The National Museum of Computing
Starting Out 3D Printing – A Teacher's guide

Dear Teacher,

Like you, I am time-poor and do not have the time to go clicking through endless pages of resources to get started with 3D printing. There is a wealth of knowledge out there, but lots want you to log in and then you get reams of information you don't have time to plough through! So, I have written a few short pages to share with you what I learnt carrying out a 3D print project. You can sign up for so much but what I really wanted to know was:

- What is a 3D printer?
- What do I do with it?
- How / what will it help my students to learn?

With a piece of kit like this the possibilities seem endless and bewildering. In these short notes I will share my experience with you as briefly as possible.

What is a 3D printer?

A 3D printer takes a computer designed item and moulds into material using heat extrusion. They can work with a range of materials - some can print with metals and even chocolate, but most affordable ones used in schools will probably be plastic printers. There are also lots of different types of plastic. I have largely been working with PLA which is robust and flexible. It is one of the most popular materials used in desktop 3D printing as it can be printed at low temperature and does not need a heated bed.

What do I do with it?

The obvious answer is print with it - but what and how? There are quite a few ready-made items online that you can take and use, some of which can be adapted. You can also create things yourself.

Thingiverse and Tinkercad!

These really useful online tools have: -

- A gallery of 3D modelled projects that you can use
- Educator and student profiles, allowing you to manage your students designs – unfortunately you cannot write and manage content at the time of writing
- Prewritten lessons for you to follow and use with your students

There are 3 phases to any 3D print project:

- **Design** – you will need a Computer Aided Design (CAD) program to do this. There are many out there and a whole suite of options for Autodesk. I used Thingiverse as it was free, open source and web based so I didn't need to download anything.
- **Slice**– this is a program which turns your CAD design into a printable form. Again, there are lots of options for slicers. They are either free or attached to the hardware you acquire.
- **Print**- once you have 3D printable files you load them onto an external device. This is usually an SD card which is supplied with the printer. If your computer does not have an SD reader, you can get a USB plug in device to enable it to do this. Some printers can be connected directly to the computer.

How and what will it help my students to learn?

The possibilities are endless and are really limited by time and resources. As part of this project the museum has made replicas of a bust in the museum collection, replica of a thermionic valve which can be taken apart and gears showing how prime numbers are used to create unrepeating patterns.

Computer Science – there are many concepts that can be explored with the use of 3D printers.

Maths –

- Cartesian co-ordinates X Y Z thinking in 3 dimensions,
- Proportionality – resizing the designs changing the ratios gives the students a chance to use this mathematical concept in the real world,
- Shapes – working with 2D and 3D shapes to make designs,
- Measuring distance and volume

Art – The Smithsonian Museum has a Tinkercad profile with lots of interesting objects. There are lots of modern sculptures that have been turned into stl files.

https://blog.tinkercad.com/smithsonian-artifacts-added-to-tinkercad

Design technology – the use of 3D printers in creating prosthetic limbs and making custom made assistive technology is well documented. There are designs on Thingiverse or you can create your own.

History – You can use a 3D printer to make historical replicas. (see additional sheet)

Common problems

During the project we ran into a few common problems and figured out how to resolve them.

- The 3D print file doesn't print correctly. This can be down to a design flaw. Before you create the .stl file to send to the slicer, view the model from all angles and make sure the bottom of the model is on the baseplate, and that all the parts of the model are connected to make a solid.
- Your model prints but has 'spaghetti' hanging down. You may need supports to prop up overhanging parts of the model. This can be done in the slicer.
- The printer won't read the file. Make sure your slicer is set to produce a file format that your printer recognises.
- The quality of the print is not good. Performing a printer calibration can often improve the quality.

> *Top Tip: Get a helpful volunteer*
>
> This could be an eager student, parent, or any other helpful person. I found it very useful having a volunteer to help me set up the machine and run the print of the items so I could focus on teaching. If you are lucky you may have a tech savvy parent or student who would love the chance to have a play

First Steps

Step 1. Getting a printer

- **Beg**! https://ultimaker.com/en/resources/23406-grants-and-funding-resources
- **Borrow**!
    - https://www.createeducation.com/loan-scheme/
    - Take your files to a Fablab to be made https://www.fablabs.io/labs/map
    - Some local council libraries have 3D printers that you can use so it's worth contacting your local library – but note that many are closed at the time of writing.
- **Buy**! The National Museum of Computing (TNMOC) bought a printer from Prusa as a kit. The one we bought came recommended and buying a kit worked for us as we have lots of capable volunteers who love the challenge of putting it together. However, there are many on the market both in kit form and ready built. It is worth figuring out what you want and then getting our volunteer to find a good match with a machine.

Step 2. Set Up your Printer

You will need a space with a flat surface and a fair amount of space around it as the printer has moving parts.

> *Top Tip: Some 3D printers can get hot*
>
> TNMOC added Perspex screens to keep the hot heated plate where the 3D designs are printed, away from inquisitive little fingers

Your printer will come with set up instructions from the manufacturer - if you are short of time you may want to get a volunteer to help with this.

It is very important that you calibrate your printer before you use it for the first time so it produces accurate 3D models. It may also be necessary to calibrate periodically to ensure accurate printing continues. See your printer instructions on how to do this and how often.

Spending time on making sure your printer is set-up correctly can pay off later with good accurate rendering of 3D designs. Try some of the ready-made designs on the internet to test out your 3D printer as you know what they should look like!

Step 3. Create a Computer Aided Design

There are many programs which allow you to create 3D designs. This project used Tinkercad. The program is free open source and online (so you don't have to download anything). Teachers can sign up for an educator profile which allows you to view all your students designs in one place. They have online familiarisation lessons that teachers can look at before teaching students and some pre-written lessons for you to use.

See https://www.tinkercad.com/join

There is also a gallery of existing designs to inspire and enthuse your students. In some cases, these designs can be adapted (tinkered) and made your own.
You will need to create a stl file which will either be exported or saved to be used in a new application.

Step 4. Make your design 3D print-ready

This uses a slicer program. A slicer program takes stl files and turns them into files that can be read by your 3D printer. There are two free programs that you can use:

> https://ultimaker.com/software/ultimaker-cura
> https://slic3r.org/

These will need to be downloaded onto a computer to be used. Once you have downloaded your slicer program, make sure it is set to your printer so that the right code is generated.

These programs have lots of features which you won't necessarily need. You may need the function that creates supports for overhangs. You may have creative students that want to create designs that won't work from being layered from bottom to top. You can often find videos on you tube to show you how to do this for your slicer program

Step 5. Put your printer files onto the machine

Some 3D printers can be connected via a network, via USB or you can use an external memory device such as an SD card or USB stick. Just follow the instructions with your printer to find out how to do this, select the file and set it printing.

But remember, 3D printing on home or educational based printers is not quick. The more complex or bigger they are, the longer it will take. It is fascinating watching your creation take shape one layer at a time but you do have to be patient. Start small and get to know your 3D printer before embarking on something more ambitious.

But above all, have fun and be creative.

The National Museum of Computing.
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