



## Illustration and tactile image: 3D printing in favour of the creation of inclusive materials and its use at the intersection with workshop printing techniques.

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### Abstract

This article is about a search for the creation of tactile images and illustrations from the use of workshop printing techniques and 3D printing. Explorations in the search for communication and expressiveness, produced in ESAD.CR as part of investigation projects and classroom projects with teachers and students. This article reveals how exercises and experimentations in classes and in workshops led to the creation of accessible resources, promoting practical reflection through them. The article begins by providing an overview of visual and tactile images created with students, then focuses on the possibility of creating tactile illustrations by using 3D printed plates and printing press techniques. This article reveals how, approaching working through experimentation and comprehension, led to the creation of accessible resources and practical reflection on them. Focusing on the creation of accessible materials for different projects and purposes, the explorations presented result in finished work for specific audiences, but also as work in progress, as directions for continuous research in tactile illustration, images, and communication.

### Introduction

The Convention on the Rights of Persons with Disabilities (made into law in Portugal by Resolução da Assembleia da República N.º 56/2009) on its article 24th states that persons with disabilities should have the right to develop practical and social skills to participate based on equal opportunity in education as members of a community. The World Report on Disability, from 2011, states that about 15% of the world's population had some form of disability. To create accessibility is to create physical conditions for access and enjoyment of places, experiences, and objects. To create interpretation, conditions for the promotion of each individual's vision, mirroring diverse ways of being and thinking the human experience. Having cultural material in accessible formats is having culture in an accessible format. Creating accessibility in culture puts into relation ways of being and creating that, starting from differentiated wills or objectives, gain expression in formats that reference ways of inhabiting the world.

## Tactile Images

Inclusion means soliciting the ideas, opinions, and viewpoints of the target group (Ambrose & Harris, 2010). Developing work in favour of a specific audience implies creating empathy. The creator (or producer) puts himself in the role of the audience by reflecting on the production of communication and its effectiveness. Research through practice allows testing, establishing hypotheses and communicating principles. Research by doing sets out steps and processes for an object to emerge, be feasible and reproducible.

Seeking to raise awareness, explore potentialities and possibilities of communication, in classes and workshops, challenges were created, in the School of Arts and Design of Caldas da Rainha (ESAD.CR), for students and participants with distinctive characteristics (including a few students with blindness or low vision). In a workshop, in 2015, the creation of images with tactile characteristics was proposed, based on photographs of monuments, through the exploration of printing workshop techniques. Using silkscreen to apply colour and linocut to create relief on paper, the students first decision to be made was the printing order, whether to first apply colour and then relief or to produce in reverse order. By direct drawing on an acetate sheet, each student created the image to be transferred to the silk screen. After deciding on the printing colour, they made decisions about the illustration to be created in a tactile way. Styling the lines and shapes of the chosen monument they proceeded to cut the linoleum board to enhance the creation of relief by means of pressure. The results were printed images with overlapping visual and tactile reading.



In another workshop, in 2017, the creation of images with tactile characteristics was proposed using the agglomeration of found materials on a cardboard plate, a creative process that refers to the collagraph printing technique, in which materials are glued onto a base, creating a three-dimensional plate, a matrix which after being inked results in a printed image with relief. As a starting point and communication aim, each student chose the image of a publicly recognised painting, and by agglomeration of materials tried to produce a relief plate that would become a recognisable translation of the original image into a tactile image.

In an exercise, in 2016, students were asked to produce images in graphite and indian ink by exploring different textures, gradations, and line thicknesses. The drawings were scanned and digitally worked on, to increase contrast and remove details in order to clean and accentuate the clarity of the image. The tactile plates were produced using a 3D printing technique.

**Fig. 1.** Example of a linograph plate and its printed image.

**Fig. 2.** Example of a plate and its print.

**Fig. 3.** Examples of the original drawing and the resulting printed plates.

**Fig. 4.** Example of the printing and of the printed sheet before being folded into an Instant book.



In another exercise, proposed in 2018, the challenge was to make use of silkscreen printing with two colours and relief with a 3D printed plate as a means to tell a story. The exercise resulted in an Instant book with tactile and graphic information that complement each other. When overlapped, the tactile and graphic information are repeated, when separated in the sheet of paper, the printed elements work as complementary elements.

The printing processes used in these exercises and workshops are differentiated in their approach to creating the matrixes. The matrix resulting from the linocut technique is created by reductive technique while the matrix created through 3D printing arises by addition. While the linoleum plate allows working manually from a smooth surface that has uniform height, and its expressiveness can be explored by cutting its surface, the 3D printed plate, produced as additive manufacturing, allows working mechanically from a predefined image whose height can be defined in a pre-printing phase, and its expressiveness can be explored with materials used to paint or draw.

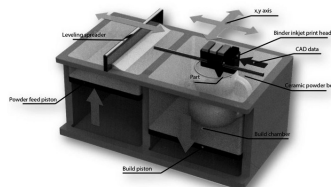
### From Pixel to 3D

The first experience of creating tactile images was carried out in 2011 in the Digital Prototyping Lab of ESAD.CR, as previously described in the article “Imagens Tácteis - Transformação multissensorial de uma pintura”, based on a proposal by the teacher Josélia Neves, who was involved at the Polytechnic of Leiria in several accessibility projects for blind people, attempting to find solutions that would transform images into three-dimensional elements.

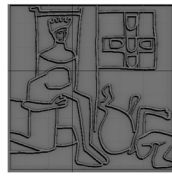
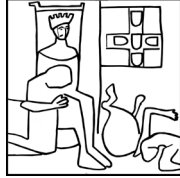
The project was about the possibility of giving images to “see” to people who are blind or have low vision. The challenge would be to find solutions that would appeal to other senses, namely hearing and touch. By combining these two senses, through audio description (image description) and touch, it would be possible to make images accessible to people with different degrees of visual impairment.

At the time, the ESAD.CR laboratory had a ZPrinter 450. A 3D printer based on a technology that works by binder jetting. This process, called 3DP, was originally developed by MIT and patented by Sachs (Sachs, 1993), as three-dimensional printing techniques.

**Fig. 5.** Scheme of the 3DP process.



It is an additive manufacturing method that employs two materials: the building powder and the binder liquid. The liquid is selectively deposited by print heads that aggregate the pulverised materials into a bed filled with the same powder. The distributed binder liquid will combine with the powdered material to form a rigid layer of a given shape.



**Fig. 6.** Painting “Aljubarrota” by Mário Rita.

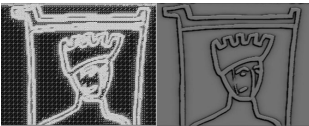
**Fig. 7.** Base image with contours only.

For a first test, the painting “Aljubarrota”, by Mário Rita, present in the collection of the Batalha Community Museum, was chosen. In this specific case and considering the expressionist character of the painting, we tried only to reinforce the main lines to simplify the distribution of the pictorial volumes in the two-dimensional space.

Using image editing software, the colours were eliminated, and the contours of the figure were drawn respecting all the drawing elements. After obtaining a monochrome model, some traces and areas of noise were still visible and were eliminated, as they were not considered truly relevant to the final objective.

In the three-dimensional conversion a 3D modelling software was used, and displacement mapping techniques were tested (Karhu, 2002), which allow interpreting the grey tones as level elements.

With the described process, it was possible to prepare a 3D mesh based on the 2D displacement map, which, with appropriate parameterization and sufficient subdivisions, guaranteed the intended 3D effect.



**Fig. 8.** Rendering and base image.

**Fig. 9.** Detail of the result with the initial image.

**Fig. 10.** Detail of the result with the blurred image.

The 3D object was printed for a first tactile test. The results were not very pleasant. Although it was possible to read, the edges were too rough and made the interpretation process uncomfortable for those with high sensitivity to touch.

The high contrast of the colours caused sharp edges. It was necessary to adjust the thickness and softness of the stroke for the effective tactile recognition of the image.

The problem was partially solved by editing techniques and through specific filters that allowed the image to be slightly blurred. Repeating the process, changing only the base image, the quality improvement in the edges was notorious.

The printed piece was finally tested in a real context in the Batalha Community Museum. Having verified advantages and disadvantages it became clear that the tactile perception only happens when it is combined with verbal explanations - leading the “look” of the fingers - passing also

through the important sound complement of a more subjective and emotional character of sound effects and music.

The innovative character of the proposal lies in the techniques and materials used in the construction of the tactile images and in the combination of complementary means to replace vision in the perception of images.

**Fig. 11.** Rendering and blurred base image.



**Fig. 12.** The 3D printed final model.



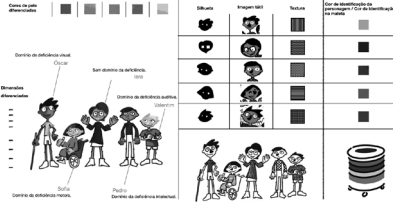
### Tactile Visual Illustrations and Characters

In the scientific research and technological development (IC&DT) project ProLearn4ALL, aimed at the development of playful-pedagogical products accessible to children of the 1st Cycle of Basic Education (CEB), seeking to increase the knowledge of children about the characteristics of disability, the challenge proposed, in 2019, was to create resources about the main domains of disability (auditory, intellectual, motor, and visual). Using a problem-based research methodology (Ulger, 2018; Yew & Goh, 2016), possibilities were explored, tests were made, and materials produced using the printing techniques that were previously explored in classes and workshops.

As previously described in the article “Personagens de representação Inclusiva: em busca da diversidade de representação no projeto ProLearn4ALL”, in order to make a connection between the different resources and to create empathy with the themes, five characters were designed. Differentiated by their own characteristics, each one linked to one of the principal areas of disability. Their story was explored in an illustrated book. The book was built in the harmonium format, allowing the pages to be opened entirely on a flat surface and be touched, so that the story can be explored by readers with distinct characteristics. On each page there is text, superimposed as visual and braille. The visual and tactile illustrations have matching colours and textures, line thickness and depth, making use of three levels of height that create a parallelism with the depth representation of the visual illustration. In some of the illustrations there are visual clues that do not correspond to tactile clues and tactile clues that do not correspond to visual clues, encouraging discoveries and dialogue between children when handling the book.

Andrew Hall (2011) states that an image has the power to address an audience, to place the reader inside, enhancing a direct link to emotions, memories, and experiences. Each character was created to be differentiated, by colour, texture, silhouette, visual cues, and specific details. Each character was created regarding representation, a somehow potential mirror for the reality existing in a classroom, trying to show diversity as the norm.

The visual graphic style resulted in the use of simple forms, using contained distortion to create expressiveness, not losing the visual reference of joints such as knees and elbows, so as not to lose the relationship with the observable in a human body. There are defined contours for the shapes, which are present depending on the illustration because the application of colours sometimes goes a little out of the delimited spaces (as



**Fig. 13.** Example of the printed harmonium book, with graphic and tactile information.

if they could have been painted by children). In some of the illustrations, besides the duplication of information in the main elements of the narrative and the characters, there is a complement between the visual part and the tactile part, as some visual elements exist only as printed image or as printed relief.

**Fig. 14.** Relations of colors, textures, silhouettes and lines thickness for the graphic and the tactile images of the characters.

## Conclusions and Observations

The production of tactile images using printed 3D plates and workshop printing techniques has potential to be explored in the creation of tactile illustrations and inclusive materials. It's a process where there will always exist some amount of margin for errors, due to being partially handmade, and it is a process that is not suited for substantial amounts of prints. When tactile image and printed image are created and printed in a collagraph logic the process is not time consuming as it only involves applying ink and making a print. However, in an example like the illustrated book, three successive impressions were made: a first one for the image and visual text (uv printing), a second one for the braille text and a third one (with the sheet being moistened) for the tactile image. The succession of processes made the printing and assembly of the illustrated books a time-consuming process. There are difficulties to be overcome regarding reading some of the resulting images. The image printed by means of a force applied on the moistened paper leads the paper to adapt to the grooves creating depressions on the front of the sheet of paper. However, for tactile reading, the relief to be read using the fingers must be the one on the back of the sheet, because it appears printed as height. This relief on the back of the sheet does not appear as a result from the direct contact with the matrix, which sometimes causes reliefs to have less defined contours. Tests and fine-tuning are essential to control variables such as the characteristics of the paper to be used, the way the matrix is created, and the amount of force applied. The matrix created by additive manufacturing of binder ejection must be applied on a base to create resistance to the action of the press. Without applying the matrix over another surface that serves as its base and without reinforcement of the binder agent layer, the

matrix will break. The pressure limit that can be applied and the height of the relief to be produced are factors and variants to be considered when producing the readable tactile image. Attention should be paid to the grammage of the paper, its ability to be visually printed before the tactile print is made, and the paper should also have water absorption capacity and elastic capacity. The expressive potential for the use of 3D printing technology as an intermediate point between the creation of illustration and communication by tactile and visual image is great and deserves future exploration, either in the continuity of the use of printing by material extrusion or in the exploration of the use of material ejection printers. Explorations in creating prints to be matrices, creating prints as plates to be read, the use of different printed materials, printing on paper or printing without paper. Currently, at ESAD.CR, the processes described in this text are used in the production of tactile books using matrixes produced with the technologies of editing, modelling and 3D printing for subsequent printing on paper.

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