3D Printing for touch readers – A format for the future?

Leona Holloway & Matthew Butler
Inclusive Technologies, Faculty of Information Technology
Monash University
https://www.monash.edu/it/hcc/research/inclusive-technologies

Abstract

For children who are blind or low vision, graphics are most commonly represented using tactile graphics, descriptions, or at-hand materials. 3D printing offers a new low-cost means of creating 3-dimensional representations of graphics for use by vision impaired students and their sighted peers. 3D printing may also be used to create customised classroom modifications.

In a 3 year Linkage Grant funded by the Australian Research Council, Monash University is partnering with the Round Table on Information Access for People with Print Disabilities, the Victorian Department of Education and Training, the Royal Institute for Deaf and Blind Children (RIDBC), Royal Society for the Blind (RSB) and Guide Dogs Victoria. The project aims to investigate the use of 3D printing for access to graphics for people with vision impairments in the fields of education and Orientation & Mobility. When are 3D prints the most appropriate format? What are the design considerations for 3D models to be used by touch? What skills are required to create and print 3D models? And what support do schools and producers require to enable adoption of this new medium?

In this presentation, Monash researchers will outline the project, describe the work done so far, and extend an invitation to SPEVI to get involved in the project as a member of Round Table.

Real objects and 3D models

Real objects and 3D models may be easier to understand than tactile graphics because they rely less on abstraction.

The real object **usually** gives the most immediate access and is easiest to understand. 3D models may similarly be easier to understand than tactile

graphics. However, it is not always possible to access a real object or model, for a variety of reasons.

As an example, consider taxidermy birds housed in a museum. In nature, living birds are too rare and difficult to access. They might even be considered dangerous, and certainly uncooperative. Obviously, it is very difficult to find a bird that is cooperative enough to allow full tactile exploration. Taxidermy birds might be an option if you live in the US or Canada where there are museums that loan out taxidermy animals for touch access. But in this example, there is a “do not touch” sign because the specimens are considered too delicate and difficult to reproduce.

You might also consider buying plastic toy birds, if you can find any that are large enough for tactile detail, affordable, and you can wait for shipping.

It may not be possible to access a real object or model because it is too rare, too expensive, too delicate, too remote, too dangerous, too big or too small.

3D printing for accessible graphics?

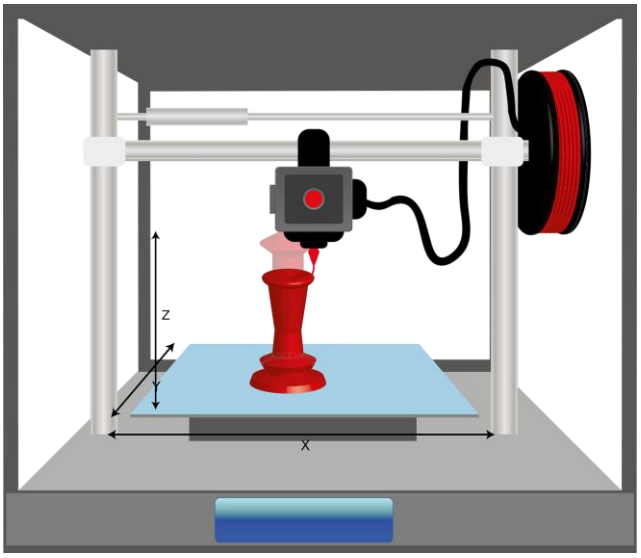
3D printing offers a new additional means of creating 3D models. Commodity 3D printers are now available in many schools libraries and business, enabling production of 3D models at comparable effort and price to tactile graphics. Most hand-held prints cost only a couple of dollars in materials, which is equivalent to the cost of a piece of swell paper.

3D printing 101

The most common 3D printers in use are Fused Deposition Modeling (FDM), at a cost of around AU$2,500 for a good quality printer.

The most common materials are PLA or ABS plastic costing around AU$45 per kilogram. PLA is more reliable, gives better definition and is more environmentally friendly. However, ABS (the plastic used to make lego) is more durable and can be treated after printing to give a much smoother finish for touch readers. Other filaments of interest include nylon for a squishy touch or wood for a distinct wood smell.

The material comes on a reel. It is melted in the 3D printer head then the head moves to print one thin layer at a time. You can adjust settings to determine the thickness of each layer and resultant speed and quality of the print. As the print is built up, sharp overhanging parts must either be avoided or supported with temporary structures that can leave a rough finish.



The steps in producing a 3D printed model are:

1. Find a model, for example at Thingiverse or BTactile OR
2. Design your own model, for example using TinkerCAD, SketchUp or Touch Mapper.
3. Set your print parameters, send the model to the printer and wait. Large prints can take up to a day to complete. Other models may require several parts to be printed separately and then assembled.

ARC Project: Investigating the use of 3D printing for access to graphics by people who are blind or have low vision

We are conducting a 3 year project, which started in October 2018, investigating the use of 3D printing for access to graphics by people who are blind or have low vision.

There are four main aims to the project:

1. Identify the most appropriate uses for 3D printing for accessibility, with a focus on application for education and orientation & mobility.
2. Consider touch reading strategies for 3D models.
3. Develop or identify technologies for accessible labeling of 3D models.
4. Build capacity for 3D printing within the accessibility sector.

Project partners

The project is funded by the Australian Research Council, with an emphasis on researchers and the accessibility sector working together. We are hugely thankful to all of our partners and invite your active participation in the project.

Monash University is responsible for the project administration, with Chief Investigators Prof Kim Marriott and Dr Matthew Butler, and project administrator Leona Holloway.

The named partner organisations are making in-kind and cash contributions to the project:

- Round Table on Information Access for People with Print Disabilities, with support from its members including SPEVI.
- Department of Education and Training, Victoria. Debra Lewis of the Statewide Vision Resource Centre (SVRC) is a Partner Investigator.
- Royal Institute for Deaf and Blind Children (RIDBC). Sonali Marathe is a Partner Investigator.
- Royal Society for the Blind of South Australia (RSB)
- Guide Dogs Victoria (GDV)

An Expert Advisory Group meets quarterly to ensure that the project is on track and meeting the needs of the sector, to provide expert advice, and to encourage involvement of their organization in the project activities. The group consists of representatives from all of the project partners in addition to Blind Citizens Australia, Vision Australia and the Queensland Tactual Mapping Committee.

Work packages

In order to address these aims, we have six work packages, each with its own timeframe and focus partners:

- **WP-Map:** Maps and plans for orientation & mobility
- **WP-Place:** Using maps for teaching place and geography in education
- **WP-TacLit:** Teaching tactile literacy

- **WP-STEM:** Teaching technical areas, such as math, science & technology
- **WP-Int:** Adding interactive audio labels.
- **WP-BldCap:** Building sector capacity

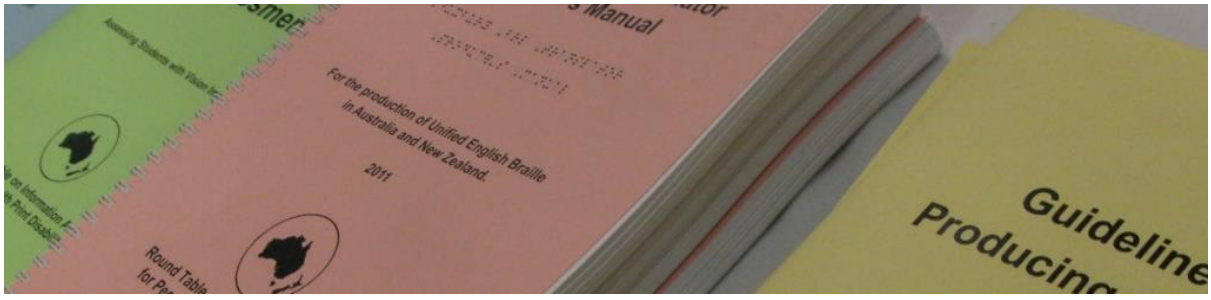
Guidelines (WP-BldCap)

The accessibility community has agreed upon a collection of excellent guidelines for tactile graphics, based on empirical research that has been going on for more than a century. We know what are the best width for lines, we know what spaces we need between things, and we have a collection of textures to use that we know can be distinguished from one another. But right now, we don't have any of that for 3D printing for touch.

Work package Building Capacity aims to research and report empirical findings to support the creation of Round Table Guidelines on 3D printing for touch readers. Some of the issues we are investigating include:

- When is 3D printing best suited?
- Where to find suitable 3D models?
- How to design your own 3D models
- Design guidelines for touch reading

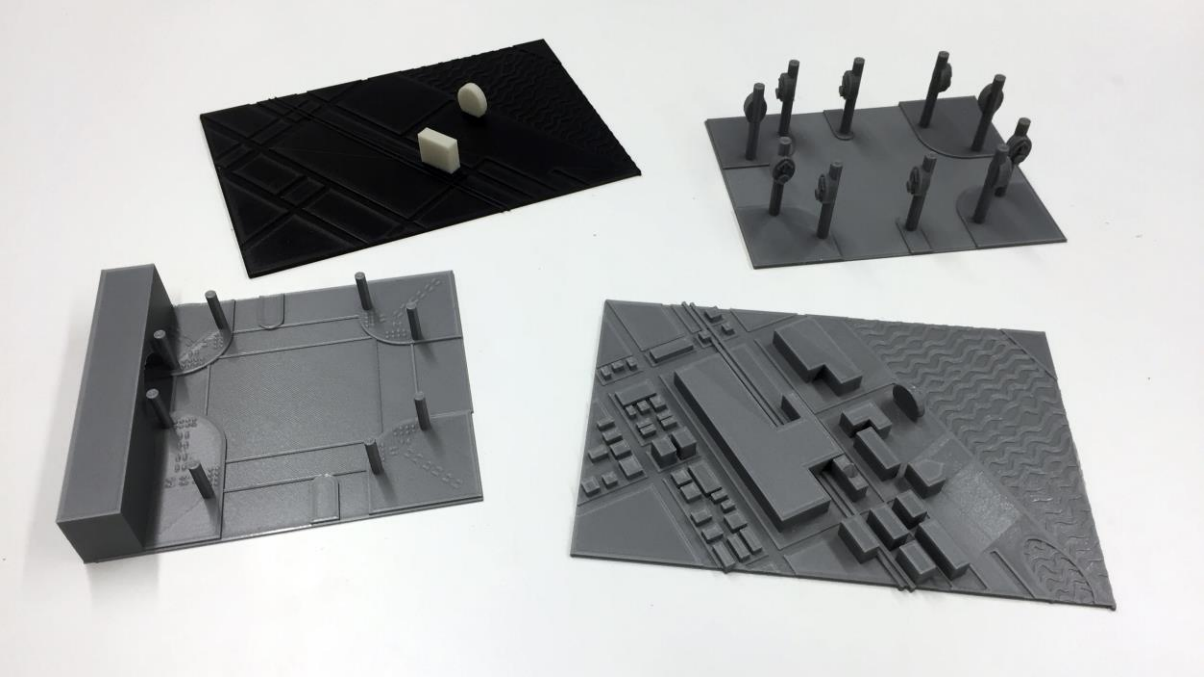
Another component of this Work Package is working with the project partners to support their first attempts at 3D printing.



Mapping (WP-Map & WP-Place)

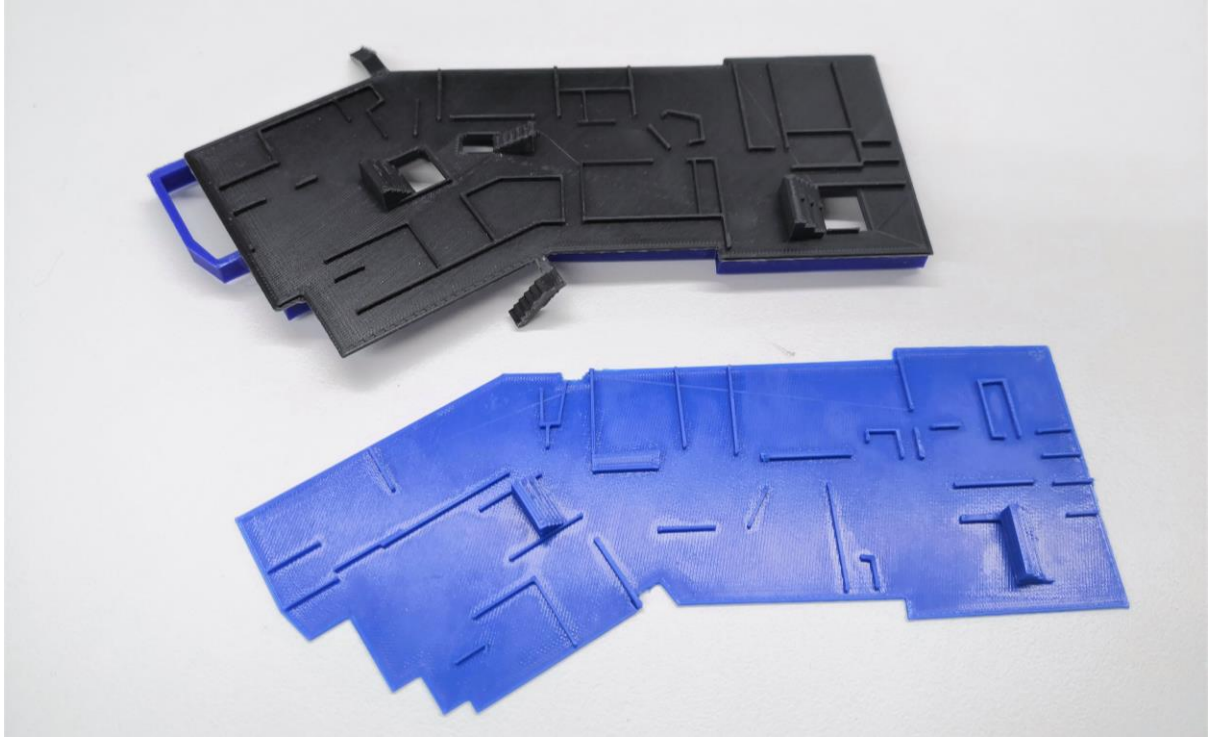
Work Packages on Mapping and Place explore the use of 3D printed maps to support O&M and education.

At the 2019 Round Table Conference we ran a workshop and provided maps of the Conference location: street maps, floor plans and street crossing created using at least two different styles to gauge preferences.



In collaboration with Guide Dogs Victoria, we created a large outdoor map of the Melbourne International Flower and Garden Show. It was placed at GDV's sensory garden at the 2019 Show and we gathered feedback from visitors on site. This work has been published as [3D Printed Maps and Icons for Inclusion: Testing in the Wild] at CHI 2019. We plan to do further work on design and evaluation of 3D printed icons for touch.

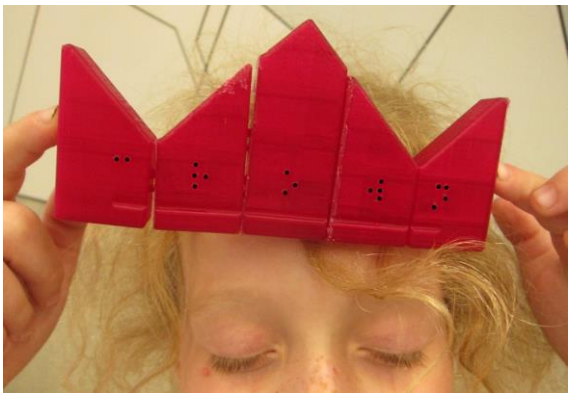
Again in collaboration with Guide Dogs Victoria, we created a series of school maps for use by students starting at a new school. Danielle Kruger will present this work in a separate session at this conference.



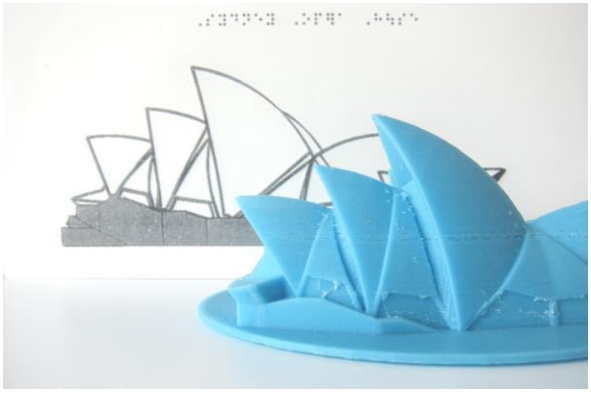
Tactile Literacy (WP-TacLit)

Work package Tactile Literacy explores the use of 3D printing to support the development of tactile literacy in young touch readers. Here, we are defining tactile literacy in two distinct ways, and are interested in both aspects.

Firstly, 3D prints may support tactile literacy through engagement with a rich variety of tactile materials. The image below shows a child playing with a 3D printed Fittle puzzle with a braille letter on each piece. When the puzzle is pieced together, it forms the shape spelled out in braille.

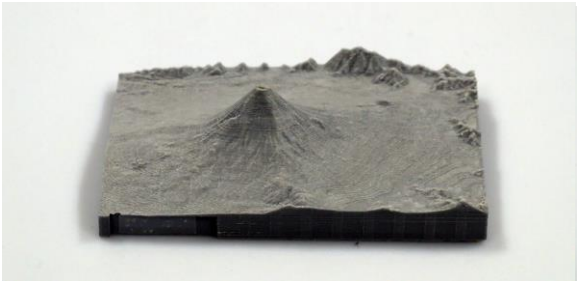


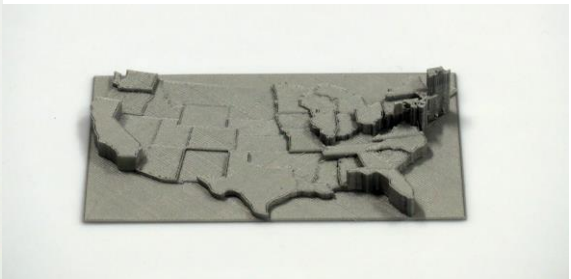
Secondly, 3D models may provide an easier way to understand concepts that can then be transferred to learning how to interpret 2.5D tactile graphics. For example, the photograph below shows a 3D model of the Sydney Opera House, which is very difficult to understand through description but is meaningful when accessed as a 3D model. Tracing the outline of a model and exploring only the front side may help in understanding concepts such as silhouettes and perspective. The UBIS group in Europe have already done some good work on using 3D models to transfer to an understanding of 2.5D graphics.

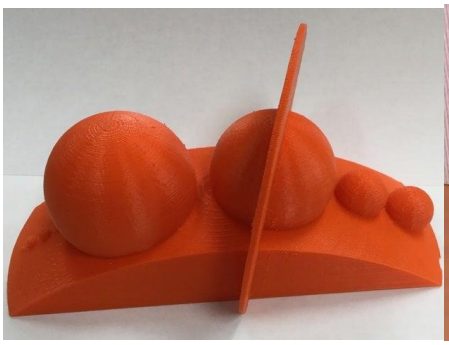


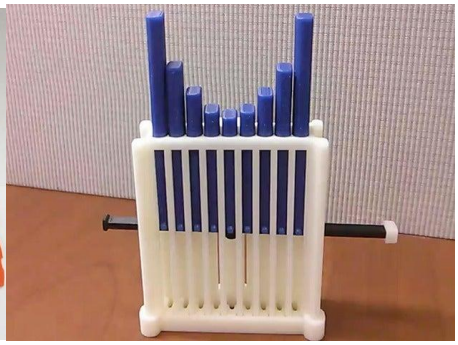
Further educational materials (WP-STEM & WP-Place)

We will next move on to Work packages on STEM and Place, both with an emphasis on education. For example, the images below depict 3D models of Mount Fuji and surrounding terrain, USA states with height representing population density, the inner ear, the solar system against the curve of the sun, and a manipulative to explain the effect of b on the position of a parabola.

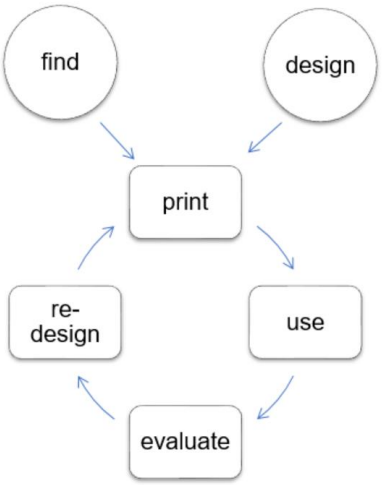








The first step of the evaluation cycle will be to find out what is needed. Which concepts are difficult to explain using 2.5 tactile graphics? In collaboration with our partners, we will then find or design 3D models, print them and share with the community to use, and evaluate. Further adjustments will be made based on your feedback and final designs will be shared.



Labelling (WP-Int)

Labelling is important for allowing and encouraging independence, and for the joy that comes with discovery.

The image below shows building blocks with braille and raised letters. These were printed with the braille on the side. Because the braille is embedded in the design, they cannot be printed at a different size. They also raise the issue of which way up and context (upper or lower cells).

We are exploring a range of options for labelling of 3D models.

Braille labels can be embedded within a 3D model design, however this is usually not recommended because it means that the model can only be printed at one size, space on the model is usually limited, and because it will only yield good quality dots if printed on the side. Instead, sticky braille labels may be more practical.

An accompanying tactile graphic with an outline of the base and braille labels may be a simple way of indicating which way up and providing space for lengthier labels.

Shakers or magnets may be inserted inside models to give audio cues or for attraction to a metal base.

Several methods are available to easily provide audio labels, for example the Pen Friend, QR codes, RFID and Talking Tins. For permanent, high-use models it is also possible to create inbuilt interactive audio labels.

Getting involved

We are keen to work with as many people as possible in the accessibility community.

At the SPEVI 2020 Conference you are invited to come along to our workshop or to try our 3D printed textures sample bag.

Teachers, parents and accessible formats production staff are invited to respond to our survey on materials for early tactile literacy at http://accessiblegraphics.org/2019/12/18/survey/

If you are teaching, you could trial materials and provide feedback.

If you are designing or printing your own materials, you could contribute to or test our draft guidelines.

Finally, http://accessiblegraphics.org/research/3dprints/arc/updates/ gives monthly reports so that you can follow our progress and highlights upcoming projects or events.

Contact us

Please contact us, as listed below.

Leona Holloway – Research Assistant
Leona.Holloway@monash.edu
042 042 6823

Matthew Butler – Chief Investigator
Matthew.Butler@monash.edu

Kim Marriott – Chief Investigator
Kim.Marriott@monash.edu

Sonali Marathe – Partner Investigator, Round Table & RIDBC
sonali.marathe@ridbc.org.au

Debra Lewis – Partner Investigator, SVRC
lewis.debra.d@edumail.vic.gov.au

Website: http://accessiblegraphics.org/