# When graphic design comes to life: 3D models designed and created by students with vision impairment

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## Abstract:

The benefits of 3D printing for creating quick accessible models and tactile graphics are becoming increasingly well documented, but what about including the students in the design process?

With an increasing educational focus on STEM, educators are set with new challenges to ensure access for students with vision impairment. Of particular complexity are areas of STEM that are primarily visual including 3D graphic design.

This presentation outlines the experiences of students from the South Australian School for Vision Impaired (SASVI) during their participation in a South Australian Department for Education program promoting 3D printing in primary schools, in conjunction with Makers Empire. It also follows students continued involvement in SASVIs '3D printing club'. Exploring the design thinking process and the promotion of spatial skills and 3 dimensional concepts as students work to improve accessibility for themselves and others with vision impairment. We will also explore the Makers Empire 3D printing software, including the challenges for low vision accessibility and strategies that were used to ensure inclusion and enjoyment for the students involved.

## Who are we?

Image: Photo portraits of Hannah left and Adrian right.

- Adrian – SASVI O&M teacher, keen interest in the applications of 3D printed resources in teaching methodologies.
- Hannah – SASVI SSS advisory teacher, Language (Japanese) Specialist and ICT teacher.

Hannah has taught at SASVI in the classroom as well as in specialist teaching roles, including the Arts, Japanese and Resource Based Learning (RBL) since 2010. She is also an advisory teacher with the SASVI Statewide Support Service. She was the ICT teacher during 2018.

Adrian has taught Orientation and Mobility since 2006, including at SASVI since 2015. His interest in the development of tactile graphics and 3D printing lead him to also be involved in the Makers Empire 3D Printing in Primary Schools project.

Both presenters have a philosophy for inclusion and the development of independence and self-determination. Hannah and Adrian worked collaboratively on the 3D printing

project with a small cohort of students with low vision from SASVI during 2018 which is the main subject of their presentation.

## Overview

Image: Cartoon drawing of a projector screen with a check list displayed on it.

- STEM and students with vision impairment
- SASVI's 3D Printing Club
- Markers Empire
- 3D Printing in Primary Schools project
- Benefits
- Continuation
- Video

## STEM for students with vision impairment

Image: A Geometro manipulative rod model arranged flat over the top of a 2D representation of square pyramid.

We'll start by discussing the challenges for students with VI accessing STEM activities.
Currently there is limited data in this area

- Main challenges being students needing to access visual graphics. In this case access to visual tasks to create and manipulate visual graphics.
- Vision impaired students can have reduced abilities in interpreting 3D shapes from 2D representations of 3D images (Kaneko, et al., 2010).
- Key point: Students with vision impairment are underrepresented in participation in STEM subject areas and in STEM careers (Supali, et al., 2014).
- Access to 3D printing can help to encourage STEM engagement (Buehler, et al., 2014).

## SASVI 3D Printing Club

Image: 3 students sitting cross legged facing each other while they work on iPads with the Makers Empire app.

How did we go about it?

- As this was a trial for SASVI the participating class was chosen based on their low vision needs. Varying levels of low vision with experience with using iPads with low vision accessibility features (All students had functional vision to use Makers Empire visually – level of exclusion of students with severe low vision or blind).
- Trialing of accessibility options for each student using iPad accessibility (magnifier, zoom, smart invert).
- 7 participants

- Initially with a year 4/5 class.

## 3D Printing in Primary Schools project

Image: The Makers Empire logo. A large M in the centre with the top of a building above it, shaded to look 3 dimensional. Makers Empire, in text, is written bellow the M in all capital letters.

3D printing in primary schools

- SASVI applied and were selected to participate in the 3D Printing in Primary Schools project
- Project is a partnership between the South Australian Department for Education and Makers Empire (An Adelaide based company who have developed an app with the aim of engaging and educating primary school students in 3D printing).
- Included training and development provided by Makers Empire to teachers involved in the project, including creating learning activities, developing projects and how to use the Makers Empire app.
- About 50 schools from across South Australia were involved with the aim of completing their own individual projects to design and build using 3D printing. The learning and designs were then showcased at an event held at the Adelaide Convention Centre with over 500 students, teachers and guests in attendance.

## Makers Empire

Image: The Makers Empire world map displaying the Training Lab, Game Zone, Competition Area, Daily Challenges, Challenge Central and Launch Pad. 2 avatars are displayed on the map alongside the Game Lab and Launch Pad. The top of the page has links to the World, Gallery, Create, My Designs and Avatar pages.

Pros of software

- Pros
- From non-VI perspective. Only software designed with education focus for primary aged students.
- Step by step challenges and activities for students to gradually build skills for 3D design.
- Makers Empire staff member with experience working with children with vision impairment. Able to liaise directly with her regarding access issues and possible solutions (not much implemented unfortunately).
- Braille font setting allowed students to add braille to models (limited capacity to add contractions).

## Makers Empire

Image: The Markers Empire Create page with a design of a jet fighter over a 3-dimensional grid board. The right of the page displays shape options, tools and a colour pallet.

Cons

- Purely graphic until the model was printed.
- No built-in accessibility features (large print/icons, voice over/audio description capacity) so had to trial other ideas using standard iPad accessibility (magnifier, inverted colour) and changing background and shape colours used on the app.
- Exclusion for some students at this stage who rely heavily on accessibility features.

## SASVI expectations

Image: A group of students sit in a circle cross legged with iPads on the floor in front of them. Adrian is also sitting on his knees in the circle talking to the students.

- Learning and design took place as a once a week lunch time activity.
- Students were given a choice to participate.
- Needed to commit to the whole project if they decided to be involved.
- Students were expected to follow the design thinking process.

## Student learning and design thinking

Image: A work sheet titled 'Design Thinking for Students'. The text reads 'You've got a problem to solve – make a record to show how you use Design Thinking to find a solution!' The worksheet has 5 sections. Empathise: Who are you trying to help? What do they need? Define: What is the problem you are trying to solve? How can you turn the problem into a 'How might we...?' Question? Ideate:  How many ideas can you come up with? What is your most original idea? Prototype: Which idea will you try first? What will you design to test your idea? Test: What is working well? What improvements could you make?

- Plan: SASVI students project was to design and create aids that would assist people with vision impairment with everyday activities.
- Students brainstormed ideas as a group and individually.
- Design: involved students using whatever medium worked for them (drawing, building, crafting). Encouragement of building for students to note the 3D nature of their design in a real-world sense prior to graphic design of 3D model.
- Create: Developing skills with using Makers Empire and understanding of 3D design.
- Building skills to use Makers Empire software to design 3D models. Learning how to create, size and manipulate shapes on a graphic platform.
- Print: Trial and error, modification to design.

## Challenges

Image: A 3D design of 4 tactile arrows sitting on a grid base. 3 arrows are designed with a triangular head on a rectangular base, the other arrow is just triangular in shape. One arrow is selected with designs tools displayed on the corners of the selection area.

Challenges faced

- Accessibility of software (e.g. zoom only worked for the model but needed to use magnifier for the menus and tools).
- Time constraints as a lunch time activity, rather than classroom activity.
- Different abilities and levels of understanding. Some students had experience with apps like Minecraft which function in a similar way while others needed time to grasp.

## Successes

Image: 5 students sit cross legged holding their 3D models. Behind them is a table and display showcasing their 3D models and information about their designs.

Positive outcomes

- Students gained understanding and enjoyment from the process to design, build and print 3D models.
- Improvements with interpreting 3D shapes from 2D representations of 3D shapes.
- Improved ability to manipulate shapes by rotating, reorientating and resizing them. This may also have helped with interpreting 3D shapes.
- Showcased their own designs to over 500 students, teachers and guests.

## Benefits beyond STEM (Expanded Core Curriculum)

Image: 2 SASVI students explain their designs to 2 students from another school in front of the SASVI showcase display.

Beyond STEM benefits: Link to the Expanded Core Curriculum

- Adaptive technology (managing access settings on iPads to maximise access to Makers Empire app).
- Functional vision skills to visually interpret and manipulate 3D objects of a 2D platform.
- Self-determination required to design and print with errors, then go back to fix errors. Philosophy for developing self-sufficient adults as much as possible rather than being reliant on others for resources.
- Social skills required to interact with students from other school and invited officials at the showcase day (including the South Australian Minister for Education).
- O&M getting to showcase day by public transport and return to school.

## What would we do differently?

Image: A student looking into the 3D printer to watch a print in progress. Other models, including one of the Eiffel Tour, sit on top of the printer.

What we'd do differently

- Take time to ensure each student is well set up to maximise accessibility with device(s) and software.
- Go through the basics in detail. Particularly with students without experiences manipulating 3D graphics and those who find 2D representations of 3D shapes difficult.
- Plan strategies for inclusion of students with little or no functional vision (supports/software options).

## What now for SASVI?

Images: 4 3D designs. The top left is an Australian Rules football on a stand. The top right in a gold trophy on a black base. The bottom left is a snow man. The bottom right is an angel Christmas ornament.

Post project

- 3D printing club continued as a lunch time activity through 2018 and 2019, given more students the opportunity to gain 3D printing opportunities.
- Mini project like, trophies for footy tip comp and Christmas decorations, tactile labels (hand out some designs).
- Aim to move 3D printing into classroom activity.

## Video

## References

Kaneko T. et al. (2010). Comprehending and Making Drawings of 3D Objects by Visually Impaired People: Research on Drawings of Geometric Shapes by Various Methods of Projection. In: Miesenberger K., Klaus J., Zagler W., Karshmer A. (eds) *Computers Helping People with Special Needs.* ICCHP 2010. Lecture Notes in Computer Science, vol 6180. Springer: Berlin.

Supalo, C. A., Isaacson, M. D. & Lombardi, M. V. (2014). Making Hands-On Science Learning Accessible for Students Who Are Blind or Have Low Vision. *Journal of Chemistry Education.* 91. 2. pp.195-199.

Buehler, E., Kane, S. K. & Hurst, A. (2014). ABC and 3D: opportunities and obstacles to 3D printing in special education environments. In: *ASSETS '14: Proceedings of the 16th international ACM SIGACCESS conference on Computers & accessibility*. pp. 107-114.

## Questions

Image: 2 SASVI students show off some 3D models at the 3D Printing in Primary Schools Showcase. Behind them is a table with 2 printers and more 3D models. Behind the table is a large crowd of people.