3D Printing in the Classroom

SPEVI 2021

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Leona Holloway works at Monash University on an ARC Linkage Grant looking at 3D printing for touch readers. The project is supported by SPEVI through Round Table. The other Linkage Project partners are the Victorian Department of Education, RIDBC, RSB and Guide Dogs Victoria.

Navkaran Virdi (Nav) works at the NSW Department of Education's Braille and Large Prints Services on a project exploring the use of curriculum-based 3D prints in the classroom for students with vision impairment.

Both Leona and Nav are members of the 3D printing group run by the Australia and New Zealand Accessible Graphics Group (ANZAGG).

Overview

This presentation will briefly touch on the basics of 3D printing, go into some detail about the advantages of 3D printing for vision impaired students and to create an inclusive classroom, and also cover the practicalities of how vision specialist teachers in Australia and New Zealand can source 3D prints.

- The basics of 3D printing
- The benefits for VI students
- Inclusive classrooms
- How to order

The basics of 3D printing

We will begin by looking at the basics of 3D printing: what it is and why it is important.

What is 3D printing?

The creation process

3D printers are becoming more common in schools, libraries, homes and through 3D printing services. The most common type of 3D printer is known as FDM, printing one very thin layer of melted plastic at a time to build up a physical object. This is why 3D prints may have ridges on the sides.

Other types of printers are also available for more fine detail, different materials and

colour imaging.

Size

Most printers, like those you will find in schools, are generally limited to a 20x20x20cm size. But of course, a larger model can be made by joining several pieces together.

Production

3D printers are intended for small-scale production or prototyping. It should be noted that 3D printing is slow - the tiniest models take 15 minutes to print and larger hand-sized models can take up to 24 hours, so it is not suited to mass production of a lot of copies. Creating new 3D designs is the most difficult and time-consuming part of the process.

Sources of designs

Your accessible formats production team may have some 3D models that they can recommend. A lot of other designs are available for free online. Refer to the ANZAGG guidelines on where to find 3D printing designs on the Round Table website at http://printdisability.org/about-us/accessible-graphics/3d-printing/repositories/.

Why 3D printing is important

Handmade models of the past

In the past, handmade models were considered best practice in teaching for blind students. For example, an enormous tactile globe was produced for the Perkins School for the Blind, which still stands in the school foyer and has been used to teach many generations of students. The Perkins School and Ohio State School had many such materials used within the teaching curriculum.

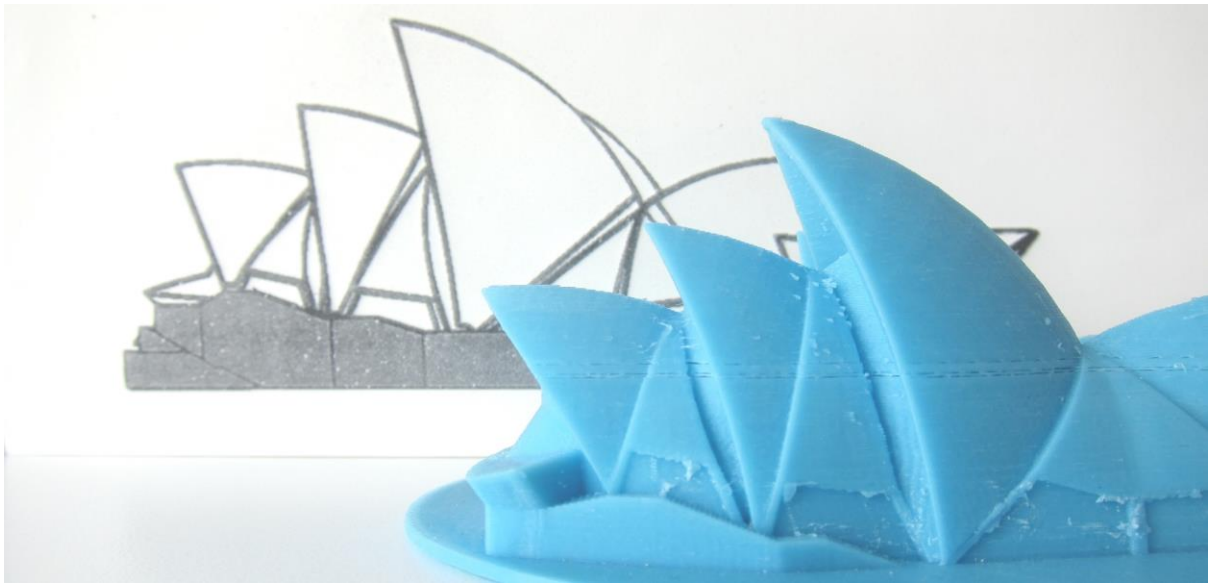
More locally, R.F. Tunley, who was known as the “Fairy Godfather of Blind Children,” made many innovative models including a model of Queensland’s Braille House which lifts on a hinge to reveal the internal rooms.

As use of large and fragile models becomes less practical with integration into mainstream schools, 3D printing offers an alternative that is sturdy, reproducible, and can be printed on site.

2D versus 3D

2D images and 2.5D tactile graphics are based on flat images created when light hits the back of the retina and rely on conventions such as silhouettes, perspective, foreshortening, obstructed views and birds-eye views, all of which need to be explicitly taught to congenitally blind children and require mental manipulation to be understood. By contrast, 3D objects relate much more closely to the real world and the way that it is encountered through touch by blind students. It also provides a means of accessing objects through touch that would otherwise be inaccessible because they are too big, too small, too dangerous, too rare or too fragile.

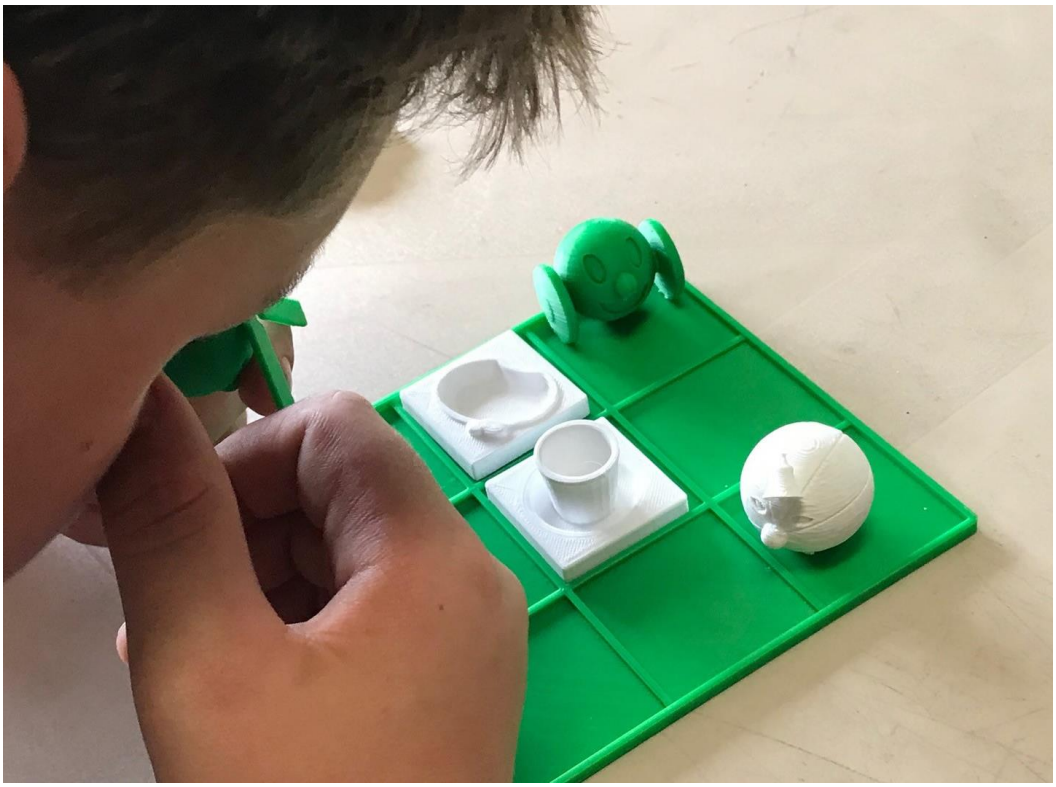
For example, the architecture of the Opera House defies adequate description and a tactile graphic can show only one perspective, relying on visual conventions. A 3D model of the Opera House provides that “aha” moment of insight when a congenitally blind person can finally understand the structure of the building for the first time.



Engagement and inclusion

3D printing is also important because the models tend to be more engaging, with more to explore or parts to manipulate. This leads students to spend more time exploring the material and asking more questions, extending the potential teaching opportunities.

3D printed items are also more inclusive as they can more easily be used by blind and sighted students together.



Ballyland 3D prints by Sonokids

Supportive evidence

Early research provides evidence that 3D printed models can be beneficial for students with vision impairment. For example, recognition of 3D objects by touch is far superior to recognition of 2.5D raised line drawings (Klatzky et al., 1985).

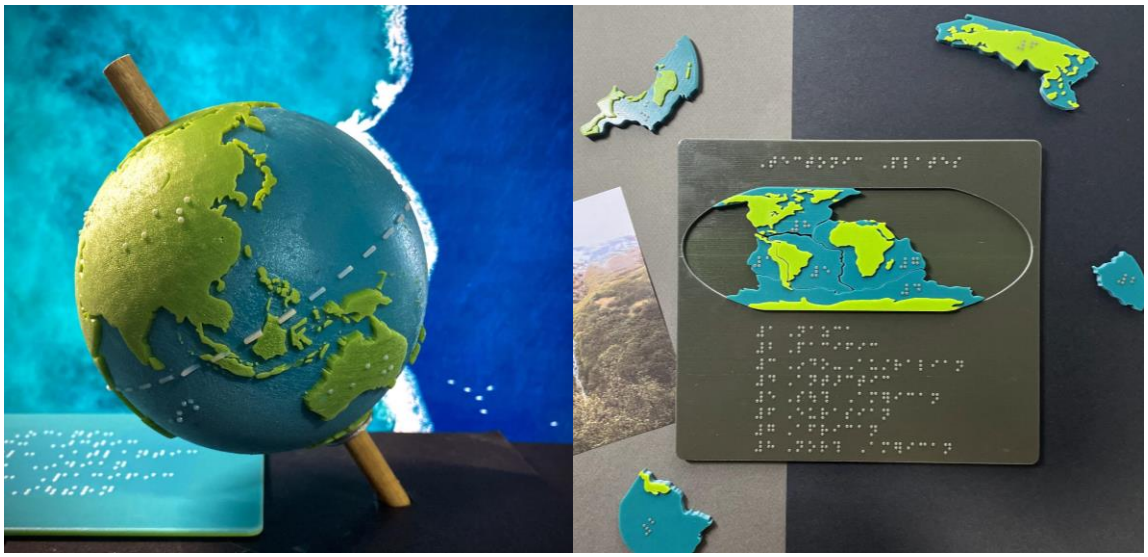
Space and text memorisation by students who are blind was improved when using small scale models compared with raised line drawings (Giraud, Brock, Mace & Jouffrais, 2017).

3D models have been demonstrated to be useful for people who are blind to learn and understand anatomy (Wong 2011), chemistry (Wedler 2012), micro-organisms (Reynaga-Pena 2015), Teshima 2010), earth sciences (Koehler 2017, Rule 2011; Teshima 2016), mathematical concepts (Mikulowski & Brzostek-Pawlowska 2014; Sun 2017), planetary science (Rule 2011), maps (Gual-Ortí, Puyuelo-Cazorla & Lloveras-Macia 2015; Holloway, Butler & Marriott 2018) and architecture (Bearman 2011; Celani & Milan 2007).

The benefits for VI students

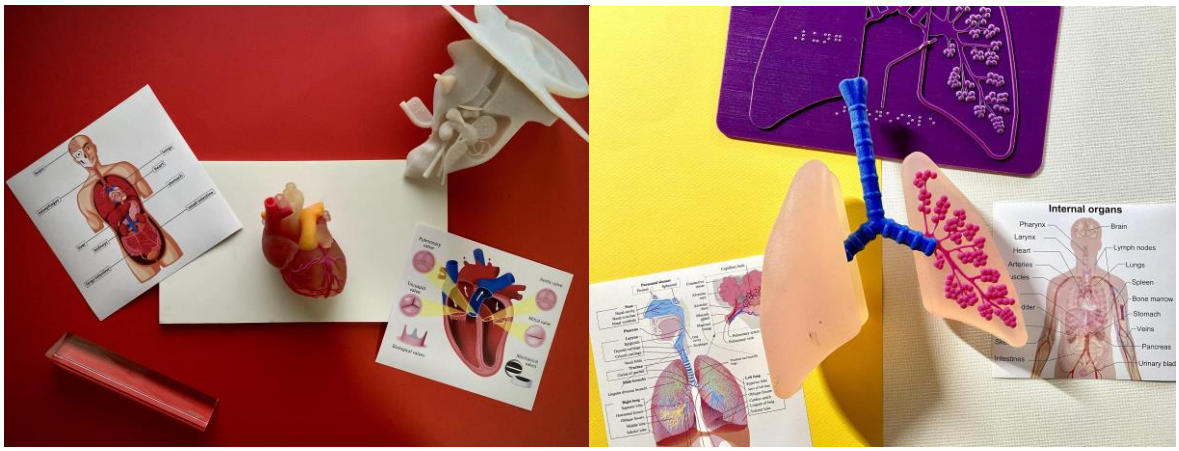
Creating curriculum supportive resources

3D prints allow students with vision impairment to build upon knowledge they have gained through traditional resources such as braille or large print text and raised line diagrams. Where traditional resources allow students to gain a bulk of information, 3D prints allow them to take a step back and experience that information in context. Appropriate representation of size scale, internal features, textures, and colours shows a student how, for example, the earth looks as a globe, and how the continents fit together.



3D prints can be applied across all key learning areas in all stages of education.

While certain prints will have direct benefits at certain stages, most Australian curriculums build upon prior knowledge, meaning a 3D print of a pair of lungs is relevant to a year 7 student and a year 12 student – it is the context in which it is used that changes. Prints across Geography and Earth Science, Ancient and Modern History, Biology and Anatomy, Astronomy, and Australian Politics have all been met with praise by Vision Support Teachers and students. Concepts that were difficult to teach via traditional resources have been simplified and made exciting to students.

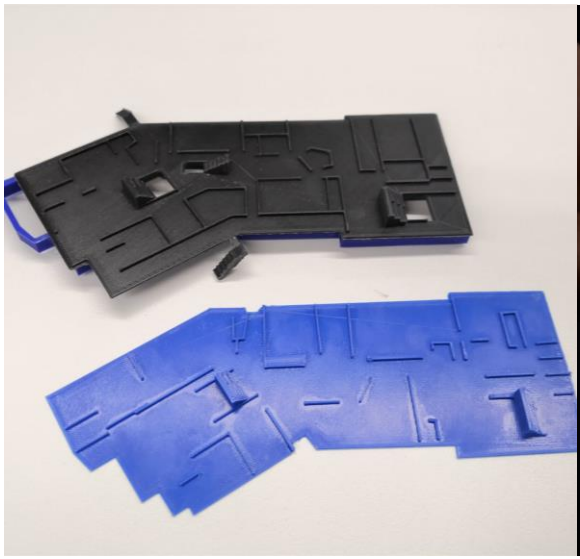


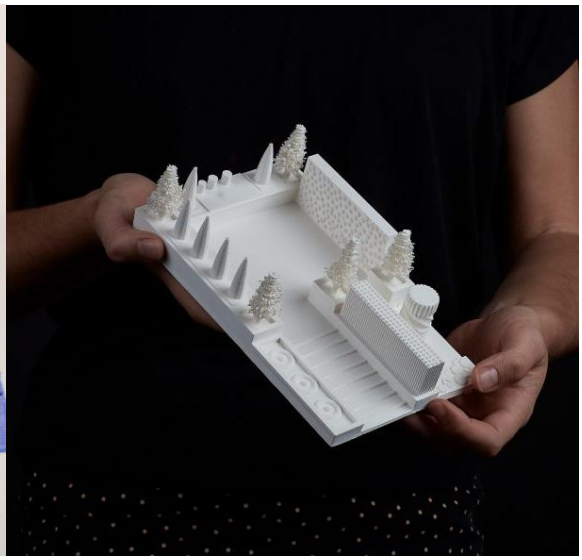
Students who are blind or have low vision can learn key independent learning skills through 3D prints. After an initial introduction to the print from the Vision Support Teacher, students are able to independently find embedded braille labels, navigate 3D prints to find key information, and gain insights into concepts through intuitive understanding. When given 3D prints in a set, like prints of the Parliament House exterior along with prints of the House of Representatives and the Senate, students can use the information from one print to gain knowledge of the other(s).

Supplementary teaching aids

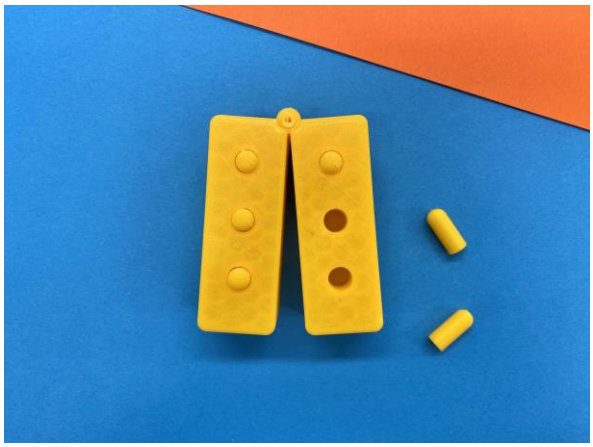
Beyond the classrooms, 3D prints can help students gain key skills needed when navigating a world without sight.

3D printed maps allow students to better transition into new schools during their orientation and mobility sessions. Maps allow students to explore building internals, find staircases and fire exits, decipher between grassy and concrete play areas, and gain knowledge of surrounding roads and streets and crossings.

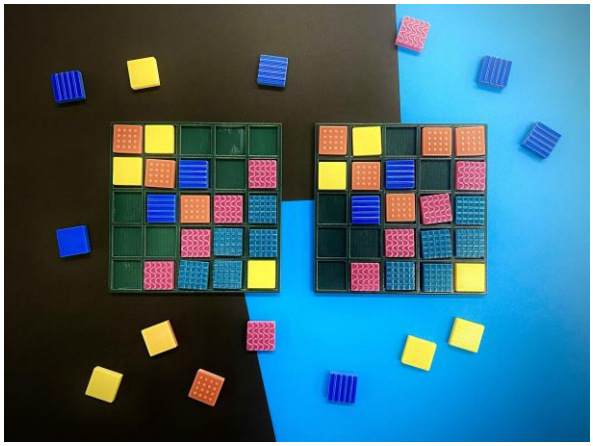




Teaching aids that assist with learning to read and write braille are extremely beneficial to students with degenerative eye conditions. Braille is a code with its own tools, so prints like braille alphabet tiles, swing cells, and Perkins Brailler finger guides allow students to learn through interactivity.



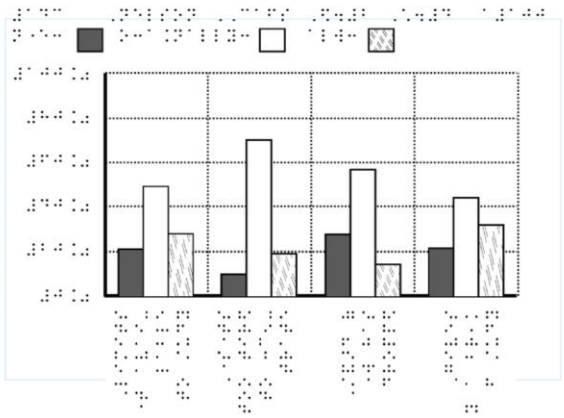
Beyond this, the loss of sight means difficulty developing key skills such as pattern recognition. Applying 3D prints here in the form of tactile mosaic tiles and tactile puzzles allows students to build strength in tactility and recognising specific shapes and textures.



3D prints encourage students to learn through interaction from an early age. This often leads to intrigue and comfort in the unknown for students who have grown up with interactive learning. This generally means that they are more likely to explore objects and surroundings independently.

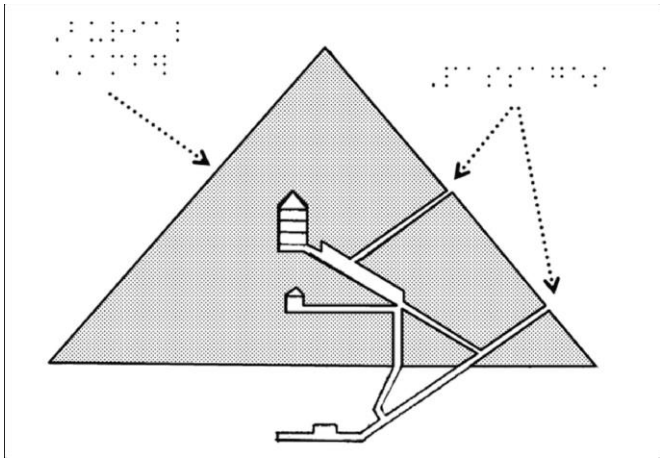
Multimodal learning

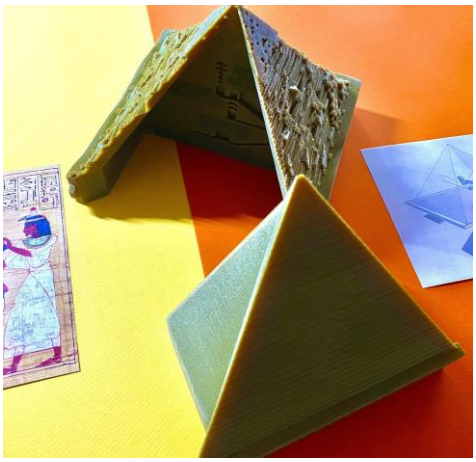
By building upon knowledge gained through traditional resources, 3D prints allow students to contextualise their observations. For example, when presented with a chart of ice shrinkage in the Arctic, students can gain a lot of information from the data set alone, however when this data is represented in a 3D print, students can explore how this translates to the real world. They can observe how significantly ice is melting, make quick comparisons of data from 1980 and 2012, and gain insights into how this affects surrounding islands and land masses.



Pairing 3D prints with traditional resources creates a tailored learning experience for students. These resources enhance each other, benefitting the students and the teachers. 2D provides dense information, and 3D provides contextual observation. In this example of a pyramid, braille labels would be too large for the 3D print, however

geometry, texture, and context can be shown on the 3D. The tactile diagram and 3D print work together to provide the most information possible.





Not every student learns the same way. Some may prefer traditional resources, while others may jump straight on 3D prints. Providing options allows students to learn comfortably and at their own pace.

An inclusive classroom

Discussion-based learning

3D prints create an “essential for some, useful for all” mentality in the classroom. While they are targeted to students with vision impairment, every student – and even teachers – can benefit from them. We’ve observed that when a student with vision impairment uses a 3D print in the classroom, other students around them want to touch and hold the print as well. This sparks discussion and constructive conversations that can benefit all students.

Discussion-based learning generates excitement and liveliness in a classroom. This creates a safe and active learning environment where students and teachers bounce ideas back and forth, where all students are encouraged to participate, and students often end up learning without realising they’re actually learning. 3D prints act as catalysts for this type of learning experience.

Feedback

Throughout testing 3D prints in the classroom for vision impaired students, we’ve been asking vision support teachers for their feedback. We’ve found that the vast majority of teachers found 3D prints made it easier to explore complex concepts as they provide a whole picture, and 3D prints reduced the amount of resources needed as they could simply refer to different parts of the print when students asked questions.

Anecdotal feedback from the teaches include stories of students loving the interactivity of prints, and discussions around how exciting and engaging the prints mde learning

Students found that 3D prints made learning exciting and engaging. In most situations they asked their support teachers more questions than they ordinarily would with traditional resources, they intuitively explored different parts of the print, and they were eager to race ahead and explore on their own.

Some teachers had difficulty getting 3D prints back from students as they wanted to keep them for longer. Other teachers did not want to return prints themselves as they made teaching easier and more streamlined, even for sighted students. Most teachers were quick to borrow more prints after their loan period ended.

Tips for using 3D prints

When using 3D prints with VI students, it is important to provide initial context for the print, rather than making them guess what it is. Students have prior knowledge they can apply to prints.

Focus on the extremities of the prints – look out for corners and edges, internal features, find key details to discuss with students.

Encourage students to move their hands over the entire print and seek out different textures. Often prints will have textures applied to them after the printing process. Some may have paints mixed with sand to great natural dirt textures, others may have model-making grass applied, and others may be printed in flexible and unique materials. Allow students to feel the different textures and make observations.

Assist students with connecting what they already know to the 3D prints. If the student has learned this concept with traditional resources, ask them what new insights they gained from the 3D print, and how their understanding of the concept has changed or evolved.

And lastly, give students time. Let them learn at their own pace and don’t rush them. Encourage them to explore specific areas, but also allow them to find their own details. Students may fixate on a specific area – this can lead to discussion and learning that was not initially intended.

Further guidelines on touch reading 3D printed models have been produced by ANZAGG are are available at http://printdisability.org/about-us/accessible-graphics/3d-printing/touch/

How to order

3D printing is still a relatively new technology and is in different stages of adoption by accessible format producers.

In New South Wales, ISTVs (Itinerant Support Teacher - Vision) can access 3D prints via Braille and Large Print Services' Oliver catalogue. They can also contact Nav to discuss prints not within the catalogue. The catalogue, which requires Department of Education login details, is located at https://oliver14.library.det.nsw.edu.au/oliver/home/news.

Also in New South Wales, RIDBC have been designing and printing 3D prints for their Teleschool program for some years. They are now in the process of opening requests through the accessible formats team and a catalogue will be available soon.

In Victoria, the Statewide Vision Resource Centre (SVRC) have 3D prints included in their online catalogue at https://svrc.vic.edu.au/transcription-services/alternative-format-catalogues/. Other prints may be available by negotiation with Sarah Hayman.

In South Australia, small scale provision of 3D prints is possible at the South Australia School for Vision Impaired (SASVI) but needs to be negotiated on an individual basis through the Accessible Formats Production team.

In the ACT, requests should be made to the ACT production team. A model can be 3D printed if a suitable existing file can be found. To date, the team has printed approximately 20 models.

The SSENS (School of Special Educational Needs Sensory) production team in Western Australia have a 3D printer but have not yet started using it. Hopefully soon!

The Education Department in Queensland have just purchased their first 3D printer and hope to be able to start producing materials soon.

In New Zealand, 3D prints are available from BLENNZ by request through YinYin

Htay or Karen Gilligan.

Vision Australia do not have a 3D printer, however they do have a new UV printer that can print layers and a laser cutter that can be used to produce layered models like topographies. University students can access their services for educational materials and library members can request models for personal use through the free personal support service.

It should be noted that it is much easier to print a model that already exists. It is helpful if you first look for existing models. Thingiverse is the largest repository of free 3D printable models but there are many other sources, including some that are specific to blind users or for specific educational fields. Again, ANZAGG has produced guidelines available on the Round Table website at http://printdisability.org/about-us/accessible-graphics/3d-printing/repositories/.

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