data**. View displays visualization, color and lines. In **Data** you can change the shape of the dice.
8. The next step is to add another form to the dice. Then we choose one form of the yellow shapes near the top of the bar.
9. Choose **the cylinder**, then **Add**. Then a cylinder appears to the left of Labels & Attributes below the Cube. You can change the name of the items by right-clicking the items in Labels & Attributes and selecting **Rename**.
10. The shape of the cylinder can be changed in Data, the option is to select the degrees of the circle in the Angle.
11. You can change the position of the cylinder on the cube by selecting the **Data-Placement Position** and pressing the arrow. Then you can change the numbers on the x, y or z axes.
12. You can change the angle of the object by selecting the green dice on the toolbar near the top. For example, Set to top view, we see how the item looks from above. You can see all the sides of the object.

Exercises:

- **Make your school name in braille.** Design and 3D print braille blocks that spell out your school's name.
- **Keychain with your name on it.** In this project you'll learn how they can make a keychain by connecting letters together to make a solid object for 3D printing.

Student projects: A, B, and C

This part consists of three projects for students to work on.

Project A is the least complicated and is planned with the youngest students in mind, or ones with a limited attention span. Project B requires more planning and has a room for development if the teacher feels the students are up for it. Project C probably requires the most planning, and students are encouraged to arrange for a user testing before presenting the final result to find out if it is as useful as they hope, or if they may have overlooked something.

Each project is divided into several sessions, but depending on each group of students, one or more sessions may need to be divided up (split in two). Each project lists a few useful or interesting websites and videos, and Appendix II includes a more extensive list, which teachers are encouraged to check out.

Resources: For this implementation the following will be needed:

- Computer
- Network connection
- Tinkercad account, or CAD-software
- 3D printer
- PLA (plastic for printing)

Project A. Sign or marking

Project: A sign to mark specific places or to help blind or visually impaired people navigate. For example, a sign for WC, library, cafeteria, library, or any other place people are likely to look for (think of icons or pictograms).

The goal for this project is to introduce students to 3D printing, social inclusion, and visual disabilities through playfulness and by sparking their interest in technology.

Through this project, you will learn about designing 3-dimensional work in computers, what can be created, limitations, and such. You will also become aware of what it means to be blind or visually impaired, and how society can help include people with disabilities.

Session 1: Introducing 3D printing

Ready-made models can be found here, among other places:
Thingiverse - *a website where user-created digital design files are shared for free (https://www.thingiverse.com/)*
MyMiniFactory – *over 60,000 free and paid 3D printable objects (https://www.myminifactory.com/)*

The first session introduces 3D printing:

- What it 3D printing?
- What can be created?
- What it 3D printing currently being used for?

Useful / interesting videos:
1. **Blind man guessing 3D-printed objects of oversized things**
2. **3D printed Eiffel tower time lapse** (5 min. video, but in real time it took about 20 hours to print)
3. **Stages of service learning**

You will get to pick one model each from a number of models pre-picked by the teacher. These models will then be printed before the next lesson.

Session 2: Introducing the printing process, and identifying a need.

You will get a time to examine and play with the printed objects from last session, and discuss how the objects can be used, developed further, or personalised.

Identify a need: Is there something at school that needs a better sign? Is there any object for lessons that blind students lack or would benefit from having? Look for pictograms on the internet. Could they be used or improved for this purpose?

You should discuss, with a fellow student, areas or places that would benefit from a clear or better sign or marking. Collectively pick 1-2 projects to draw/sketch during the next session.

Session 3: Sketching and brainstorming

Useful / interesting weblinks:

- **Tinkercad** is a free online software (no download required), and very user friendly. Their website offers simple tutorials to get users familiar with the interface and basic movements. When you have your final design, it can be exported and saved as a printable file.
- **Tinkercad: Learn how to import .svg to Tinkerca**d
- **Braille standards for 3D** (size, height, spacing, and more.) **Also here.**
- **Inkscape: Learn how to vectorize image using Inkscape** (turning a 2D drawing into a 3D model)
- **Teaching material from Fab Academy** about 3D printing and 3D scanning
- **Accessible Maps for the Visually Impaired**

You will have to sketch your ideas for the sign or mark the group decided on. Try to come up with multiple solutions (literally, brainstorm), and discuss what might or might not work, and why.

Pick one solution (or possibly two) to either 3D print, or to work further on or refine. At the end of this session (or session part), the teacher should show the you and your group how to change a 2D image to a 3D model, using computer software.

Steps:

1. Draw on white paper with a black marker (sharpie)
2. Scan
3. Import image to Inkscape trace bitmap and turn image to vector
4. Save as .svg in Inkscape
5. Import .svg model to Tinkercad
6. Edit model in Tinkercad
7. Export as .STL
8. 3D print

Before next session: Print the object.

Session 4: The final product

Now it's time to paint raised lines/parts of the product, if possible and if needed. When the paint has dried, present and explain the final product to a group of fellow students.

Drawing from experience:

In the Valencian school IES Benlliure, a student in the Design and 3D printing course created a sign for the school's toilets (WC signs). At first the design looked like a standard WC sign, a human form indicating a female (woman in a dress) and another one indicating a male. The sign consisted of a black background and a yellow icon/picture. After a feedback from a visually impaired person, who explained they were finding it difficult to tell the male and female forms apart, the designs were changed. The human form was omitted and the female and male figures took on a more styliesed look in the form of a triangle and a circle; a triangle pointing upwards indicating a female dress while a triangle pointing downwards indicating a masculine shape of broad shoulders and a narrow waist. A circle marked the figure's head on both symbols. The background was changed from black to white, and the figures' colour from yellow to black. The added contrast makes it easier for people with different types of visual impairments to recognize the forms.

Project B. List of bus or metro stops

Project: A list of bus or metro stops, or a map of bus/metro system.*

The goal for this project is to introduce you to 3D printing, social inclusion, visual disabilities, and to design a simple diagram to help visually impaired people navigate. It is equally important for the seeing and the visually impaired to experience independence, and maps like this may help the latter navigate the public transport system. While it is useful to have oversight of the whole system, creating a complete map of many lines or routes may be too complicated and difficult to understand. Therefore, it might be best to start with making single [bus/metro] lines.

Through this project, you will learn about designing 3-dimensional work in computers, what can be created, limitations, and such. Students will also become aware of what it means to be blind or visually impaired, and how society can help include people with disabilities.

Session 1: Introducing 3D printing

The first session introduces 3D printing:

- What it 3D printing?
- What can be created?
- What it 3D printing currently being used for?

Useful / interesting videos:

1. **Blind man guessing 3D-printed objects of oversized things**
2. **3D printed Eiffel tower time lapse** (5 min. video, but in real time it took about 20 hours to print)
3. **Stages of service learning**

- Discuss visual impairments and problems visually impaired people might encounter.
- Discuss what information would be needed and are relevant on each map or access guide. How can we avoid too much information on one map?
- Discuss how the blind and visually impaired get around and problems they might encounter with public transportation.

3D modeling software:
Computer Aided Design (CAD) programs

There are many types of 3D modeling software available, both commercial software and free open-source programs.

For beginners we recommend using **Tinkercad**, but more advanced users might prefer either **Fusion 360** or **FreeCAD.**

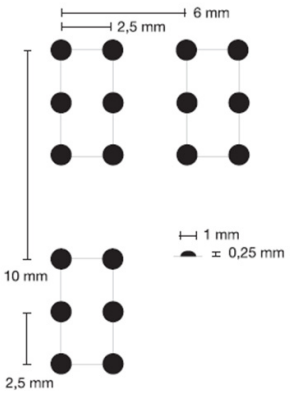
Useful/interesting weblinks:

- **Tinkercad** is a free online software (no download required), and very user friendly. Their website offers simple tutorials to get users familiar with the interface and basic movements. When you have your final design, it can be exported and saved as a printable file.
- **FreeCAD** is another popular open source program. It requires downloading, but is available for many operating systems, including Windows, Ubuntu, Mac OSX, Fedora, and seems to run on a number of Linux-systems as well. It is much more advanced than Tinkercad, but not as user-friendly.

More useful/interesting videos:

- **Service-learning students in Hong Kong** identify a problem among blind and visually impaired bowlers, and explain the process towards a solution.
- **How 3-D printed skull plates are revolutionizing surgery** (less than 2 min.)
- **3D Now's Ultimate Beginner's Guide to 3D Printing**, part 1 (11:23 min.), covering file types, slicing types, single and dual extruders, bed types, and more
- **Practical things** – "13 things I wish I knew when I got started" (34 min.).

Session 2: Sketching and brainstorming



Choose a route (direct bus/metro route, or a route from a specific place to another) to transfer into tactile information.

Depending on the size of the map, the names of stops may need to be shortened. The name of the London station Hammersmith & City, for example, is too long. A shortened version could be "Ham./City."

Begin sketching on paper (or brainstorming), to discuss further next session. Discuss potential problems/challenges in the design process.

Session 3: Creating a 3D model and printing

Continue sketching if needed.
Discuss ideas and what might work, what might be problematic, and why.

Refine the final drawings and designs, and then move onto creating a computerized 3D-file.

Design the product using the preferred program (list of programs can be found in Appendix IV) and start the printing process.

Session 4: Finishing Touches

Hopefully, the printed piece will be done when the session begins, or shortly after. This is when the group starts gluing the pieces together (if needed), and painting outlines to make them stand out (so not only the blind but also people who benefit from their eyesight can use them).

Drawing from experience:

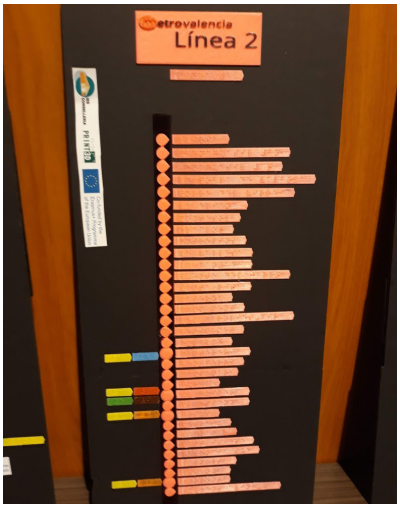
Students from I.E.S. Conselleria school in Valencia in Spain who were taking a basic training course in IT, designed and printed a tactile version of the 9 lines of Valencia's metro system. Each line was designed so that stops with transfers were easily indicated. Names of stops were printed out in braille using the Touch See website (a braille generator). A small label with the number of the line to indicate transfers. Once the designs were finished a color was chosen to represent each line.

Map of metro lines, by students of I.E.S. Benlliure in Valencia.

Session 5: Presenting the final product

The last part of the project, you and your group should formally present the product to fellow schoolmates or a target group, and describe the process as well as they can. A formal presentation can help raise awareness about disabilities in general and it can also be satisfying to show off a work well done.

Metro stations and a metro map by students of I.E.S. Conselleria



List of metro stations, by students of I.E.S. Conselleria in Valencia.

Project C. Map of an area or building

Project: A tactile map of a building or an area

The goal for this project is to introduce you to the 3D printing, social inclusion, and vision disabilities, and to create a map to help the blind or visually impaired becoming less reliant on others for navigation information.

Through this project, you will learn about drawing and creating 3-dimensional work in computers, what can be created, limitations, and such. Students will also become aware of what it means to be blind or vision impaired, and how society can help include people with disabilities.

Keep in mind: Geographical or detailed map may show a lot of information that are unnecessary for the blind or visually impaired, and can be confusing on a tactile map. You will have to think about what is of importance, and omit or simplify the rest. Important marks on the map might include:

- All or certain buildings
- Landmarks such as roads, paths, creeks, ponds...
- Entrances/Exits
- WC
- Gates, stairs, lifts (elevators),
- Statues, sculptures, water fountains

You will also have to decide how they will mark or sign/symbolize different areas. Will paths around a building have different texture than the walls of the building? Will a certain shape indicate a classroom while another indicates WC's or common areas (cafeteria, library, etc.)?

Tactile maps are available through various online sources, such as Touchmapper.org or Cadmapper.com

Session 1: Introducing 3D printing and visual impairments

The first session introduces 3D printing:

- What it 3D printing?
- What can be created?
- What it 3D printing currently being used for?

- Discuss visual impairments and problems visually impaired people might encounter.
- Discuss how the blind and visually impaired get around and problems they might encounter finding their way.
- Discuss what information would be needed and are relevant on each map or access guide. How can we avoid too much information on one map?
- Throw around ideas of places that might be good "candidates" for maps.

Relevant video:

- **Student designs 3D-printed, braille maps**

Useful / interesting websites:

- **Tinkercad** is a free online software (no download required), and very user friendly. Their website offers simple tutorials to get users familiar with the interface and basic movements. When you have your final design, it can be exported and saved as a printable file.
- **FreeCAD** is another popular open source program. It requires downloading, but is available for many operating systems, including Windows, Ubuntu, Mac OSX, Fedora, and seems to run on a number of Linux-systems as well. It is much more advanced than Tinkercad, but not as user-friendly.
- **Touch-mapper:** where you can easily create custom outdoor maps for any address of your choice.
- **Cadmapper** - Instant CAD files for any location on earth - free areas up to 1 km^2.

Useful / interesting videos:

- **Service-learning students in Hong Kong** identify a problem among blind and visually impaired bowlers, and explain the process towards a solution.
- **How 3-D printed skull plates are revolutionizing surgery** (less than 2 min.)
- **Blind man guessing 3D printed objects of oversized things**
- **3D Now's Ultimate Beginner's Guide to 3D Printing**, part 1 (11:23 min.), covering file types, slicing types, single and dual extruders, bed types, and more.
- **3D printed Eiffel tower time lapse** (5 min. video, but in real time it took about 20 hours to print).
- **Practical things** – "13 things I wish I knew when I got started" (34 min.).

Session 2: Sketching and brainstorming

Choose a place or an area you believe visually impaired people might benefit from having mapped or explained.

Begin sketching on paper (or brainstorming), to discuss further next session. Discuss potential problems or challenges in the design process.

It might be beneficial to consult with a blind or visually impaired person early on in the process, to find out what their opinion on the importance of items or information on the maps.

Ideas for exercises:

- Find out if your town/city has floor plans of buildings or apartments available online.
- Find a floor plan (any floor plan). How much information do you think is essential? How many details (if any) do you think can and should be removed? Discuss.
- How small do you think markings in braille can be, in order to be read by fingers?

Find a map of an area using a map-generator (e.g. Touch-mapper or Cadmapper) and decide which part should be used.

Make time for "user testing" among blind or visually impaired people at later stages, to find out if there is anything you might have missed.

Session 3: Getting to know the printing process

Continue sketching if needed.
Discuss ideas and what might work, what might be problematic, and why. Refine the final drawings and designs, and then move onto creating a computerized 3D-file. It is now time to design the product using the preferred program (list of programs can be found in Chapter 3 and Appendix IV) and start the printing process.

Chapter 3 explains 3D-printing to a point, but it depends on each group of students how detailed the explanation should be.

Print the map before next session.

Session 4: Product assembly, painting, details

To make the maps more accessible for visually impaired people it is advised to paint the outlines (using model paint, for instance) to make them stand out from the background.

If the map is large you might need to print out sections of it and fuse or glue them together afterwards. Printing braille can be tricky; the base must be slanted and the "dots" are not always distinct enough. It may therefore provide better results to print any text in braille separately, or using labels made with a label-maker or a typewriter (using stickers).

Drawing from experience:

In I.E.S. Benlliure high school in Valencia Spain a group of 15-16 year old students created a scaled-down model of their school. They based the model on real plans of the school and made different parts to scale. They divided into separate pieces in order for them to fit the printer and then glued them together afterwards.

Floor plan made by students of I.E.S. Benlliure, Valencia.

Session 5: User testing

Get a blind or visually impaired person to test the map, and to see if they think anything is missing, too detailed, or could somehow be improved.

Depending on their feedback, discuss whether it is feasible to change the design, and how. Sometimes, changing according to feedback may prove too complicated. If that's the case, then be prepared (as a group) to explain the group's idea, the feedback, and why it could not be adjusted. This is a learning process for all, and sometimes things do not go entirely as planned.

Session 6: Presenting the final product

Complete project finessing if needed.

The last part of the project, you and your group should formally present the product to fellow schoolmates or a target group, and describe the process as well as they can. A formal presentation can help raise awareness about disabilities in general and it can also be satisfying to show off a work well done.