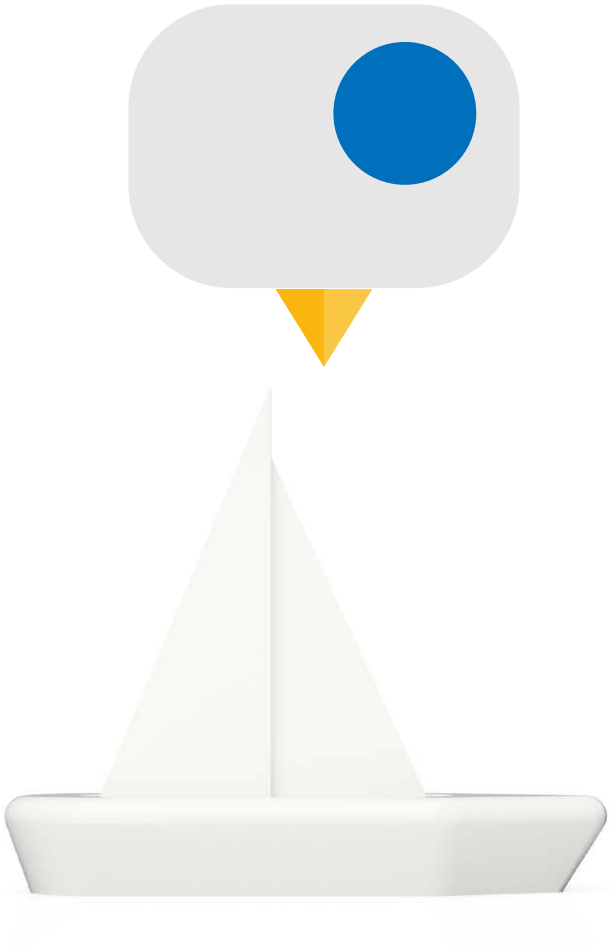


PrintLab Education Bundle Handbook

Welcome to PrintLab Education

It's an exciting time for teachers looking to integrate 3D printing in the classroom and it is our mission at PrintLab to make the process as easy, enjoyable and valuable as possible.

Our approach has been to build a 3D printing ecosystem specifically for schools, consisting of the world's best and most reliable solutions supported by learning and training materials. Together with this manual and our lifetime support, we aim to provide you with a full infrastructure to getting started with 3D printing.

The activities you will undertake throughout your PrintLab journey relate to real-world applications with the aim to prepare students for the challenges they will face in their future careers.

From urban planning projects to furniture and product design, you can be rest assured that students will be hands-on, engaged and solving problems using 3D technologies.

In addition to preparing students for the challenges of tomorrow, our ecosystem is designed to aid the professional development of teachers through a series of 3D printing activities and training courses. Acquiring these new skills will enable you to develop your own classroom materials and pass your knowledge on to your students.

This teacher's handbook is set out as a journey and it should be used as a guideline to get you started with 3D printing.

Each school's journey will be different in many ways so teachers shouldn't feel obliged to sticking to the steps of the handbook. Feel free to skip steps, include your own and please don't hesitate to ask for help or advice.

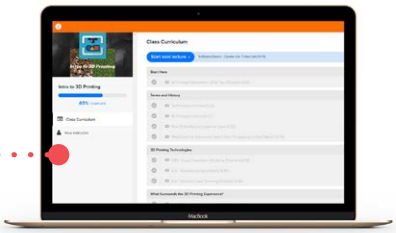
We and our partners around the world are dedicated to supporting you in any way we can.

hello@weareprintlab.com

Let’s do great things,

together.

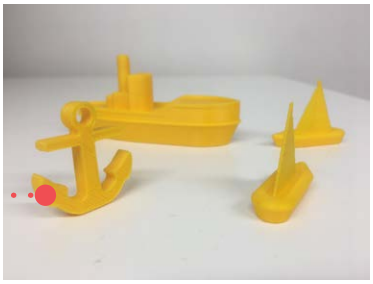
Handbook Contents



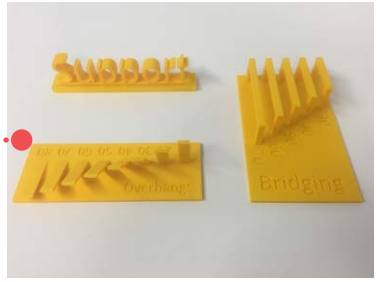
Intro to 3D Printing Online Course

The EinStart-C 3D Printer

Functional ergonomic pen

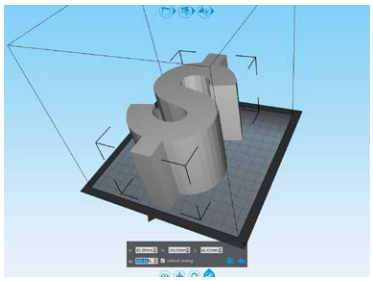


Infill/Resolution Print Kit



Design Consideration Models that you will design and print

Sculpt, Scan and Print a Classroom Object

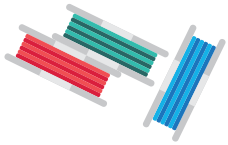


Cost Calculation Exercise

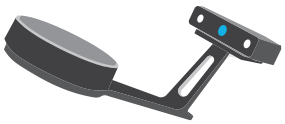
The Kideville Kit

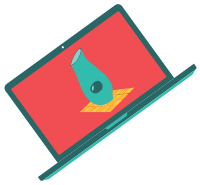
Water Decanter design in Fusion 360 Training Course

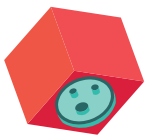



Enjoy the journey!






1.

Introduction

In the first chapter of this handbook you will be given an overview of the products included in the bundle before embarking on your journey. You'll start by going through an online training course that will give an in-depth overview of the 3D printing industry, including how 3D printing works as well as important information about safety and running costs. The introduction is finished off with some case studies in both industry and education.

001

Introduction

PrintLab Bundle Products

2 x EinStart-C 3D Printers

Designed with schools in mind, the EinStart-C is a plug and play 3D printer with auto bed levelling, full enclosure, wi-fi connectivity and 100 micron print resolution.

1 x EinScan-SE 3D Scanner

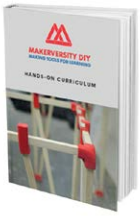
3D scanning is a great starting point for schools wanting to create their own 3D printable files. The EinScan-SE allows you to scan a physical object in just two minutes.

1 x Kideville Curriculum Kit

Kideville is a sustainable city design project, where each student is assigned a creative mission that takes them through a full design and project management process.

10 x Innofil PLA

Innofil's PLA is a biodegradable polymer with no odour and a low melting point. It is an easy material to print with and Innofil PLA guarantees a smooth printing result every time.



10 x Makerversity DIY Lesson Plans

Makerversity's exciting lesson plans enable educators to incorporate 3D printing and hands-on activities into core curriculum subjects.

002

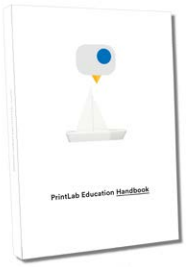
Introduction

1 x HoneyPoint3D Intro to 3D Printing Online Course

The key sections of this intro course for teachers include how 3D printing works, health and safety and the typical running costs of machines.

1 x HoneyPoint3D Meshmixer Online Course

Another exciting free software is Meshmixer. In this course teachers will learn how to edit and repair 3D scans as well as sculpt with digital clay.



5 x PrintLab Lesson Plans

From making a 3D contour model of Mount Everest to 3D printing your school name in braille, PrintLab lessons are designed to show the full process from design/scan to print.

1 x HoneyPoint3D Fusion 360 Online Course

As part of teachers personal development they will embark on an advanced CAD course in the innovative and free software, Fusion 360.

1 x Bundle Handbook

The bundle handbook will guide teachers through their journey. It includes everything from setting up 3D printers to calculating costs and how to use each product included in the bundle.


SHINING 3D
An Introduction to 3D Printing
Teacher's Guide
PrintLab
Make a 3D Contour Model
Student Workbook
PrintLab
BUILD YOUR OWN
WORKSHOP STOOL
INSTRUCTION SHEET
MAKERVERSITY DIY
MAKING TOOLS FOR LEARNING
Support

The PrintLab Education Bundle

005

Introduction

Introduction to 3D Printing

3D printing is a manufacturing process where successive layers of material are laid down on top of each other in an additive process. Although 3D printing is often spoken of as a new technology, it has actually been around for over 30 years. Around 8 years ago, patents around 3D printing began to expire and 3D printing opened up to mass audiences. The landmark point for its commercial adoption came from the open source RepRap project - a 3D printing initiative with the goal of creating low cost, self replicating 3D printers. Being open source, all the files were freely available online and in the following years we saw a large number of startups creating their own 3D printers, inspired by the RepRap project. Let's take a look at the steps required in the typical 3D printing process:

1. 3D model file

It all begins with a digital 3D model of a design. There are hundreds of software programs that enable you to design in 3D. Some free ones that are great for educators are SketchUp, TinkerCad and Fusion 360.

2. Slicing

The 3D model file is then split up into very fine layers in a software program called a "slicer". The output from the slicer is a code, which tells the 3D printer how to move and where to lay down material.

3. 3D Printing

Once the code is loaded to the 3D printer, it will begin the production process. One layer is created at a time until the model is complete. This can take minutes or hours depending on the size of the model.

4. Post-processing

Depending on the type of 3D printer and the model file you print, there may be a requirement for some post-processing. Examples include removing support material, cleaning and sanding.

006

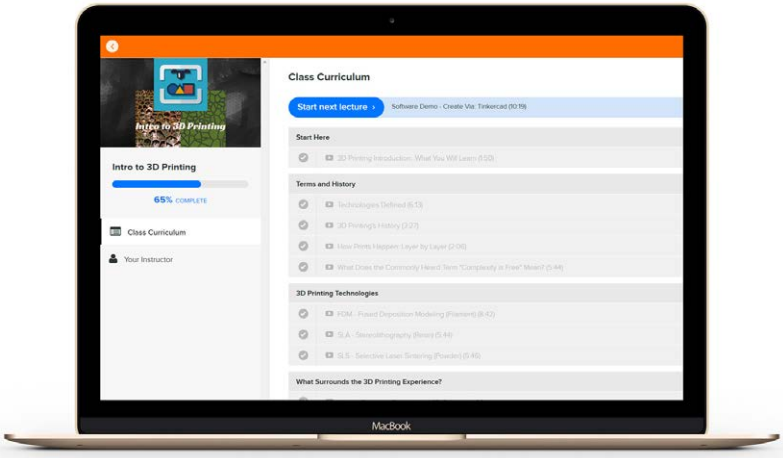
Introduction

Teacher Training Course

To delve deeper into the basics of 3D printing, we now recommend that you participate in a 2 hour training course by HoneyPoint3D. The purpose of the course is to enable you to be confident in speaking about 3D printing to your students. The background knowledge gained will also prove useful in determining running/material costs, health and safety considerations as well as learning opportunities. Course topics include:

- 3D printing introduction
- Technologies defined
- 3D printing's history
- How prints happen: layer by layer
- Complexity is free
- FDM technology
- SLA technology
- SLS technology
- Health concerns
- 3D printing costs
- 3D modelling
- Operating systems
- Types of 3D modelling tools
- Software demo - Tinkercad
- Software demo - Photogrammetry
- Software demo - Meshmixer
- Software demo - Fusion 360
- Slicing software
- Conclusion

To access the course, load the PrintLab Education USB stick into your computer and navigate to Training Courses > Intro to 3D Printing. Then click the activation link in the document or copy and paste it into your browser. This will take you to the online course enrolment.



007

Introduction

Uses in Industry

Now that you have some background knowledge of 3D printing, let's take a look at how 3D printing is used in various industries.

Architecture

Typically, architects can spend days creating physical models to explain their designs to clients. Using modern technology, they can use their existing CAD drawings to rapidly create a 3D model and print it in 3D. Not only do they save time but complex geometries that can't be modelled by hand can be produced efficiently and at a low cost.

Prosthetics

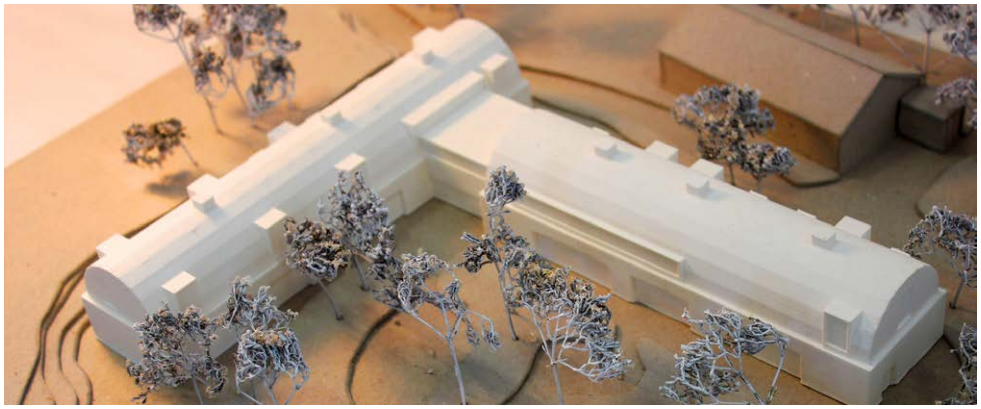
The amazing e-NABLE project use desktop 3D printers to create custom prosthetics for children at a production cost as low as $50. Being such a low cost option benefits children in particular because they grow out of their prosthetics quickly. Additionally, 3D printing allows children to choose custom options for their prosthetics such as superhero designs!

Medical

One of the key benefits of 3D printing is the ability to customise objects at no extra cost. The medical sector is taking advantage of this in various ways and one prominent field is that of hearing aids. The process begins by taking a 3D scan of the patient's ear, which ensures an accurate 3D print can be made that has a perfect fit for that specific patient.

Dental

Combined with 3D scanning technologies, dentists can now 3D print moulds, visual aids, bridges, crowns, guards and more. 3D printing eliminates the need for manual tasks, which saves weeks of time and similarly to hearing aids, each product is accurately tailored to the patient. There are many 3D printers designed specifically for dentists.



Product Design

3D printing enables product and industrial designers to create prototypes within hours as opposed to weeks through traditional methods. The cost to create a prototype can be in excess of $10,000 when you consider the tooling required for processes like injection moulding. With 3D printing, prototypes can be achieved at a fraction of the cost.

Aerospace

3D printing for aerospace purposes allows complex geometries to be created with no waste material and no tooling required. This results in innovative functional parts and millions of dollars are saved. GE aviation have even started testing the largest jet engine ever built. The engine is said to be more efficient, advanced and powerful due to its 3D printed components.

Hobbyists

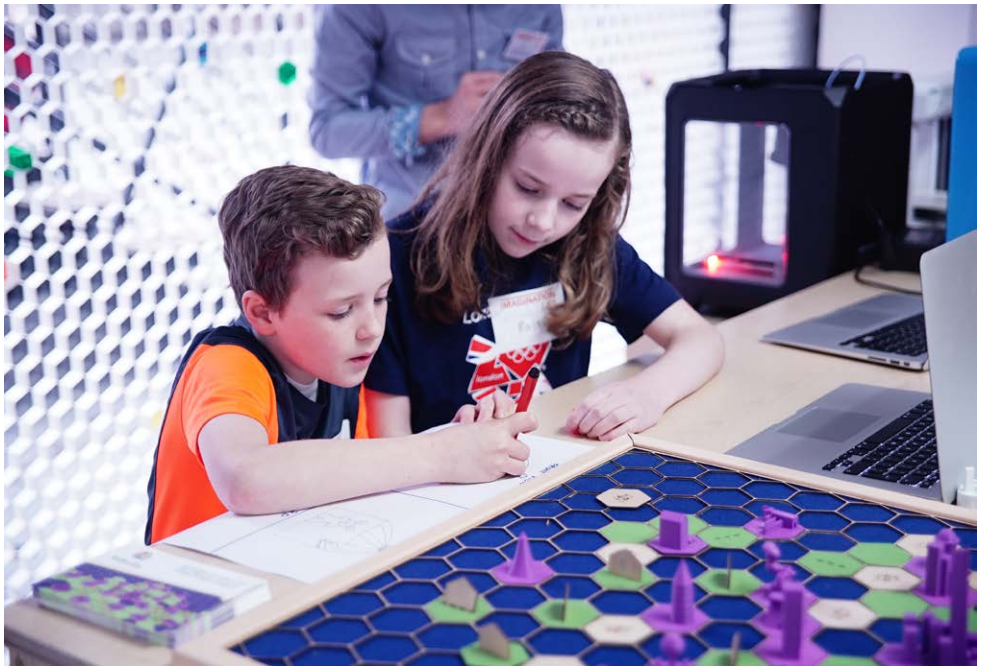
Desktop 3D printers can now be acquired for under USD$1000, which has gained the interest of many hobbyists. From 3D printing toy characters to functional items for the home, we're seeing anyone and everyone becoming part of the "maker movement". Many industry experts have predicted that in the next ten years, most households will have a 3D printer.

3D Printing in the Classroom

The 3D printing industry is set to grow from $7.3 billion in 2016 to $21 billion in 2020, and 3D printing expenditure in education is set to grow from $200 million in 2015 to $500 million by 2019. But what is the relevance of the macro scale for you, as a teacher? These facts are important because they will have a direct effect on the very students you teach. As you saw on the previous page, 3D printing is making huge waves in so many different sectors. The innovative technology is going to disrupt the design process and the supply chain that we see today.

Because of this, it is essential that we prepare students for the challenges of tomorrow. Over the next 5-10 years, we'll begin to see further advances, particularly with materials, software and printing speed. These advances will bring on what has been described as the next "industrial revolution" and the people heading up this revolution will be those who are currently in education.

In addition to preparing students for their future careers, 3D printing revolutionises the way students engage in the classroom.



The fact that 3D printing technology still needs developing actually plays to our advantage - why? Because it empowers students to solve problems and truly learn the ins and outs of how this exciting technology works. One of the biggest questions we get asked is “what can I do with a 3D printer?” - and we usually answer this question with, “what can’t you do with a 3D printer!”.

Many people seem to think that a 3D printer belongs in a D&T classroom, but what they fail to recognise is that 3D printing is seeing massive success in all areas of education. Take exploration of fossils in a History lesson for example, what better way to teach this than to 3D print examples that students can examine, hold and understand. Physics is another example, where students could print their own model boats, some hollow and some solid, to experiment with what floats, what doesn’t and why.

There is an enormous scope of opportunity with 3D printing and we are excited to assist you in your journey.

011

Introduction

3D Printing by Subject

Maths

Models of equations and volumes can be 3D printed to assist students in understanding maths for real life applications. Imagine printing a Fibonacci spiral that students can observe and hold!

History

Help students understand what it was like to live in various eras by 3D printing replica artefacts and statues. There are hundreds freely available from websites such as Thingiverse and YouMagine.

Geography

Understanding topography can be difficult by reading 2D maps, so why not recreate them in 3D. In the PrintLab bundle you will find a lesson plan where students create a 3D contour model of Mount Everest.

Science

Explore density, mass, projectiles and much more by allowing students to design objects like balloon powered boats, rockets and rubber band powered cars. It's a sure way to get them thoroughly engaged in design and problem solving.

Design Technology

Combine traditional woodworking with 3D printing, offering a fresh and modern way of designing. Included in the PrintLab Bundle is a lesson where students make a workshop stool with 3D printed connectors.

Engineering

Prototyping is a huge part of any engineering process. With 3D printing students can bring their ideas to life and create several iterations of their designs to achieve the best functional results.

Art

3D printing enables us to create complicated artistic forms that can't be produced by using traditional methods. This opens up new innovative opportunities for students to explore.

Food Technology

Food moulds and cookie cutters are a great way to engage students, whilst teaching them new design skills. We are also beginning to see a range of food specific printers such as chocolate 3D printers!

Education Case Studies

St Andrew's College - New Zealand

Vicki Pettit is a maths teacher and head of education at St Andrew's College in Christchurch, NZ. She wanted to reinforce her maths lesson by incorporating hands-on making and saw Makerversity DIY's 3D printing sandtimer lesson as a perfect fit.

The lesson uses bespoke 3D printed components alongside everyday household items (plastic bottles) to enable children to produce their very own timer.

In this case, teacher and students opted to use salt rather than sand which shows some flexibility in the lesson. It could be used as an opportunity to explore a discussion on materials, density, mass and alternative suitable materials that could be used to measure time.

The lesson is also a great opportunity for pupils to hone fine motor skills through a simple hands-on activity, whilst teaching accuracy, numeracy and measurement skills.

> Students have loved making. It has been a great learning curve. The students are deservedly proud of their work.
>
> Vicki Pettit, Head of Education

ADEC Schools - UAE

The ADEC school workshops comprised of six different Abu Dhabi schools participating in the Kideville Curriculum. It is a collaborative city design project for children, with a full curriculum for teachers.

Each student gets a design brief for a building, and they are guided through a term-long process of research, ideation, sketching, urban planning, 3D design and printing.

The curriculum includes teamwork, project management and practical skills that equip children for jobs of the future. Design and engineering teachers delivered the 14 lesson activity to a total of 150 students that made 6 unique Kideville Islands.

None of them had ever used 3D software or 3D printers before but the teacher's handbook allowed them to confidently facilitate the students.

> The Kideville experience has been one of a kind for me as an instructor and for the kids as their first hands on experience with 3D printers.
>
> Yousteena William, Teacher

Txantxiku Ikastola School - Spain

In this example, 12 year old Kepa, a student from Txantxiku Ikastola School in Basque Country, 3D printed a window handle for his teacher Jokin. Jokin explained how it all began with a simple problem at the school when he first started teaching there:

“One of the first things that caught my attention in my school was that all the handles from the windows were missing. I asked about them to some of my colleagues and they told me that some time ago, there were problems related to objects thrown from the windows by the students.

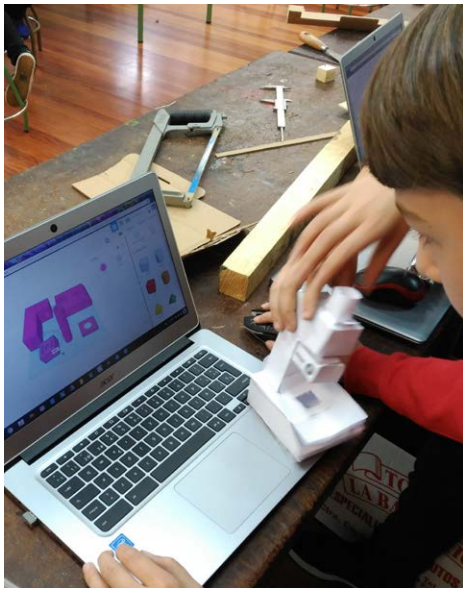
So they decided to take the handles off each window. Each teacher has their own handle (except me because I was new), so when it is hot inside they can use it to open the windows”.

Jokin challenged Kepa to design and 3D print him a new handle. Using a caliper, Kepa started measuring an original handle and in a few days, the design was completed.

Jokin 3D printed the handle and to everyone’s joy, it worked first time!

Kepa and his fellow students have also been busy 3D printing their own microscopes. This project was based on Makerversity DIY's 'Make your own Microscope' lesson plan, which uses folded paper and parts of a webcam to create a microscope. Jokin and his students wanted to take the lesson to the next level by 3D printing their own version of the microscope! Working as a team each one assumed their role and their part of the design. Every day they met at the makerspace and their project was a great success.

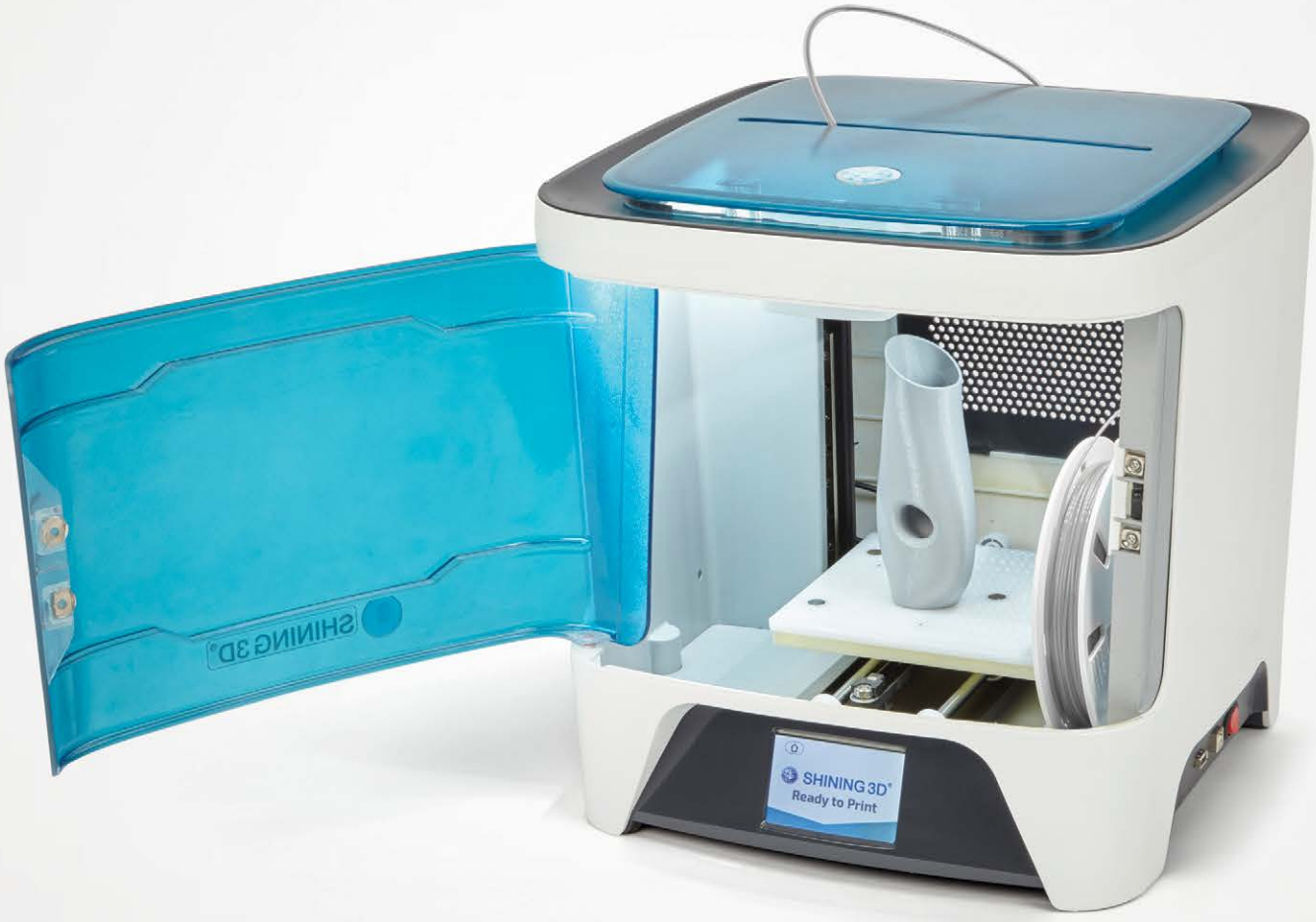
> Kepa was amazed and very proud of his job at the same time. And I was also very proud of him
>
> Jokin Lacalle Usabiaga, Teacher



2.

Getting to know your 3D Printers

Now that you have some initial background knowledge, it's time to get hands-on with the EinStart-C 3D printer. This chapter takes you through the unboxing and setup process. You will learn about the various features of the EinStart-C before creating your first two prints - an ergonomic pen and an external reel holder that allows you to use large reel filament. An observation exercise is included so you can analyse the 3D models you create. If you come across any technical difficulties during this chapter, please refer to the troubleshooting section of the EinStart-C User Manual. This is located on the PrintLab Education USB stick.


SHINING 3D
SHINING 3D
Ready to Print

The EinStart-C 3D Printer

The EinStart-C 3D printer is your perfect companion in the classroom. Its modern design and school-friendly features will ensure you have the best 3D printing experience. It uses FFF (Fused Filament Fabrication) technology and has a build volume of 153×153×153mm. The EinStart-C comes with two reels of PLA filament, an eco-friendly, biodegradable material that does not give off any fumes whilst printing.

Let's take a quick look at some of the great features it has:

Plug and Play

The EinStart-C comes fully assembled and ready to print. From opening the box to starting your first print will take you less than 10 minutes!

Automatic Levelling

One of the most frustrating yet essential things to do with a 3D printer is to keep the bed level. Luckily, the EinStart-C has a built-in feature that automatically levels the plate efficiently and accurately before each print.

Full Enclosure

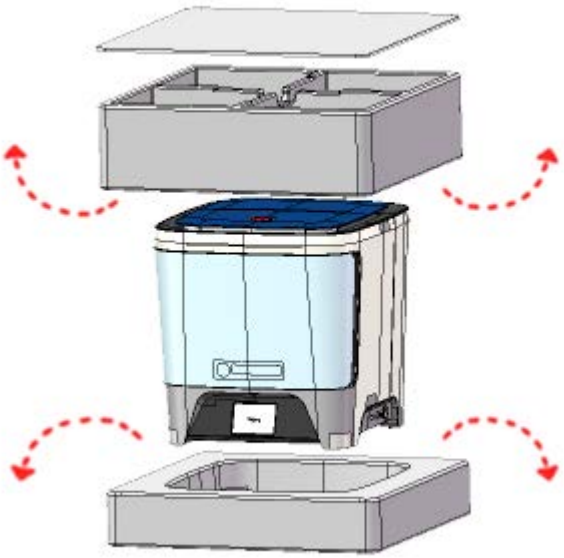
Safety comes first with the EinStart-C and a fully enclosed build chamber prevents the risk of injury. The machine even pauses printing if the door is opened (a feature that can also be switched off).

Unboxing

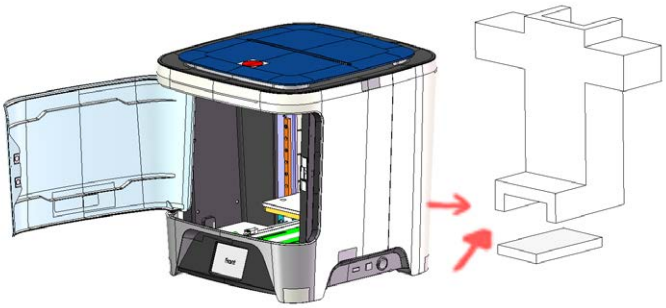
We are now going to go through the unboxing and setup process. The instructions in this manual act as a quick guide to getting started. If you require further instruction, please refer to the EinStart-C user manual provided on the PrintLab Education USB drive.

1. Open the packaging of the EinStart-C 3D printer and remove the foam inserts within the box. Included in the box you should find:

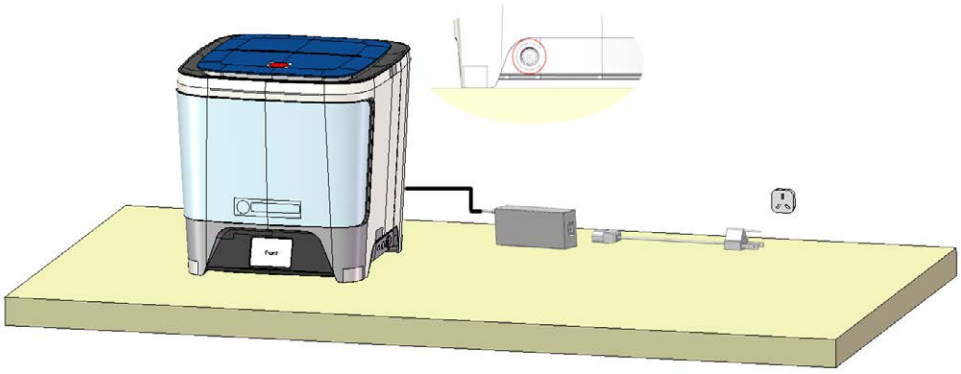
1 x 3D printer
1 x print bed
2 x PLA filament
1 x USB flash drive
1 x bowden tube
1 x power supply
1 x USB cable
1 x scraper
1 x handy tool



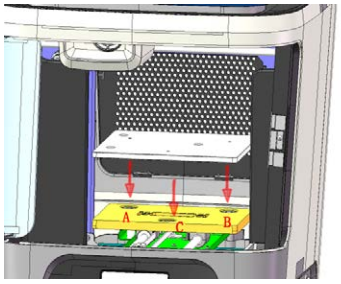
2. Open the door of the 3D printer. There are further foam inserts that you should remove.



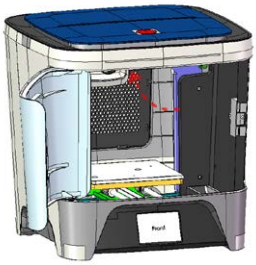
3. Connect the power adapter to the cable plug and insert the plug into the mains socket. Then plug the power adapter into the jack at the back right of the printer (see below diagram).

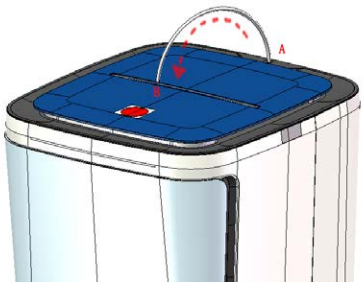


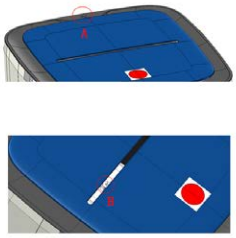
4. Open the printer door and place the print bed onto the platform holder. There are 3 magnets that hold the print bed in place.



5. Locate the bowden tube inside the printer towards the back and push the tube through ‘Hole A’ to the outside of the printer. Push the end of the bowden tube into the blue quick connector at ‘point B’ as shown below. If you ever need to take the bowden tube out of the extruder, use the handy tool and push down on the blue connector whilst pulling the bowden tube out.







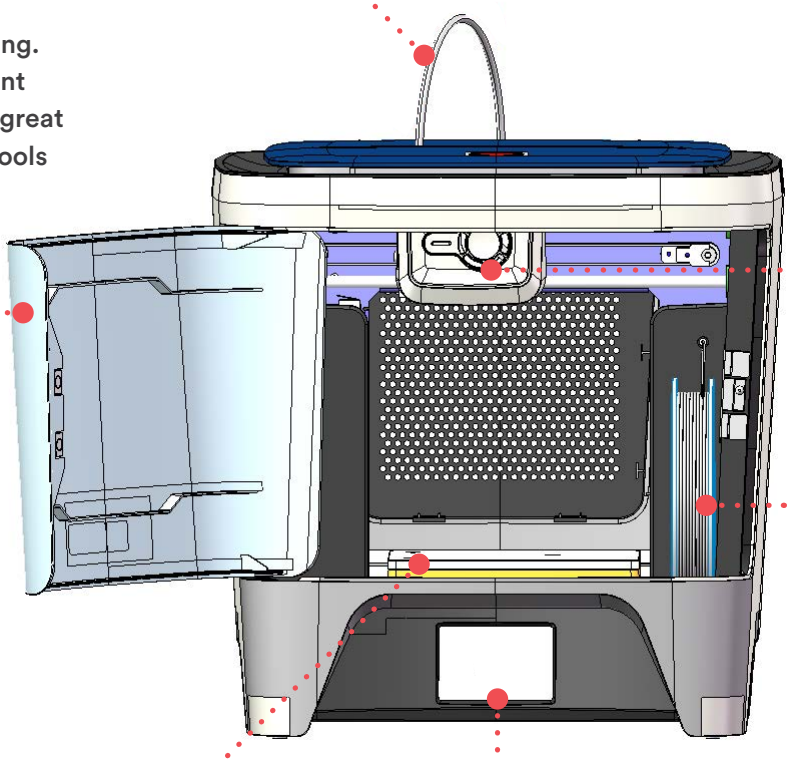
Elements of your 3D Printer

Now you have unboxed your 3D printer, let's take a look at the key elements of the EinStart-C.

Bowden Tube
The bowden tube guides the filament from the holder to the extruder module

Extruder Module
This is the housing unit that holds the extruder drive and the nozzle. PLA filament is heated up and pushed through the nozzle onto the print bed, where it cools

Door
The printer door keeps the machine fully enclosed whilst printing. This optimises the print environment and is a great safety feature for schools



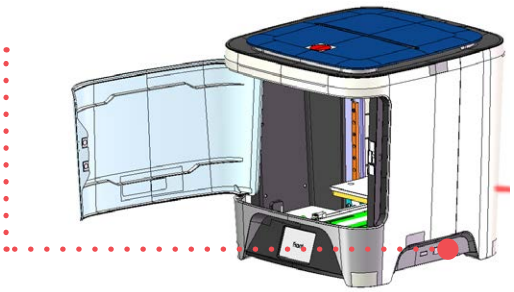
Filament Holder
This is where your filament reels will be placed. It holds 250g reels of PLA. For bigger reels you can use an external reel holder - the EinStart-C even comes with a ready-made file so you can 3D print your own!

Print Bed
The print bed is where models are created. Once the filament is heated and pushed through the nozzle, it will cool and solidify on the print bed

Touch Screen Display
This is where you control the printer in actions such as filament loading, starting/stopping prints as well as changing settings

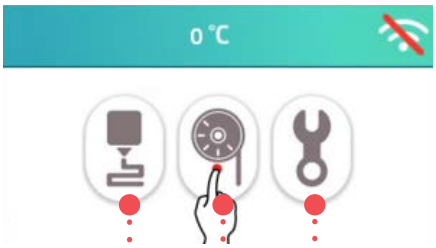
Touch Screen Options

1. Make sure that the printer is plugged in and press the red switch on the right side of the printer to switch it on.



2. You will then see the welcome screen on the touch screen display. Press the home icon to see the main menu.

3. In the main menu you will see 3 icons representing the print menu, materials menu and settings menu.



Print Menu

The print menu is where you will start your 3D prints. There are 3 options - print latest model, print from USB or print from the printer's local drive. The most common of these 3 is the print from USB option, which we'll be using throughout this handbook.

Materials Menu

The materials menu allows you to load and unload filament. For both of these options the nozzle will heat up to perform the necessary operation. The next page goes through how to load filament in detail.

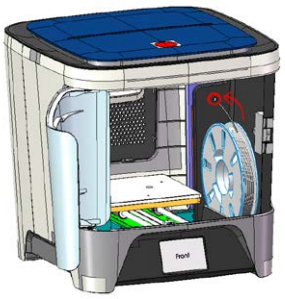
Settings Menu

The settings menu has a range of technical functions available. We'll take a closer look later but functions include connecting to wi-fi, preheating the nozzle and changing the distance between the nozzle and print bed.

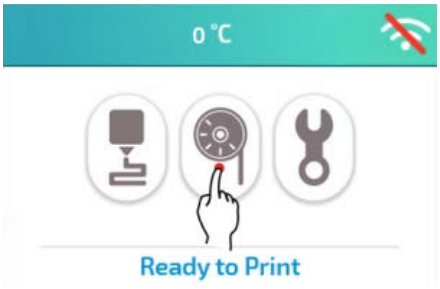
Loading Filament

1. Unpack one of the reels of filament supplied with the printer. Using a set of pliers or scissors, trim the end of the filament at an angle. This should be done each time you insert filament.

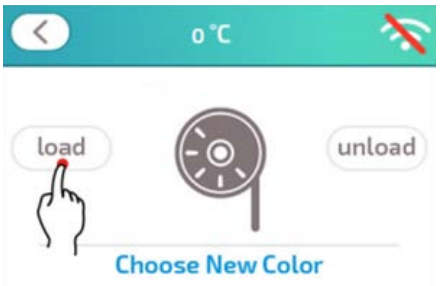
2. Place the reel in the holder and feed the filament through the hole as shown in the diagram. Continue to feed it until it reaches the extruder through the bowden tube.



3. Select the central icon on the home screen to go to the materials menu.



4. You now have 2 options, load and unload. Press load. This will heat up the nozzle so you can insert the filament.

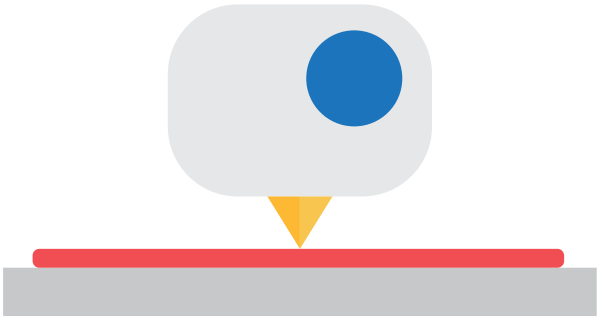


5. The printer will alert you when the target temperature has been reached. At this stage, grab the filament inside the printer and push it further through the bowden tube. This time there is a geared feeder that will grip the filament and guide it through the nozzle. Once you feel the gear 'grabbing' the filament you can let go. Wait until you see filament flowing from the extruder then click the icon at the top left of the screen to go back to the home page.

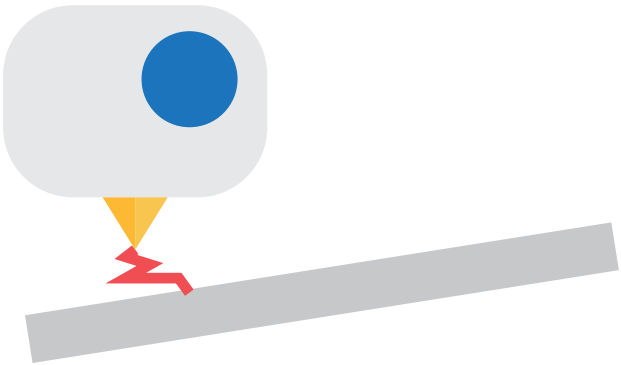
Auto Levelling Function

A very important part of the 3D printing process is having a flat print bed. The EinStart-C has an auto levelling function so you don't have to worry about manually adjusting the print bed. 3 sensors are embedded into the print bed and before each print starts, the printer will adjust itself accordingly. It also adjusts during printing if necessary.

Although you do not have to adjust the print bed, it's good to know why it needs to be flat. Take a look at the below diagrams.



1. In this scenario the print bed is completely level. When printing begins, the nozzle squashes filament onto the print bed. The squashing effect gives the model good adhesion to the bed, which is critical for a successful print.



2. If the print bed is not level, several problems can occur. At points where the print bed is too far away from the nozzle, the printer will essentially be printing in mid-air, leaving messy strands of filament in the build area. If the print bed is too close to the nozzle, the nozzle will scratch across the print bed and no filament will be extruded. This can also prevent the extruder module from moving freely.

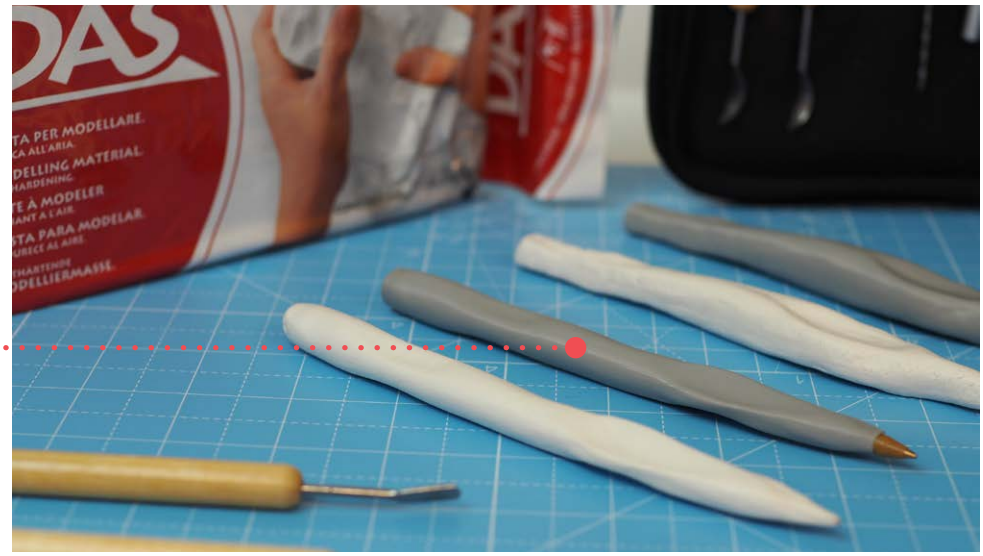
Your First Print

It's now time to start your first 3D print! The first thing required is a 3D model file (the most common format is called an STL file) and there are several ways to obtain this. You can download models from the internet, create your own in CAD or you can use a 3D scanner to turn physical objects into digital models.

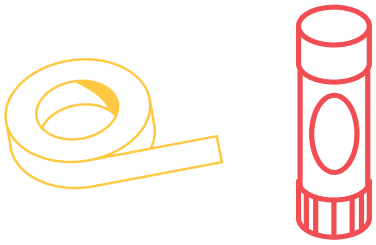
The STL then needs to be 'sliced' in the printer's software. This basically takes the model and slices it into very thin layers. A code is then generated to tell the printer where to lay down the thin layers of material. The code (known as a GSD file for the EinStart-C) is then transferred to the printer via a USB stick to start the printing process.

We'll be guiding you through the various ways to obtain a 3D model file as well as how to use the slicing software, but for now we bet you want to see the printer in action! We have prepared and sliced an STL file for you to try.

The model is an ergonomic pen, created by 3D scanning a clay model before editing it in CAD. The pen has a hole in the middle where you can insert an ink cartridge. It is designed for a Bic Cristal biro cartridge so all you have to do is take the biro that came with the handbook, remove the ink cartridge and slot it into the 3D printed model with a little bit of glue around the top to keep it in place. Included in the bundle is a lesson plan that enables you and your students to design and 3D print your own ergnomic pens to suit your unique grips!

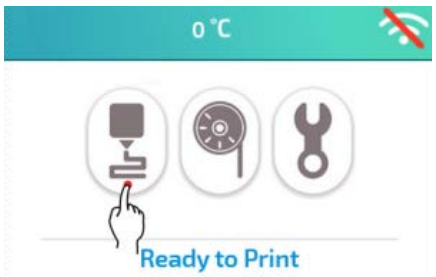


1. Before starting a print, either spread glue on the print bed or layer it with masking tape. This helps with bed adhesion.



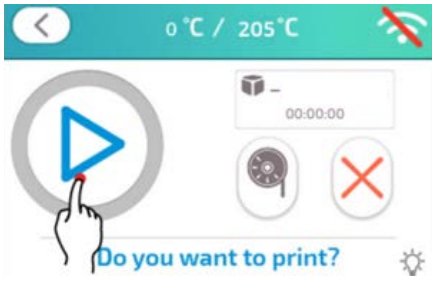
2. Take the PrintLab Education USB stick supplied with the bundle and plug it in to the USB slot on the right side of the printer. Go to the home menu using the touch screen display.

3. Press the print menu icon on the left.

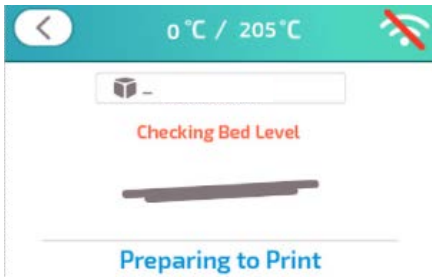


4. Press the USB icon and use the arrows to navigate to a folder called Getting Started Prints. In this folder you should see a file named PrintLab-Pen. Select this file.

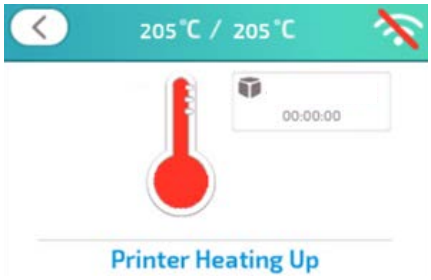
5. The file will then transfer to the printer and you will be prompted to start the print. Press the play icon to begin printing. You can remove the USB stick from the printer at any point after this stage.



6. The printer will now run through the auto levelling function to make sure the bed is flat. Observe the process and see how the print bed adjusts accordingly by using the built in sensors.



7. Once the auto levelling function has completed, the nozzle will begin to heat up. The nozzle heats up to temperatures in excess of 200 degree celcius so make sure to inform your students of this when they are operating machines.

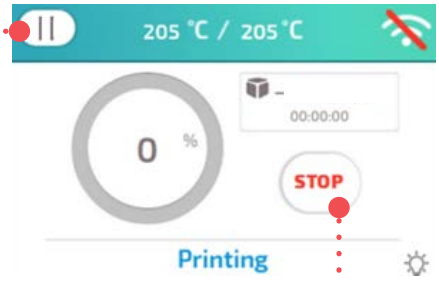


8. Once the nozzle has reached its target temperature, the printing process begins! If required you can:

Pause Print

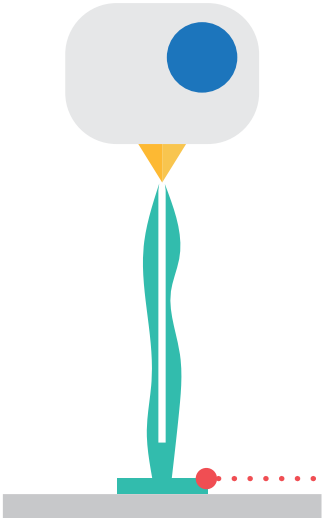
or

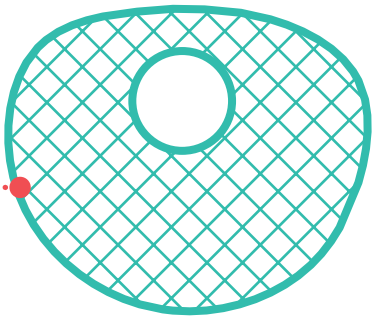
Stop Print



Printing Observations

The 3D print will take approximately 2 hrs 30 mins. You can leave the printer alone during the process but for the first print we suggest you keep the printer door open and spend a few minutes observing the following:



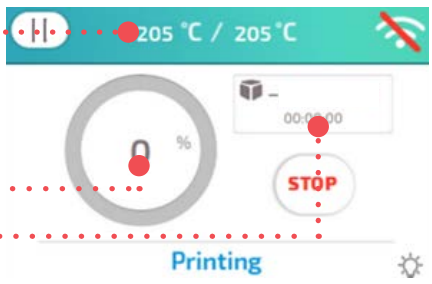


The print begins by printing a raft. Rafts are temporary print surfaces that help the model stick to the build plate. Rafts are automatically generated by the slicing software and are recommended on all prints with the EinStart-C. When the print is completed you will peel off the model from the raft.

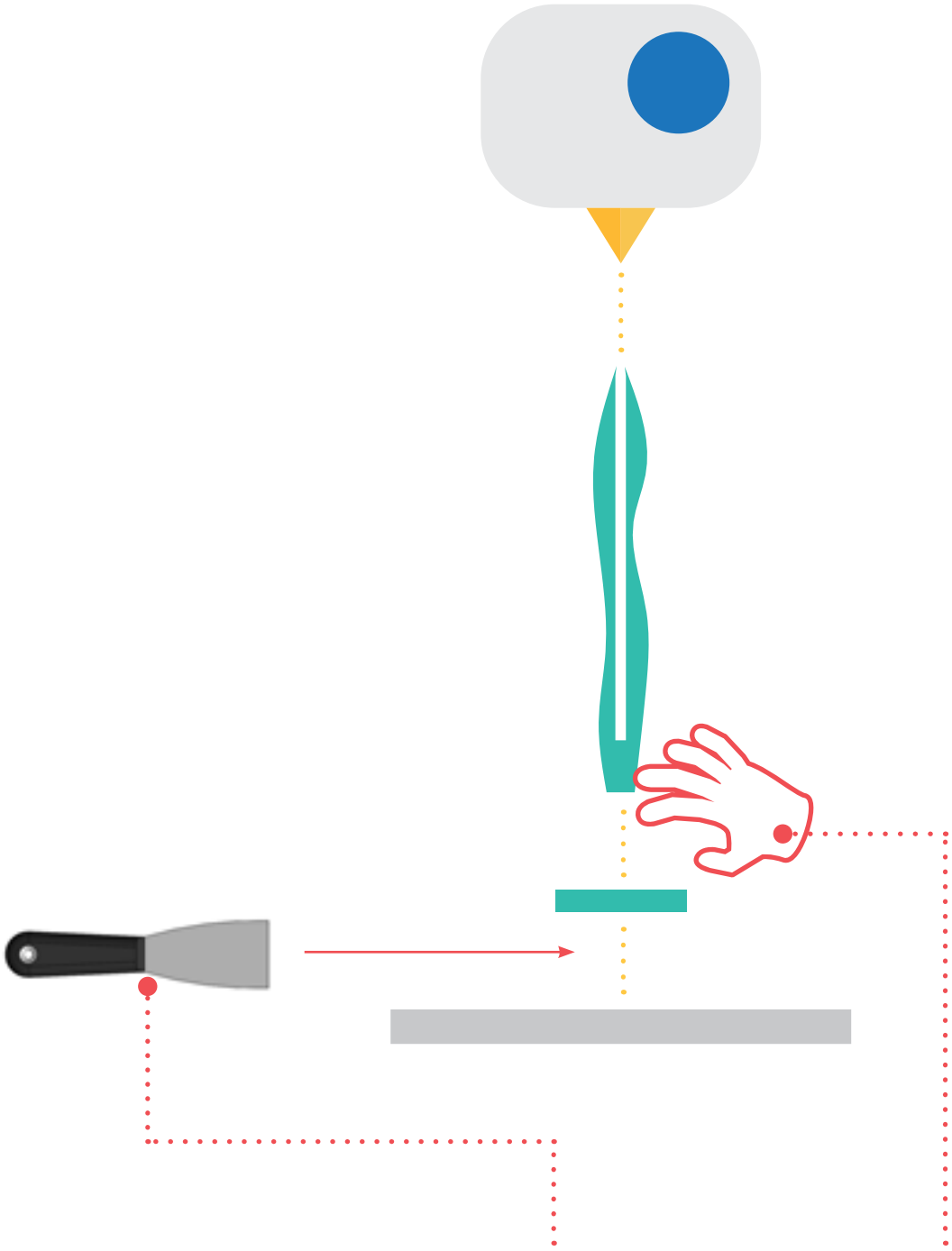
When the raft is complete the printer will move on to the actual model. The bottom layers will be printed solid but after around 5-6 layers you will notice that a pattern is printed like the above diagram. This is called infill. It is a slicer setting that means you can adjust how dense the object is, great for saving time and filament!

The touch screen display will also tell you some useful information:

Nozzle temperature
Percentage completed
Estimated time remaining



Removing the Print



1. Open the printer door and lift the print bed out of the machine.

2. Locate the scraper tool supplied with the printer and push it under the raft to prize the print from the print bed.

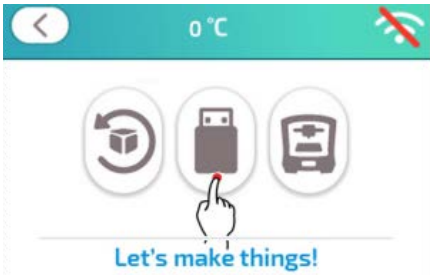
3. Snap the raft off from the model. The raft can be thrown away.

Printing a Reel Holder

In your second print we are going to put the EinStart-C to the test by printing a large model. The EinStart-C comes with 2 reels of 250g filament that fit inside the printer. There is also the option to use larger reels of third-party filament, such as Innofil PLA, which is a premium quality material that we highly recommend.

To do this we are going to 3D print our own reel holder!

The reel holder is preloaded onto the PrintLab Education USB stick. You will find the GSD file in the Getting Started Prints folder. Find the file named Reel-Holder and begin the print. Please note that the print will take 12+ hours.

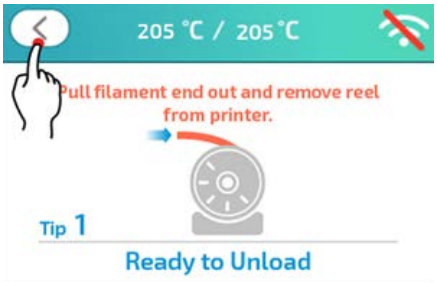


Using the Reel Holder

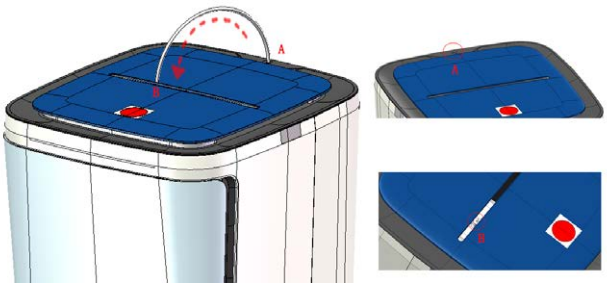
Let's now look at how to change filament to use the reel holder.

1. In the materials menu, press unload.

2. The nozzle will then heat up. Once it has reached its target temperature, the extruder will reverse the filament out from the nozzle. The touch screen display will prompt you to pull the filament out. Grab the filament from inside the printer, pull it out through the bowden tube and take the reel out of the printer.



3. The bowden tube is not required when using the external reel holder. To remove it, use the handy tool supplied with the printer, press it down on the blue connector at 'Point B' in the diagram and pull the bowden tube out.



4. Unpack a reel of Innofil filament and assemble the reel holder. Use the image on the previous page for guidance. To load filament, simply go to the materials menu and press load. Cut the end of the filament and when prompted, insert the filament through the blue connector into the extruder until the gears 'grab' the filament. Once filament is flowing through the nozzle, press the back button on the touch screen to return to the home menu.

Printer Settings

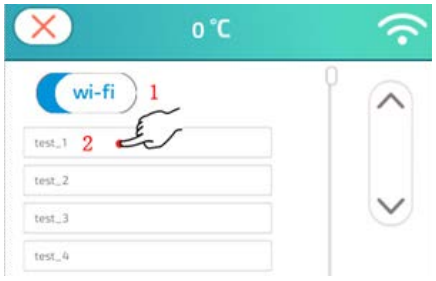
You should now be familiar with operating the EinStart-C 3D printer! The next step is to look at the printer's software so you can learn about the full process from obtaining a model file to slicing and finally 3D printing. Before we delve into the software, let's take a quick look at the settings menu on the touch screen display. There are several features in here so we recommend taking a look at the EinStart-C user manual, but we're just going to cover 2 key settings for now.

Wi-fi

'Firmware' is the printer's built in programming system that has certain control parameters. It is regularly updated by Shining3D as they constantly improve their printer settings. The EinStart-C, when connected to wi-fi, updates firmware automatically when it detects that there has been an upgrade by the company. In future firmware updates you'll also be able to send prints directly from 3DStar to your printer! Let's look at how to connect to wi-fi.

1. Go to the settings menu on the home page and then click on the wi-fi icon.

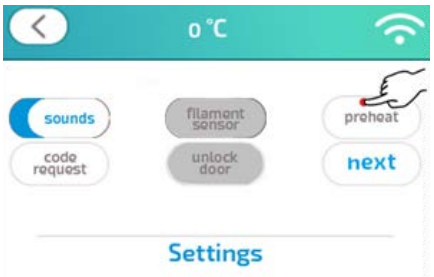
2. Then simply press the wi-fi button to enable it and select your wi-fi network. You'll then need to enter your wi-fi password.



Preheating the Nozzle

When providing maintenance or replacing the nozzle, you will have to preheat the nozzle. You may also want to change the nozzle temperature depending on what material you are using. Let's take a look at how to do this.

1. Go to the settings menu on the home page and then click on the preheat button.

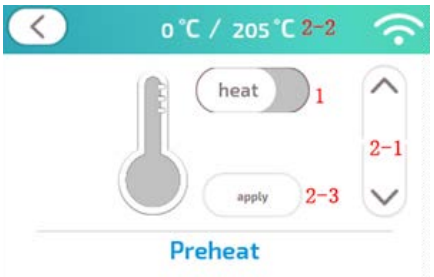


2. Use switch 1 to start or stop heating.

Use switch 2-1 to change the target temperature.

Use switch 2-3 to set the target temperature.

2-2 states the temperature that you have set.



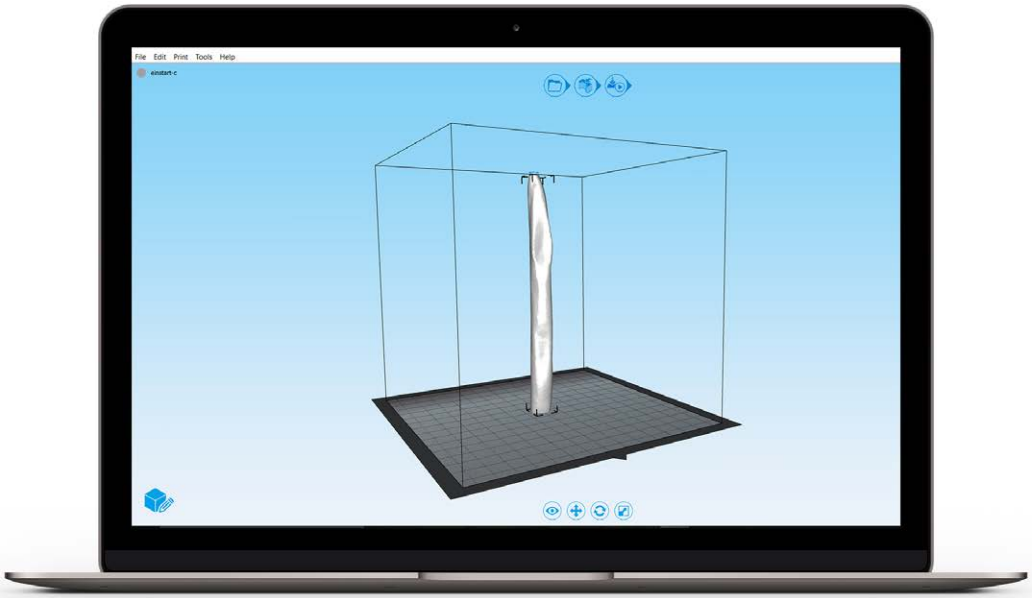
3.

3DStar Software

In the previous chapter you have been printing ready-sliced files. We are now going to look at 3DStar software so that you can slice your own models. Within slicing software you can resize and edit model files and adjust print settings such as the layer height you require. This short chapter gives instructions on how to install 3DStar on your computer before giving a brief overview of the functions within the software.

About 3DStar Software

3DStar is the EinStart-C's slicing software. It supports a range of operating systems including WIN7 32bit/64bit, WIN8, WIN10 and Mac OS. The purpose of 3DStar is to generate a GSD file, which is a code that is transferred to the printer to tell it how to move and where to lay down material. 3DStar is extremely user friendly as you'll find out in this section of the handbook!



3DStar has a range of advanced functions, but you will predominantly use it in the following way:

1. Upload STL file - Once you have downloaded or created a STL model, you will open it up in 3DStar.

2. Choose Settings - You can then resize and position your model as you require and choose various settings including such as the layer height.

3. Slice - Finally you will click 'slice' and the code will be generated. You will save the code onto a USB stick and transfer it to the EinStart-C to begin the printing process.

034 3DStar Installation

3DStar Software

1. To install 3DStar software, plug the PrintLab Education USB into your computer. Then navigate to Software Downloads > 3DStar Installation.
2. Double click the setep.exe file.
3. Click Next in the welcome window and click Agree when the license agreement appears.
4. Choose the installation path you want and then click Install.
5. After agreeing to the license agreement click Install or Repair if the Microsoft Visual window appears.
6. Complete the Microsoft Visual installation or repair by clicking Close.
7. The next window that will appear is the FTDI CDM drivers. Click Extract and continue through the guided process until the installation is complete.
8. You may need to restart your computer once the installation has completed.
9. You should now see a shortcut to 3DStar on your desktop.
10. Double click the 3DStar shortcut on your desktop to enter the software interface.

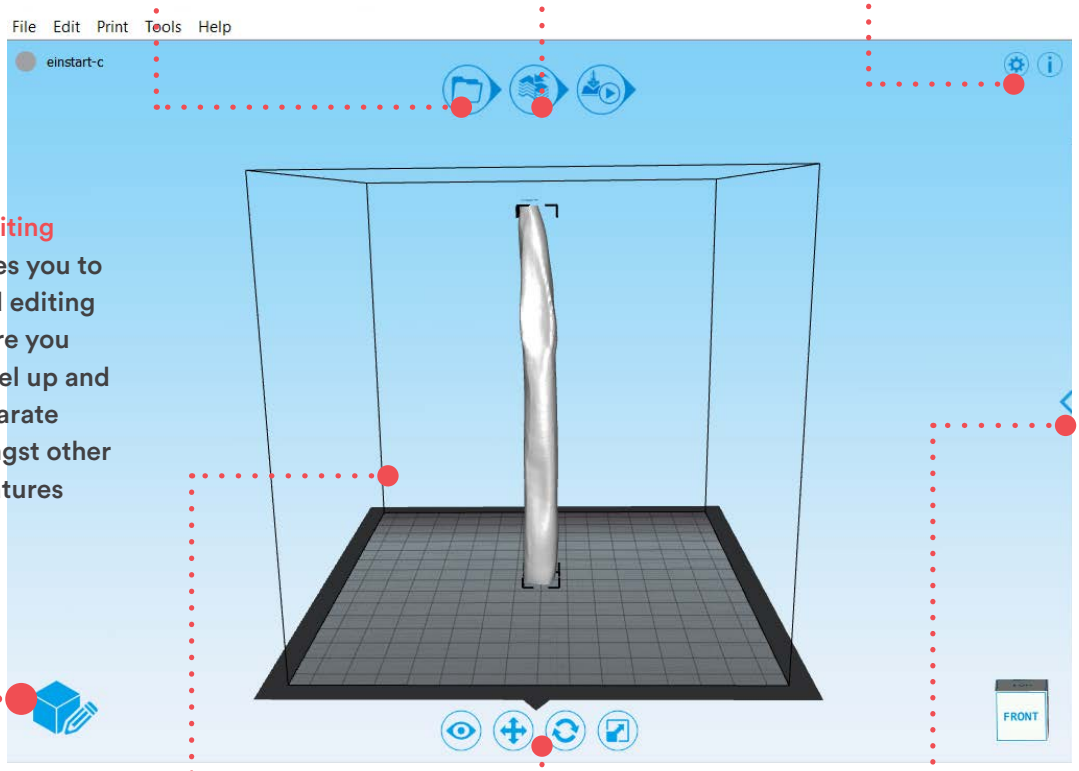
035 The Software Interface

3DStar Software

Open File
This is the 'Open File' icon. To upload a file into the build area, simply click the icon and select the STL file that you want

Generator
Once your model is placed correctly with your desired settings, you will click this icon to slice your model. A GSD file will be created in the same folder as your STL

Settings
This is where you can select the print quality, how much infill you require and several other parameters that we will learn about later



Advanced Editing
This icon takes you to the advanced editing window where you split the model up and intersect separate models amongst other advanced features

Model Preview
The platform and box represent the build area of the EinStart-C. It shows a preview of how your model will be printed when uploaded to the printer

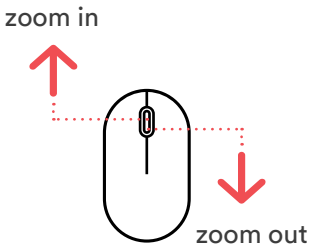
Edit Functions
This row of icons are the editing functions. They allow you to move, rotate and scale the size of your model to your requirements

Path Viewer
Clicking this arrow will bring up the path viewer. You can click this once you have sliced your model and it will give you information about the printing process

Software Navigation

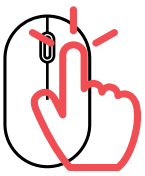
Let's take a look at how you can rotate, zoom and pan around the model preview area. Open the software and try out the following:

1. Scroll your mouse wheel up and down. Scrolling up will zoom in and scrolling down will zoom out.



2. Left click and drag your cursor within the model preview area to orbit around the space.

3. Right click and drag your cursor within the model preview area to pan across the space.

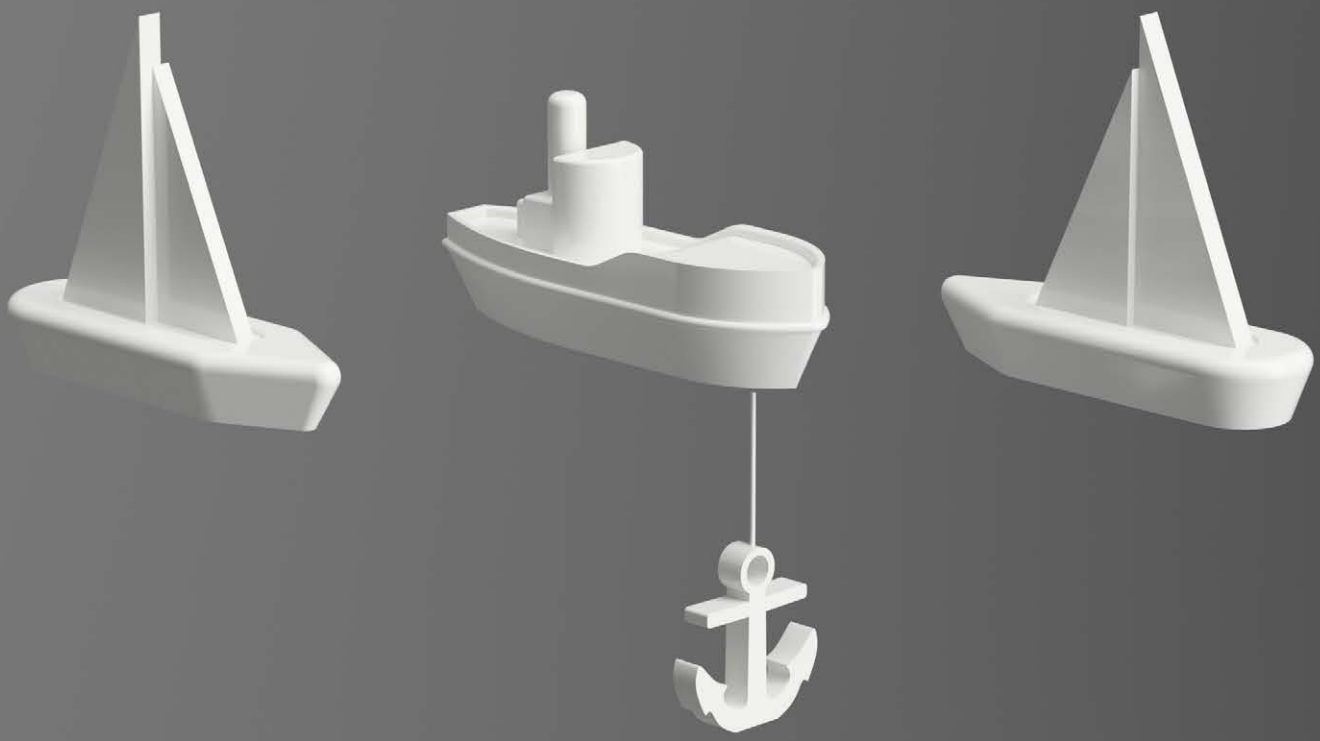


These navigation tools will help you check your model and position it correctly. In the next chapter we'll run through a series of exercises to get familiar with the slice to print process.

4.

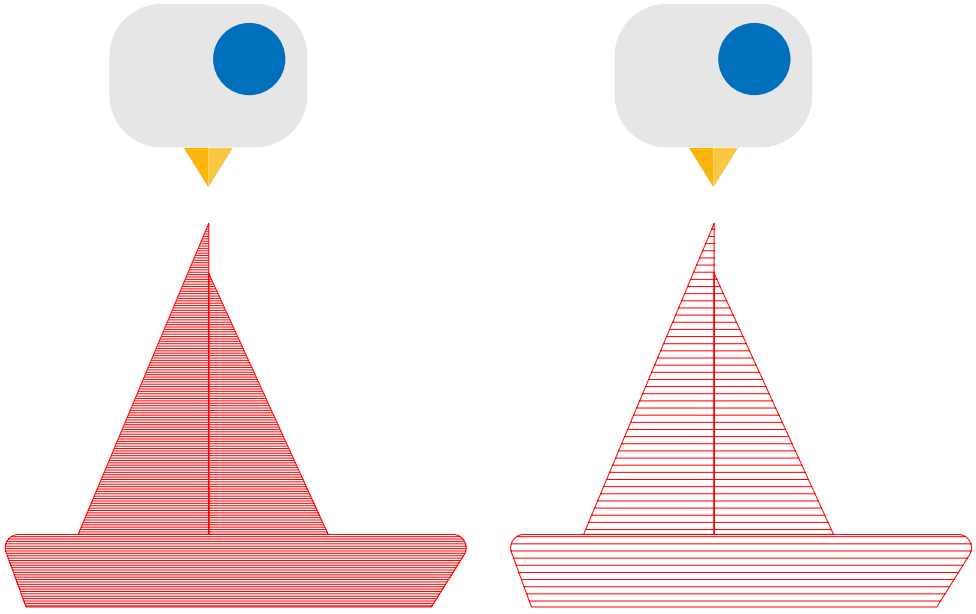
Slice to 3D Print

Throughout this chapter we will be using a set of STL files on the PrintLab Education USB stick. You will be slicing these models using different settings before 3D printing them to analyse the outcome. The purpose of these exercises are to help you get to know the various settings that can be used within 3D printing software. You'll learn about resolution and infill as well as how to edit models within 3DStar.



The Resolution Exercise

For your first slicing exercise you are going to 3D print 2 versions of the exact same model but with different resolution settings. Resolution in 3D printing terms usually refers to the layer height. Generally, the smaller the layer height, the better the surface quality. However using very small layer heights can add a considerable amount of time to the printing process. When printing in the classroom you must balance print quality with time. We'll be going through some exercises further in the handbook to give you tips on how best to manage your time with the 3D printers.



Print 1: 'Extreme' Mode

For the first model we are going to slice using the 'Extreme' mode. This is the best quality setting on the EinStart-C and it will print with a small layer height of 0.1mm. In addition to printing with a smaller layer height, this mode will print at a slow speed (40mm/s). Speed is a key factor in the quality of a print. Generally, the slower the speed, the better the quality.

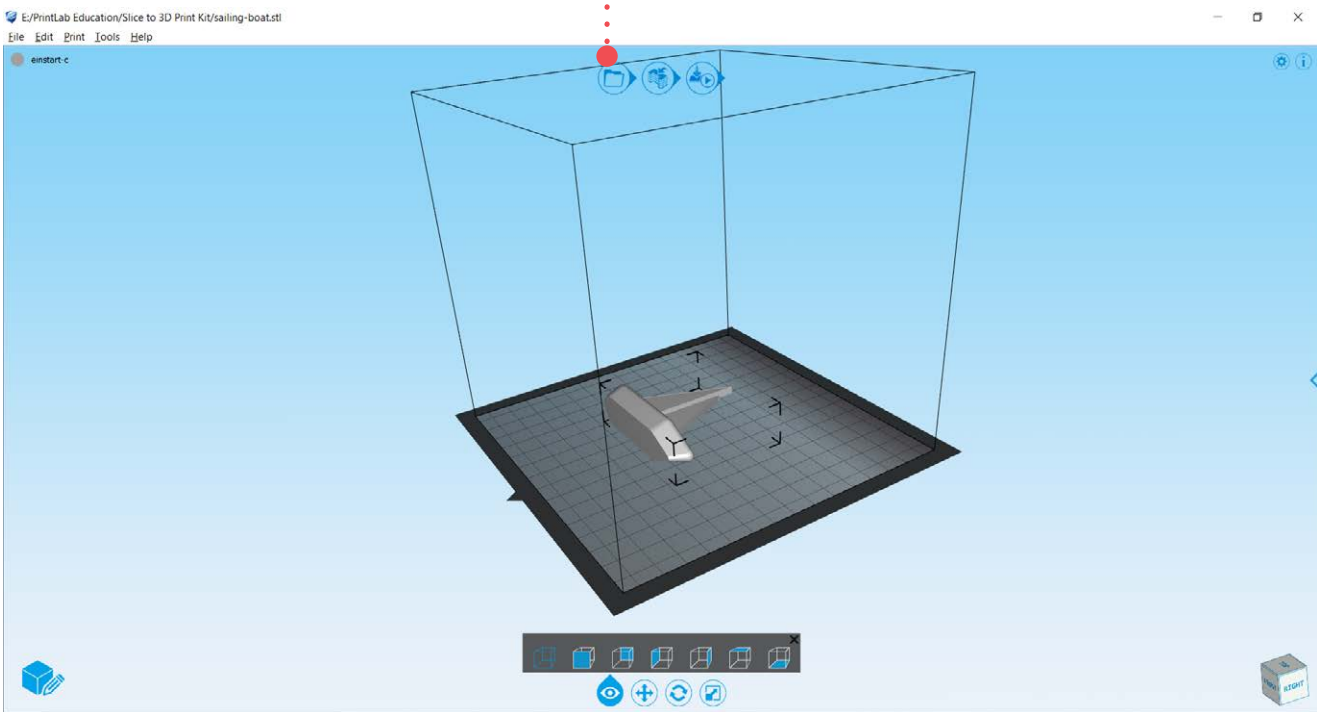
Print 2: 'Fast' Mode

In the second model we are going to slice using the 'Fast' mode. The layer height will be 0.3mm, 3 times that of the extreme mode. Surface quality will be affected but as you will find out, the printing time is dramatically decreased. This mode also prints at a faster speed of 80mm/s. Once printed, we'll analyse both the models to see the differences in appearance.

038 Open File

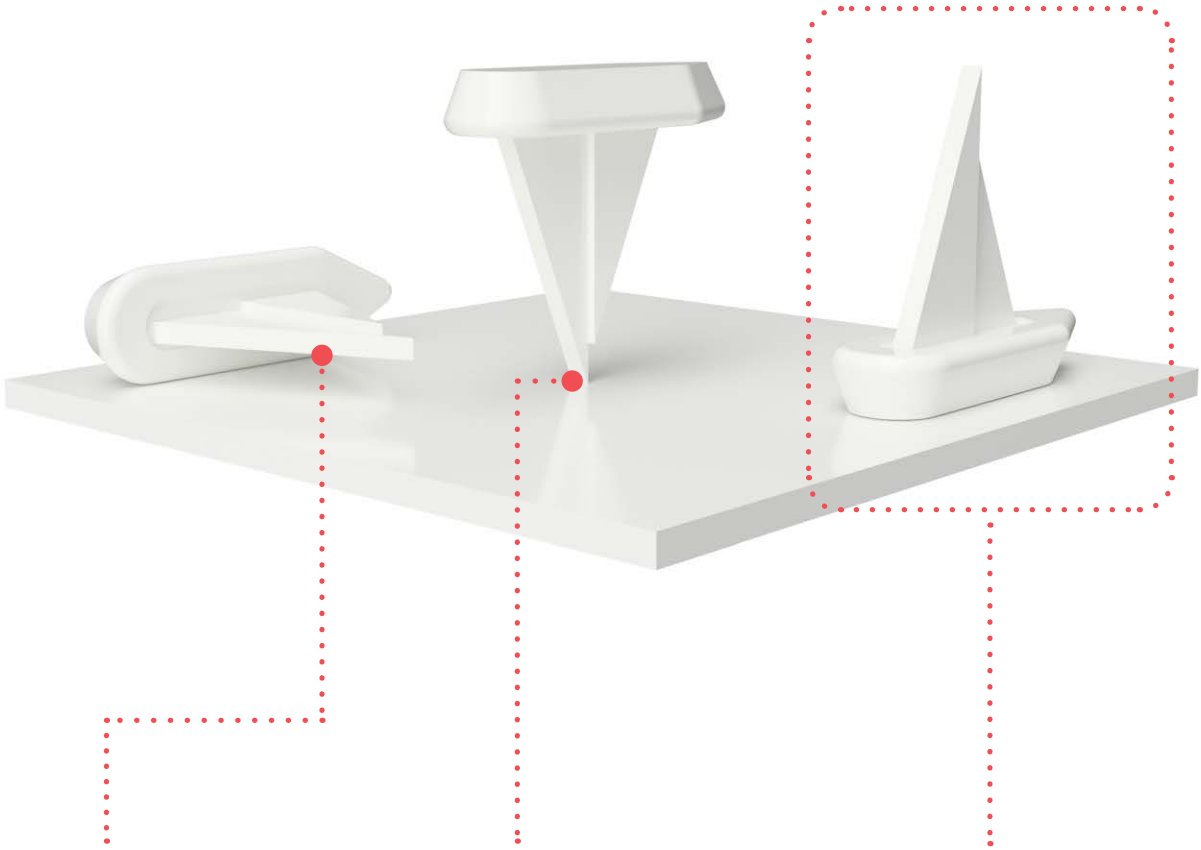
Slice to 3D Print

- Connect the PrintLab Education USB to your computer. Open 3DStar software and click the Open File icon.
- Open the folder Slice to 3D Print Kit on the PrintLab Education USB. Then select sailing-boat.stl and click Open.
- The model should now appear in the workspace! We need to position and rotate the model so it is suitable for 3D printing. It is very important to orientate models in the best possible way before 3D printing. On the next page we'll analyse what would happen if we oriented the model in different positions.



039 Model Orientation

Slice to 3D Print



Excessive Overhangs

If we placed the sailing boat model in this position, the resulting print would be very poor quality. If you look at the sails of the boat and imagine the printer creating this section, you may realise that the printer will essentially be printing in thin air. There is no material under the sail to print on top of. We'll learn more about overhangs like this later but generally, the bigger the angle and area of the overhang, the worse the surface quality.

Poor Bed Adhesion

In this scenario only a fraction of the model is in contact with the print bed. The software will generate a raft for this to be printed on but this is unlikely to stop the print from coming off the print bed when printing. Good bed adhesion is critical to all 3D prints and in order to achieve this, there needs to be a relative amount of surface area touching the print bed/raft.

Correct Orientation

For the sailing boat model, this is the best orientation. There are no areas with steep or large overhangs and there is a large flat surface touching the print bed. If you cannot avoid overhangs by rotating the model, you should orientate it to the position with the least overhangs. There is also a function in 3DStar called 'Support'. This generates a temporary structure under the overhangs and is peeled off after printing. However this also compromises surface quality.

040 Rotate your Model

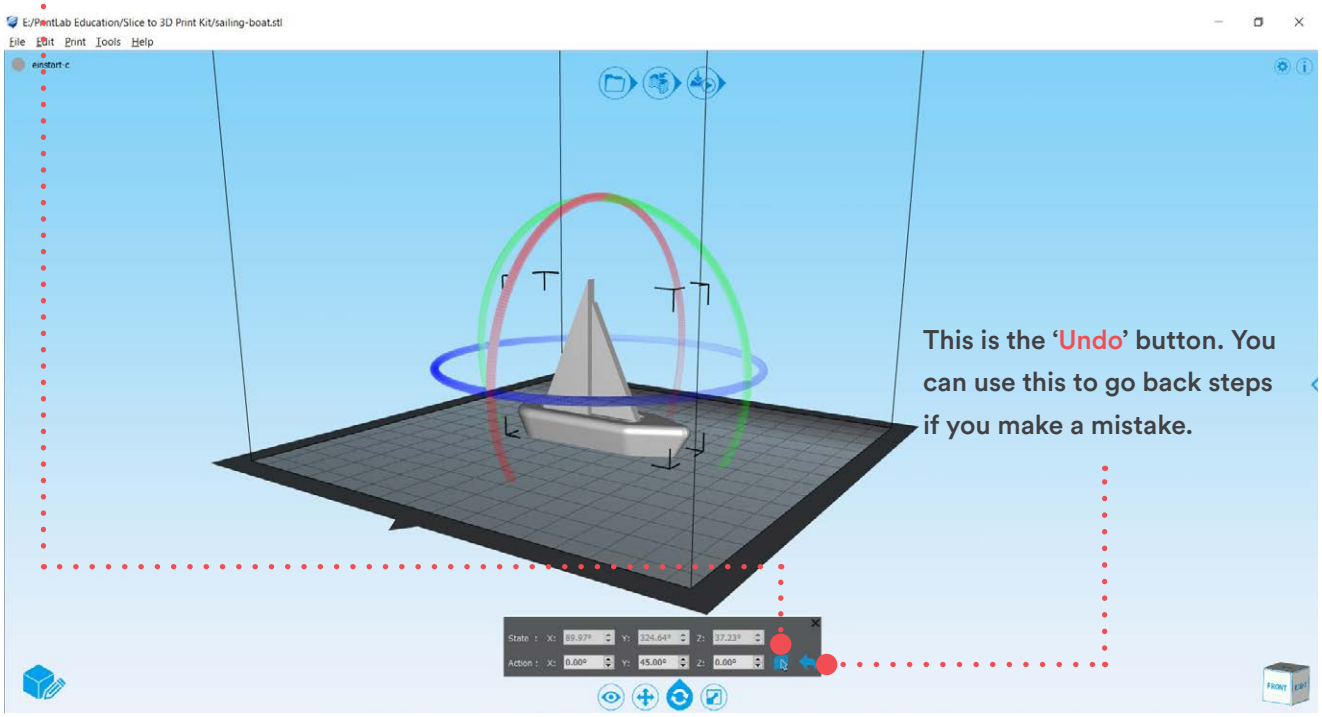
Slice to 3D Print

- To rotate the sailing boat to the correct orientation we will use the rotate tools. Click the Rotate icon and you will see red, blue and green circles appear. These represent the x, y and z axes.

- Let's experiment with the rotate tool. Click on one of the circles and wait a moment until it is highlighted. Then click and drag your cursor anywhere in the preview screen - see how the model rotates along that axis? Try this for all 3 axes.

- Whilst you are in the rotate menu you will see a box towards the bottom of the screen that has the titles 'State' and 'Action'. Try typing a number from 0-360 into one of the boxes and press enter on your keyboard - see how the model rotates by the amount of degrees you entered?

- After experimenting with the rotate tools, your model is probably in a strange position! There is a great function in 3DStar that allows you to pick the surface that you want to be touching the print bed. Click the faceRotate button and then click on the bottom surface of the sailing boat (the surface you want touching the print bed) - see how it aligns it on the print bed?



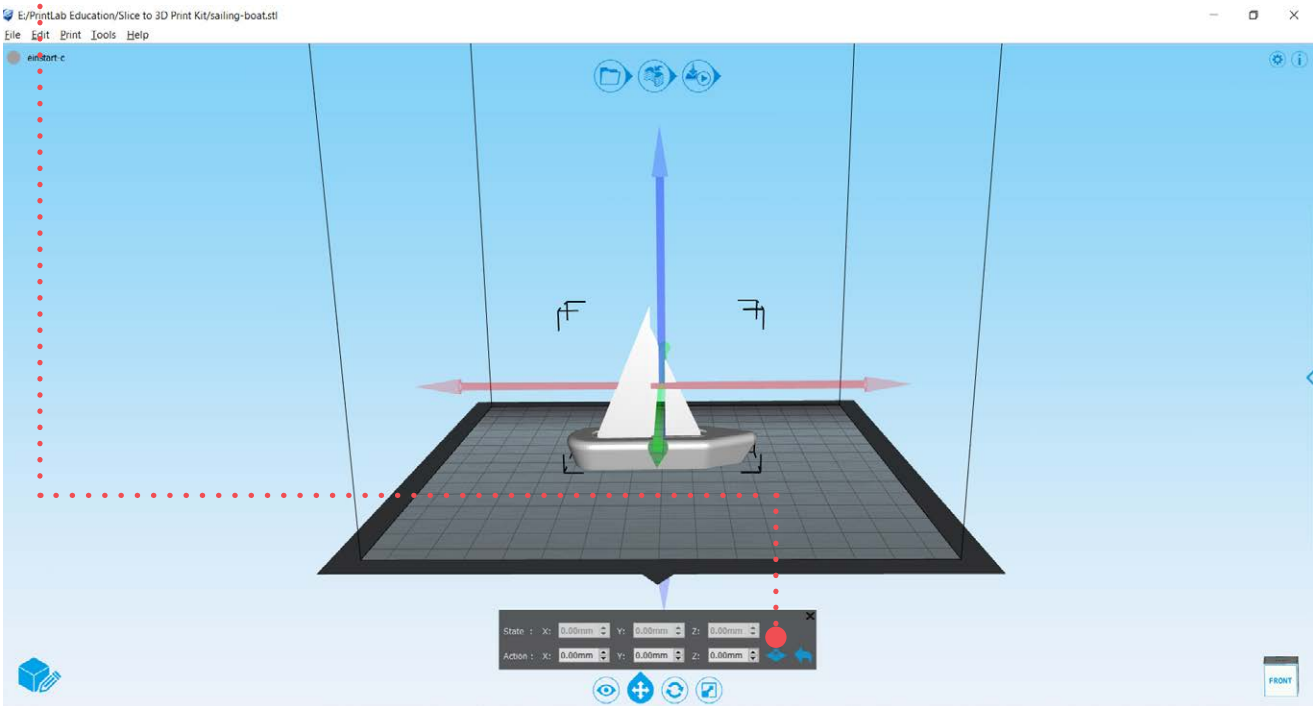
041 The Move Tool

Slice to 3D Print

- In addition to rotating your model, you can also move it into your desired position on the print bed. This won't affect the quality of your print but most people prefer to move their model to the centre of the print bed. The move tools also come in handy if you need to position several objects on the print bed.

- Click the Move icon. A set of axes appear, similar to the ones you saw in the rotate tool, but the move tool axes are horizontal arrows. Click on one of them to highlight it. Then click and drag your model - see how it moves along that axis?

- Click the toCenter button. Notice how the model moves to the exact centre of the print bed? It also puts the bottom surface flush with the print bed, another useful tool similar to faceRotate.



042 Select Print Mode and Slice

Slice to 3D Print

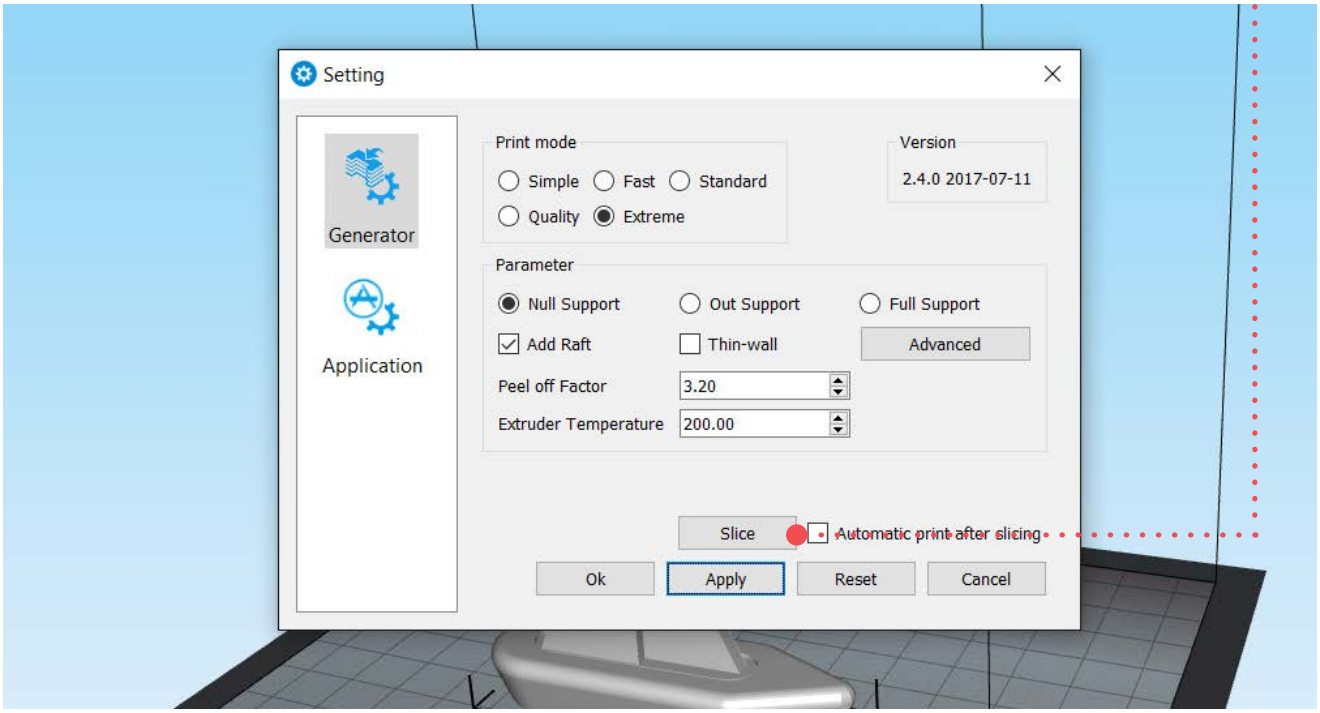
- Now that the model is in the correct position for 3D printing, we can go into the settings menu to select which print mode we require.

- Click the Settings icon at the top right of the screen and select Extreme for the print mode as per the below image. Ensure that Add Raft is selected - all prints on the EinStart-C work best with a raft.

- When you select a print mode, 3DStar automatically switches to the recommended settings for that mode, so you don't have to input the advanced parameters. You can however change various other settings should you wish to - we'll come to this later!

  Just to remind you, the Extreme print mode uses a thin layer height of 0.1mm and a slow print speeds of 40mm/s.

- Once you have chosen the correct setting, simply click Slice. The software will then begin to generate a GSD file (the code that tells the printer how to move and where to lay down material). When prompted if you want to save your changes to the model, select yes.



043 Printing Information

Slice to 3D Print

- Once the software has sliced the model, it will give you the option to open the location of the GSD file. Click the tick button to open up the folder where your GSD file is saved. It will be saved in the same folder as your original STL file.

- If you now go back into 3DStar software you will notice that a window pops up stating the expected printing information. Here's a breakdown of the information:

Print Time

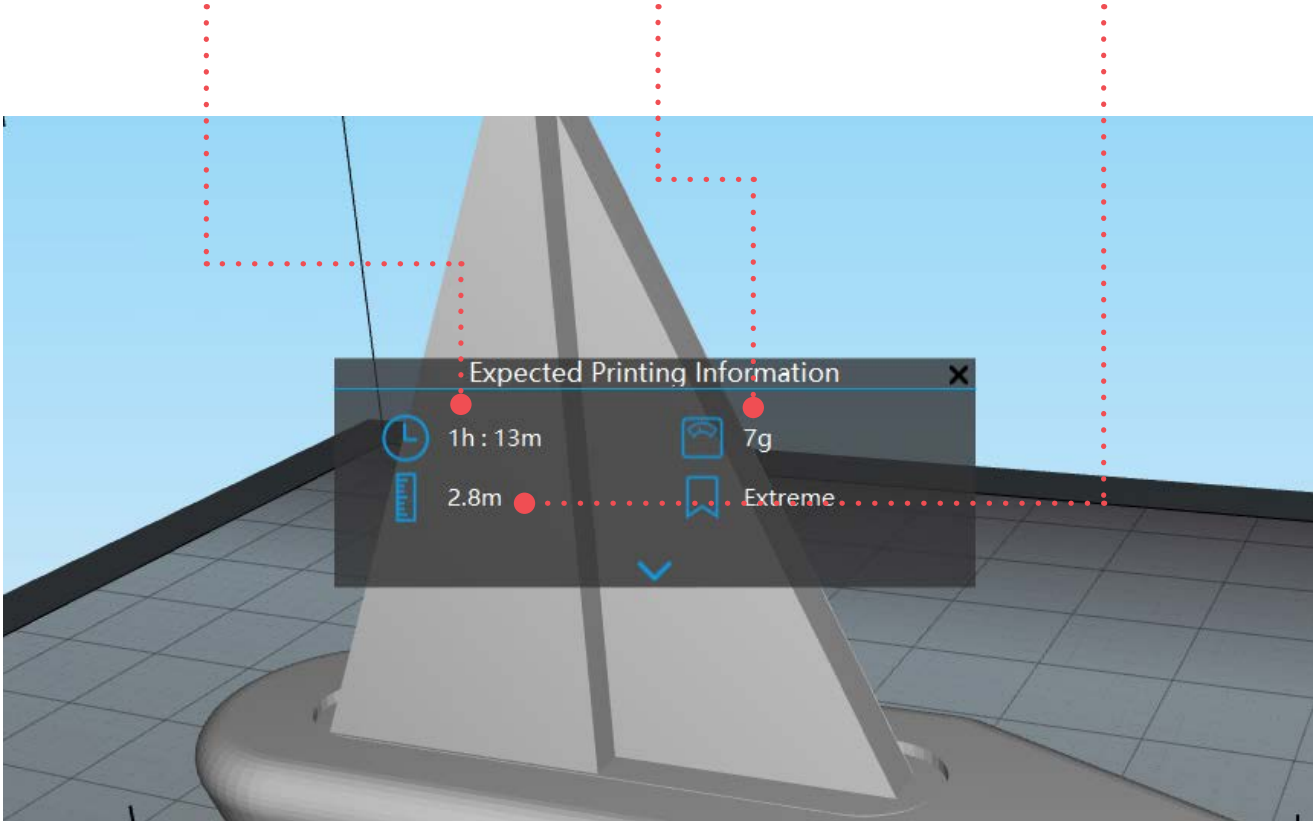
This is the estimated print time of the model. This is a very useful tool, especially to help you manage your printing time in the classroom.

Grams of Filament

The is the weight of filament you will use by printing this model. This can help teachers calculate material costs so they can budget for filament.

Length of Filament

The EinStart-C uses 1.75mm diameter filament. This value states the length of filament used by printing this model.



044 Check Path

Slice to 3D Print

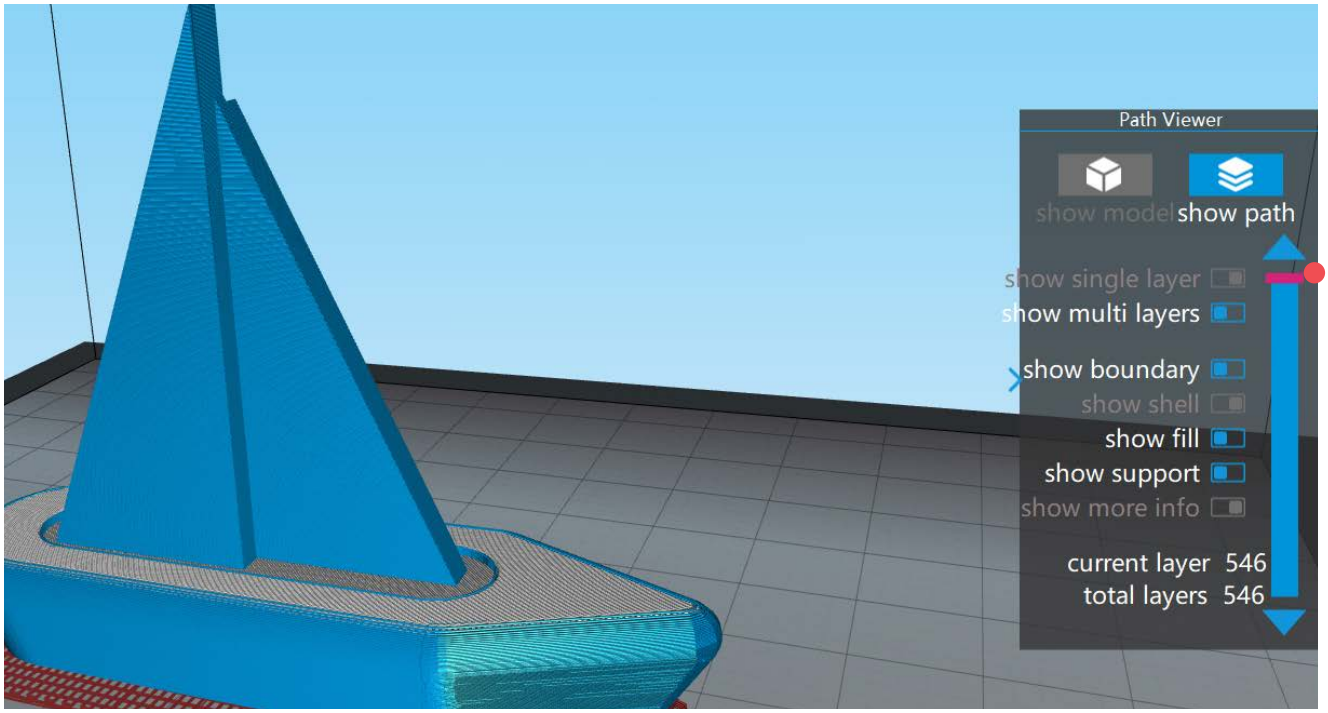
- At this point you can technically save the GSD to a USB stick, insert it into the printer and start your print. We do however recommend that you first check the path of your GSD file by going through the below steps.

- On the right side of your screen, you will see an arrow. Click the arrow to see the path viewer window. Within this window you can view the exact path that your printer will take.

- Select/deselect the icons and tabs so it matches the image below.

Now click and drag the slider on the right hand side to the bottom - this is where your print will start. Slowly drag it up and watch how the model builds up. Make sure the model looks like a solid object with no holes on the outer surface. By doing this, you are ensuring there are no errors before you start printing.

- Once checked, your GSD file is now ready for printing! First of all, head to the next page to slice a low resolution version.



045 Slice Low Resolution Model

Slice to 3D Print

- Before we 3D print the sailing boat model, we are going to slice the exact same model but with the Fast print mode. We then recommend setting up both the EinStart-C 3D printers included in the bundle so you can start both prints at the same time. This will enable you to observe differences in print speed and surface quality.

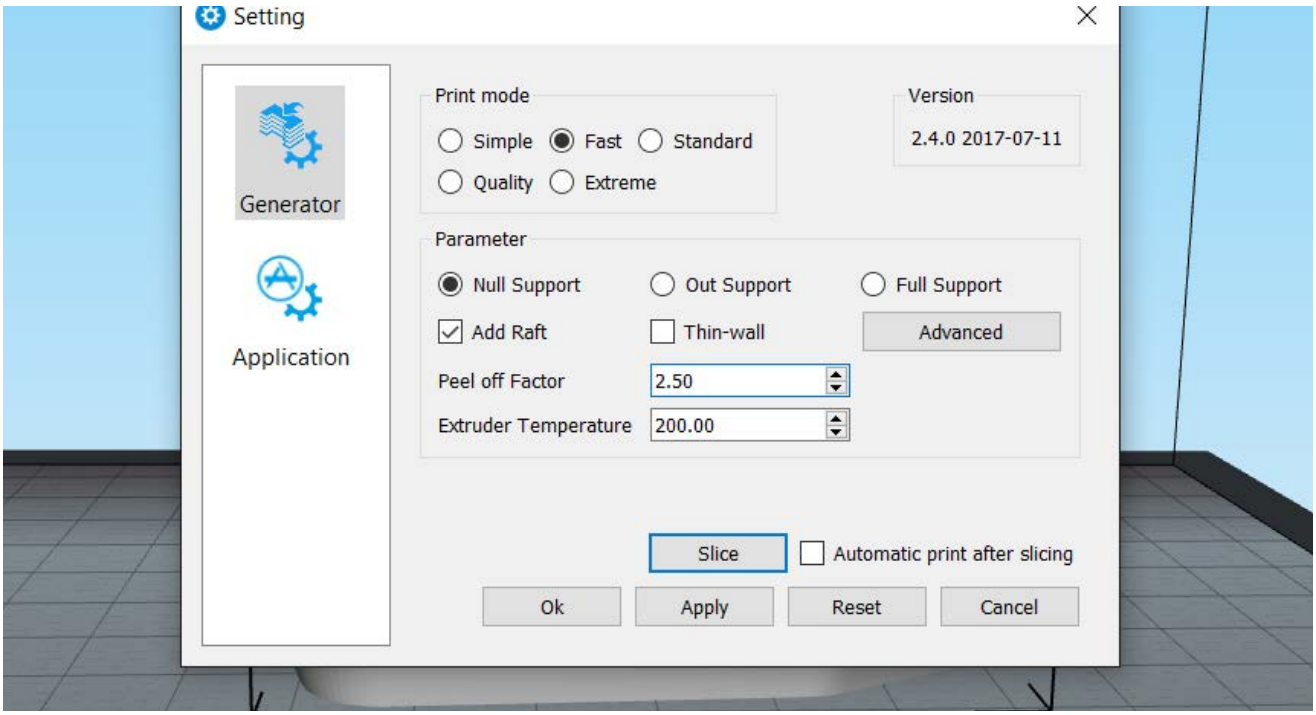
- If you are currently in the path viewer window, deselect Show path and select Show model. This will take you back to the main view.

- Go to File > Save as and save as STL file format with the name sailing-boat-lowres.stl. This will create a copy of your model that has been positioned correctly on the print bed.

- Now click the Settings icon and select the Fast print mode, then Slice.

- Once sliced you will see the printing information. Notice how different the estimated time is to your previous model?

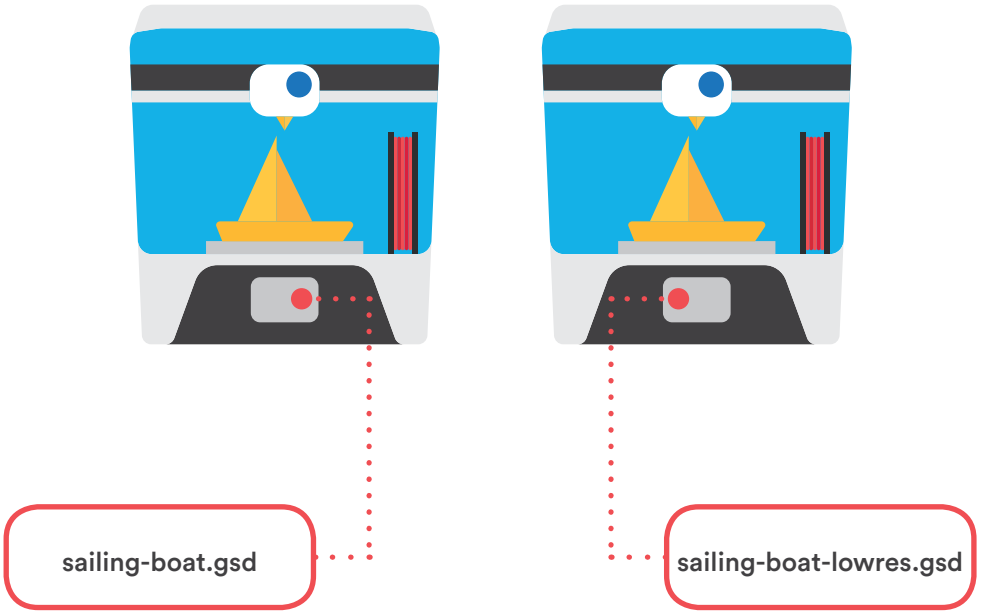
- Check the path viewer and then both models are ready to go to the printer!



046

Slice to 3D Print

Print Sailing Boat Models



Set up your EinStart-C 3D printers side by side. Using the same process as you went through when printing the pen, start printing the sailing boats at the same time. You can either transfer the GSD files on to 2 separate USB sticks and start at exactly the same time, or you can start the extreme print first to give it a head start!

Observations

Once both prints have started, observe the following things:

1. Print speed - Look at how the fast print model prints much faster. Not only is the layer height larger but the extruder module moves around quicker.

2. Surface quality - Although the fast print model prints much quicker, you will notice a big difference in surface quality. The fast print speed means that the layering of material is less accurate. This setting is great for quick prototypes but not so great for presentation models.

Once both models are completed and you have analysed them, keep them in a safe place because you'll be using these as visual aids in the classroom to explain resolution to your students.

047 The Infill Exercise

Slice to 3D Print

In addition to resolution, another key setting is infill. Infill is a cross-hatched pattern that is printed inside your model. You can amend the density of the internal pattern, which is extremely useful to save filament, time and money!

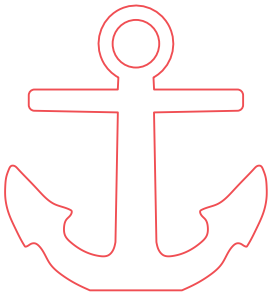
A relatively hollow PLA object will float but a solid PLA object will sink. This is because a solid PLA object has a larger density than water. We are going to demonstrate this by printing the below models with different infill settings.

Ship Model
The ship model will be printed with a large fill line distance. This means that it will be relatively hollow and should float when placed in water

Anchor Model
The anchor model will be printed solid and will therefore sink when placed in water

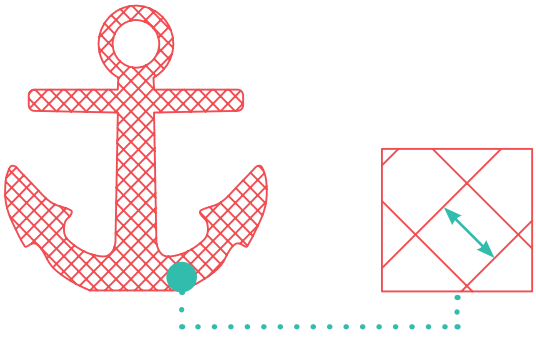
A Closer Look at Infill

Below are some plan views (looking straight down) showing different infill scenarios for the anchor model.



Hollow

Models can be printed completely hollow with only an outer shell. Many models can print hollow without it affecting surface quality but models with large top surfaces may struggle because the printer won't have material/infill to print on top of.



Regular

Most models are printed with infill lines around 4-6mm apart. In 3DStar you can set the distance between the cross hatching.

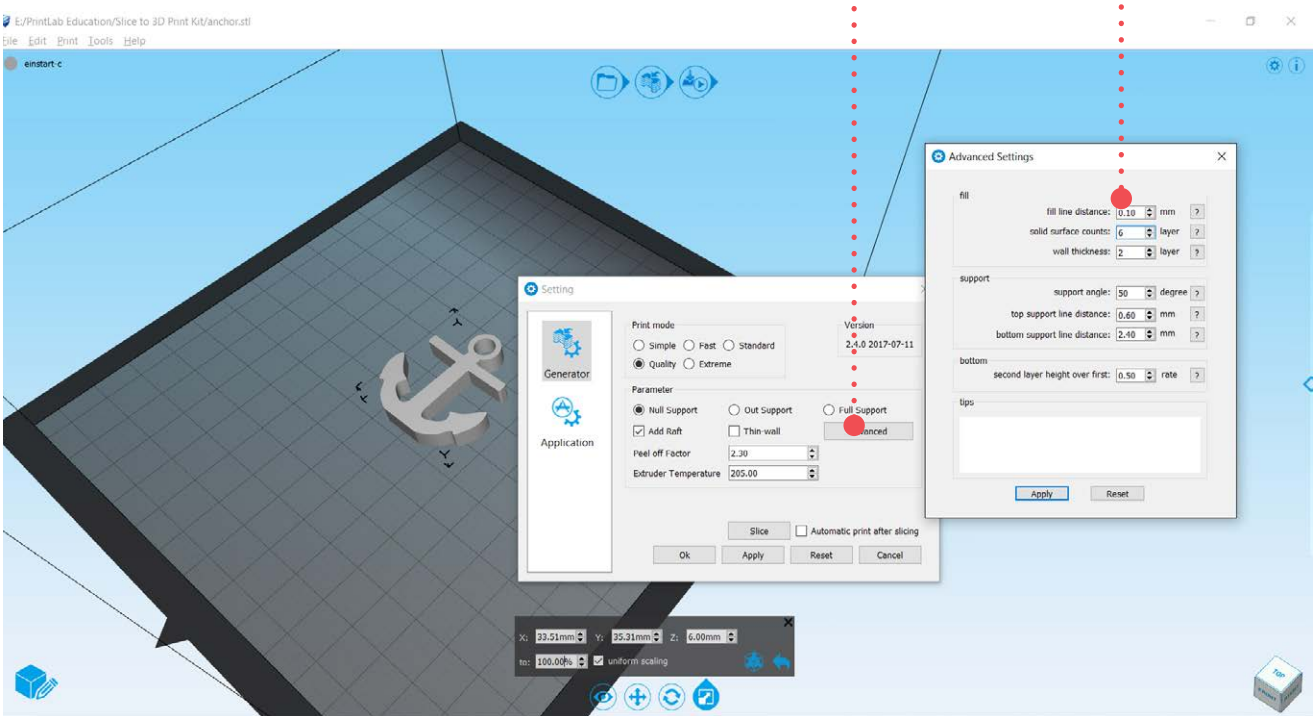
Solid

Solid models aren't very common in the classroom unless it is a functional requirement. Printing solid objects uses much more material and can take much more time but it can be a great way to teach about density and mass!

049 3D Printing the Anchor

Slice to 3D Print

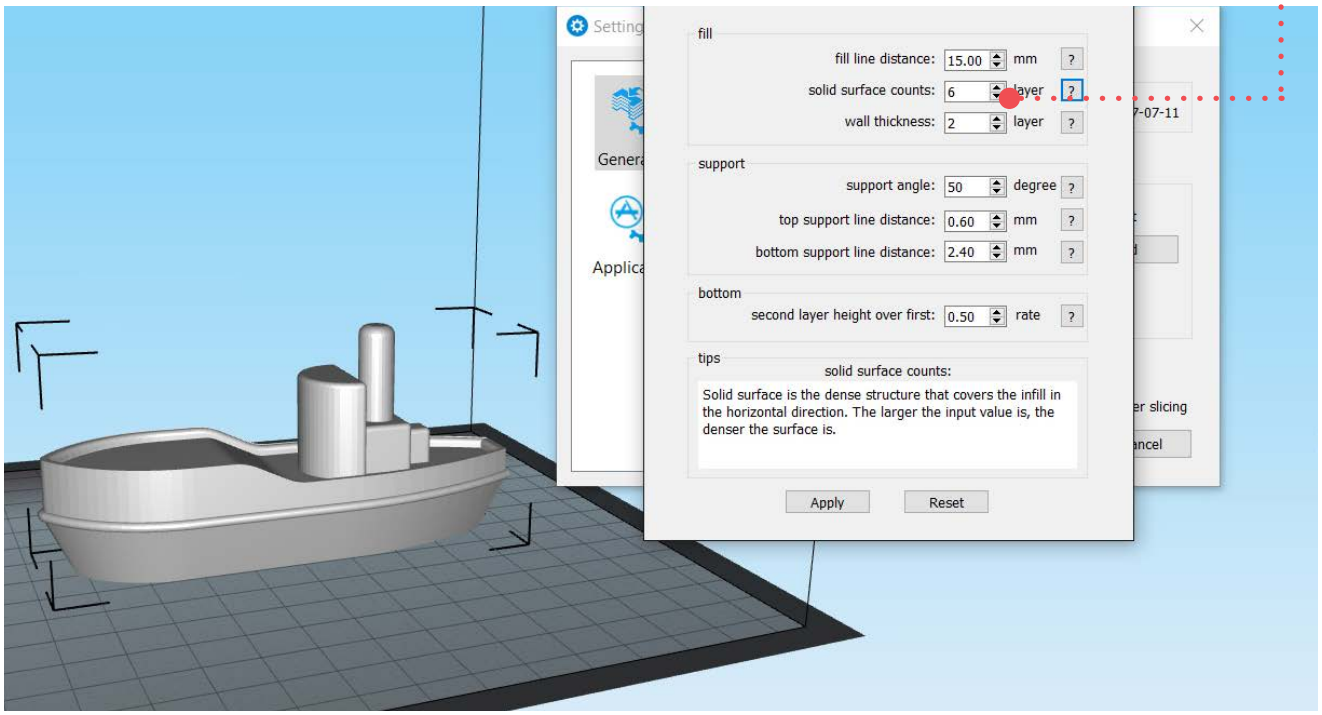
- Connect the PrintLab Education USB to your computer. Open 3DStar software and click the Open File icon.
- Open the folder Slice to 3D Print Kit on the PrintLab Education USB. Then select anchor.stl and click Open. Rotate the model so it matches the below image.
- Open the Settings menu and select Quality as the print mode.
- The other parameter you want to change is the fill line distance. Press the Advanced button to see the advanced settings.
- In the fill line distance box, enter 0.1 and click Apply.
- Now slice the model to prepare it for 3D printing. Wait until you have sliced the next model before 3D printing the anchor.



050 3D Printing the Ship

Slice to 3D Print

- To clear your model preview area simply click File > New.
- The STL for the ship model is located in the same folder as the anchor. Open the file name ship.stl. Open the settings menu and select Quality as the print mode. Press the advanced button, enter 15 for the fill line distance.
- The setting below fill line distance is solid surface counts. When printing the top surface on top of infill, the printer must bridge across the infill lines. The initial solid layers that print on top of the infill are generally not great quality. The bigger the distance between the infill lines, the harder it is to get a good top surface finish. To help this you can print more layers on top of the infill to cover up the layers that aren't smooth. Change the solid surface count to 6.
- Click Apply and slice your model. Print both the anchor and ship models using both your printers and observe the infill being printed. Once printed, place the models in water and the anchor should sink, whilst the ship floats! Store the models in a safe place as they will also be used as a visual aid to teach students about infill and density.



Downloading Models

To finish off the 'Slice to Print' chapter we are going to look at some great websites that allow you to download ready-made STL's for 3D printing! Simply head to one of the below websites and there will be hundreds of free models available for download. Once downloaded you can open the STL's in 3DStar and go through the slice to print process.

3DKer - www.3dker.com

3DKer is Shining3D's online platform. It is a thriving community which gives users free access to thousands of 3D printable models all over the world. The 3DKer team want to bring an extraordinary experience to the general public.

Thingiverse - www.thingiverse.com

Thingiverse is a an online community for discovering, making, and sharing 3D printable things. As the world's largest 3D printing community, they believe that everyone should be encouraged to create and remix 3D things, no matter their technical expertise or previous experience.

YouMagine - www.youmagine.com

YouMagine is an online community of 3D printing enthusiasts who wish to work together to share, remix and make better 3D printed things. YouMagine facilitates this community, empowers and gives you the tools you need in order to improve, invent & make.

MyMiniFactory - www.myminifactory.com

MyMiniFactory, which launched in 2013, is one of the world's leading curated social platform for 3D printable objects. On MyMiniFactory, you can find tens of thousands of 3D designs ready for you to download for free. These will work with any desktop 3D printer, and they have tested every single one so that it is guaranteed to print!

Downloading Tips

With the amount of freely available models on the internet, you might struggle finding the model you want. In addition, most of the sites allow anyone to upload designs so you want to make sure that they are 3D printable. Here are some tips for finding the right model and making sure it is printable:

Check the Path Viewer in 3DStar

Once you have sliced your model in 3DStar, make sure to check the path viewer tool to see if the outer surface is completely solid. This will prevent you from starting prints and realising mid-print that there are errors in the model.

Check out the Education Sections

Most of the websites listed on the previous page have a specific section for education. There are many teachers around the world who are active in sharing their designs. You may also be able to contact the designer using information provided on the website to ask for advice and tips!

Look at Popular Models and Read the Comments

Next to each available model you will see how many views and downloads each one has. Popular models are likely to be well-designed and 3D printable. In addition many users leave comments on the designs - reading these may help you learn about the best settings for that specific model.

Use the Search Function

All of the sites listed on the previous page have a search bar where you can type in keywords to find models. This can save you a lot of time if you know the type of model you want to print. You can even type in subject areas such as ‘Maths’ or ‘Physics’.

5.

CAD to 3D Print

Using ready-made models for 3D printing is a great way to get introduced to the technology, but the real value comes in learning the complete design to print process. Throughout this chapter you will use CAD software to design a series of models. The models you will be creating will also teach you how to design specifically for 3D printing. An important consideration when designing models is the limitations of 3D printers and the following exercises will show you why.


SHINING 3D®
SHINING 3D®
Ready to Print
PrintLab
30
40
50
60
70
Bridging
Support

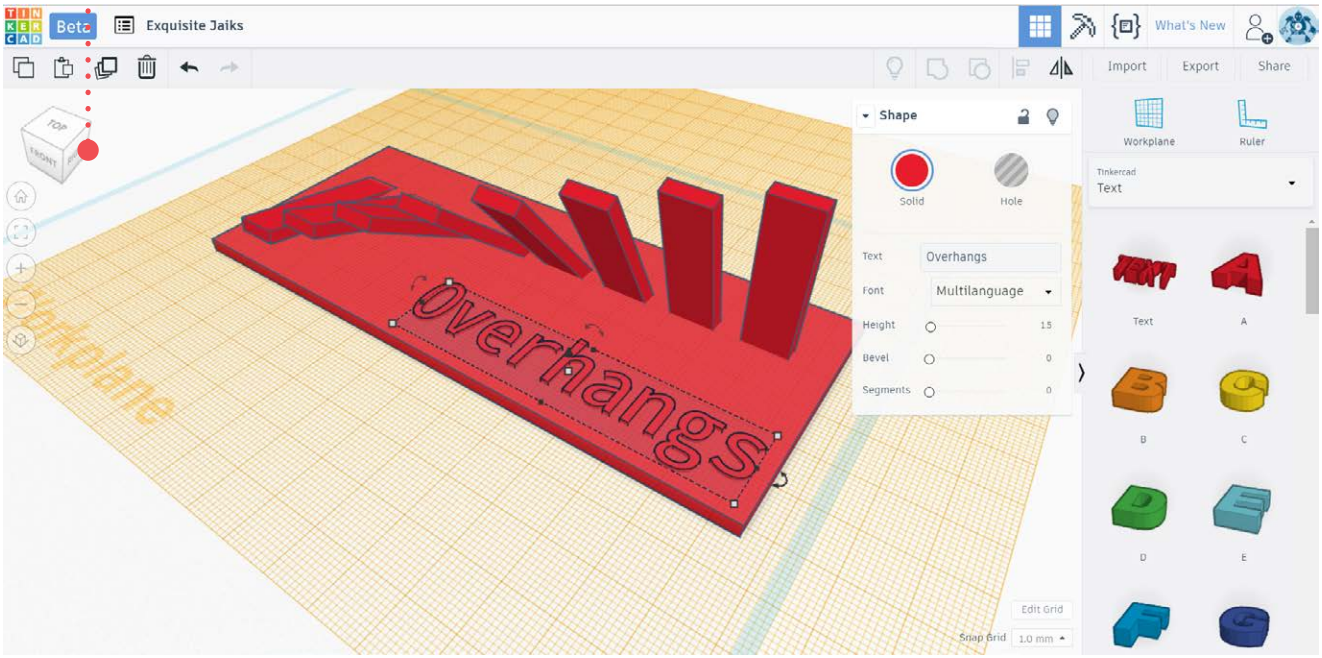
About CAD Software

CAD stands for Computer-Aided Design Software and refers to computer programs that are intended for design purposes. They can either be 2D, 3D or both. CAD was invented in the 1960's and over the years it has replaced manual drafting methods because of its speed, accuracy and ability to easily make amendments.

CAD software is used in a whole range of industries such as architecture, engineering, animation, medical and education etc. In recent years CAD software has become extremely accessible to anyone and there are now many free programs available to download. In addition to being free, there has been an increase in the availability of 'beginner' software packages suitable for those with no experience.

Tinkercad

We advise that you try out a range of the options listed on the next page. You will most likely find one that you think is best suited for your students, but it is also worth noting that different software packages are better for certain types of models. For example there are some programs that excel in digital sculpting and others that perform better at sketching and extruding surfaces. For this reason we recommend keeping an open approach and encourage students to experiment with various software options.



CAD Options for Schools

Tinkercad - www.tinkercad.com

Tinkercad is a simple, online 3D design and 3D printing app that can be used through a web browser. It is a great tool for educators at the beginner/intermediate level. Shapes are the basic building blocks of Tinkercad. A shape can add or remove material and you can import your own or work with existing shapes. Shapes can then be moved, rotated or adjusted freely in space. You can also group shapes together to create detailed objects as complicated as you like.

SketchUp - www.sketchup.com

SketchUp is another simple design software that differs from Tinkercad in various ways. Firstly it is an offline software, meaning you can work directly from your desktop with no internet connection. In SketchUp you start by drawing lines and shapes before pushing and pulling surfaces to turn them into 3D forms. You can stretch, copy, rotate and paint to make anything you like. SketchUp is used by a wide range of people, from complete beginners to architects and product designers.

Fusion 360 - www.autodesk.com/products/fusion-360/overview

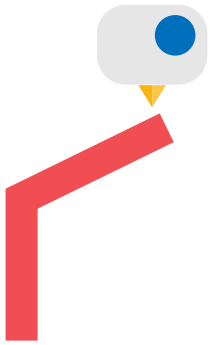
Fusion 360 is a cloud-based 3D CAD, CAM, and CAE platform for product development. It combines industrial and mechanical design, simulation, collaboration and machining in a single package. The tools in Fusion 360 enable fast and easy exploration of design ideas with an integrated concept to production toolset. Fusion 360 is an advanced design software but the amazing tools it provides makes it a top choice for educators.

Meshmixer - www.meshmixer.com

Meshmixer is state-of-the-art software for working with triangle meshes. If you need to clean up a 3D scan, do some 3D printing, or design an object that fits something else, Meshmixer can help. Think of it as a sort of “Swiss Army Knife” for 3D meshes. It excels above the other software packages mentioned on this page when it comes to editing 3D scans.

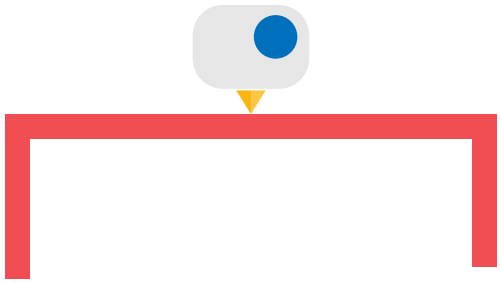
Design Considerations

There are several aspects of 3D design that need to be considered when creating models for 3D printing. 3D printers have their limitations and it's important to highlight these in the classroom. Let's take a look at some considerations before we start designing in CAD.



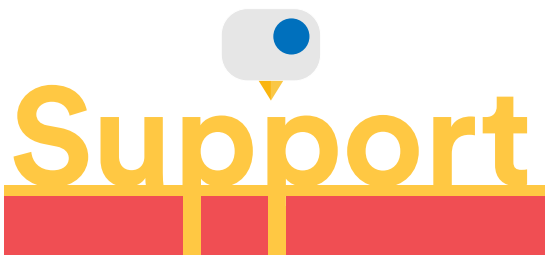
1. Overhangs

FFF 3D printers require at least a partial surface or layer to print on top of, therefore problems may arise when printing steep overhanging features. The larger the overhang angle, the poorer the surface quality.



2. Bridging

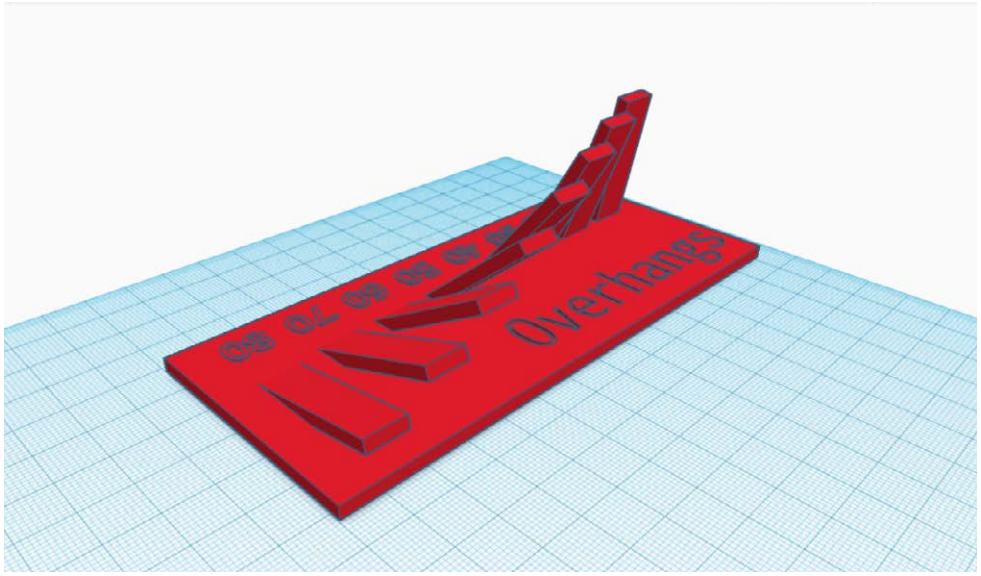
Bridging is essentially an overhang but the printer 'bridges' across two points. The larger the bridge, the poorer the quality.



3. Support

To help with overhangs and bridging, support material can be generated by most slicers. This is temporary structure that is peeled off after printing but the surface quality is usually compromised.

Design an ‘Overhang’ Model



The above image shows the first model we are going to be designing - the overhang model. When 3D printed the various angles will have different surface finishes. You can use the 3D print as a visual aid in the classroom in one of the lesson plans included in the bundle.

The software you will be using in this chapter is Tinkercad. Tinkercad is an easy, browser-based 3D design and modeling tool for everyone. Tinkercad is also your perfect 3D printing companion – it allows you to imagine anything, and then design it in minutes!

First of all let’s get you set up on Tinkercad.

1. Go to www.tinkercad.com

2. Create an account on the site

3. Go through the basic tutorials that are offered to you once your account is created

On the next page we are going to begin designing the overhang model!

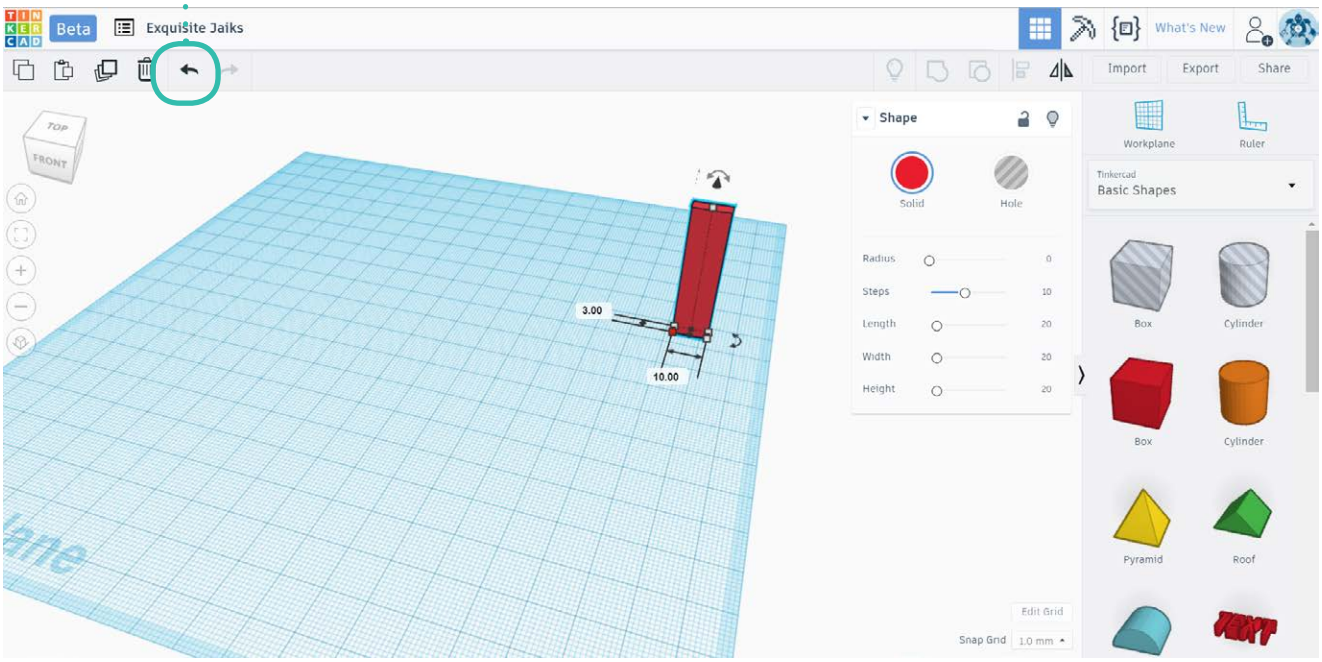
057 Draw a Box

CAD to 3D Print

First of all we are going to draw a box and give it some dimensions!

- Use the basic shapes menu on the right side of the screen to drag a box onto your workspace.
- Click on one of the white squares at the bottom corner of the box to see its dimensions. Click in the white dimension boxes and give it a length of 10mm and a width of 3mm. Refer to the image below for guidance.
- There is another white square at the top of the box, this represents the height of the box. Click this white box and give it a dimension of 40mm.
- We are going to be making 7 more copies of this box so move it to the right hand side of the workspace as shown below. To do this simply click and drag the box.

This is the Undo button. You can click this to go back steps.



058 Duplicate

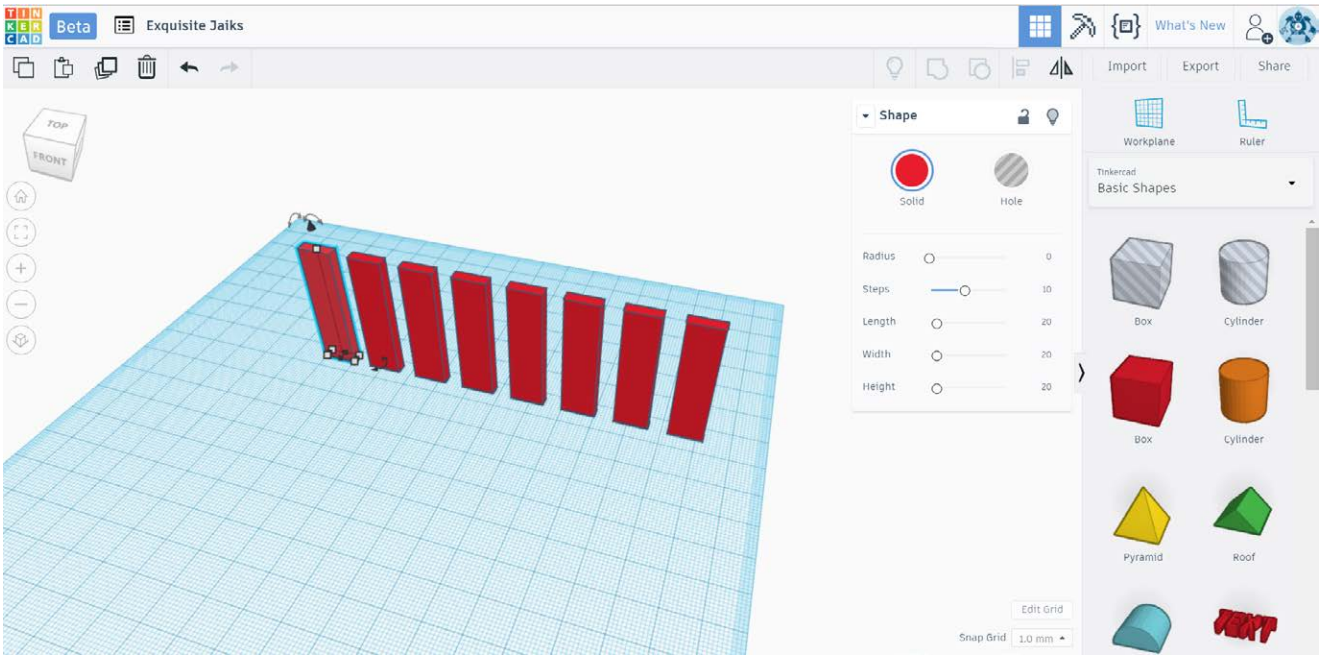
CAD to 3D Print

The next step is to copy the box 7 more times.

- Click on the box to select it and then click the duplicate tool on the top left of your screen. This will create an exact copy of the box. It is positioned on top of the existing box so all we have to do is move it.

- Hold down shift on your keyboard then click and drag the box to move it to the left. Holding down shift keeps the move tool on the X and Y axis. As you drag the shape you will see a dimension label appear. This is the distance you are moving your copied box away from the original box. Release the mouse button when the dimension says -16mm.

- Click duplicate again and you will notice it creates another copy but this time it has already moved to the left by the same distance as the previous duplication, which is what we want! Keep clicking duplicate until you have 8 boxes.



059 Rotate

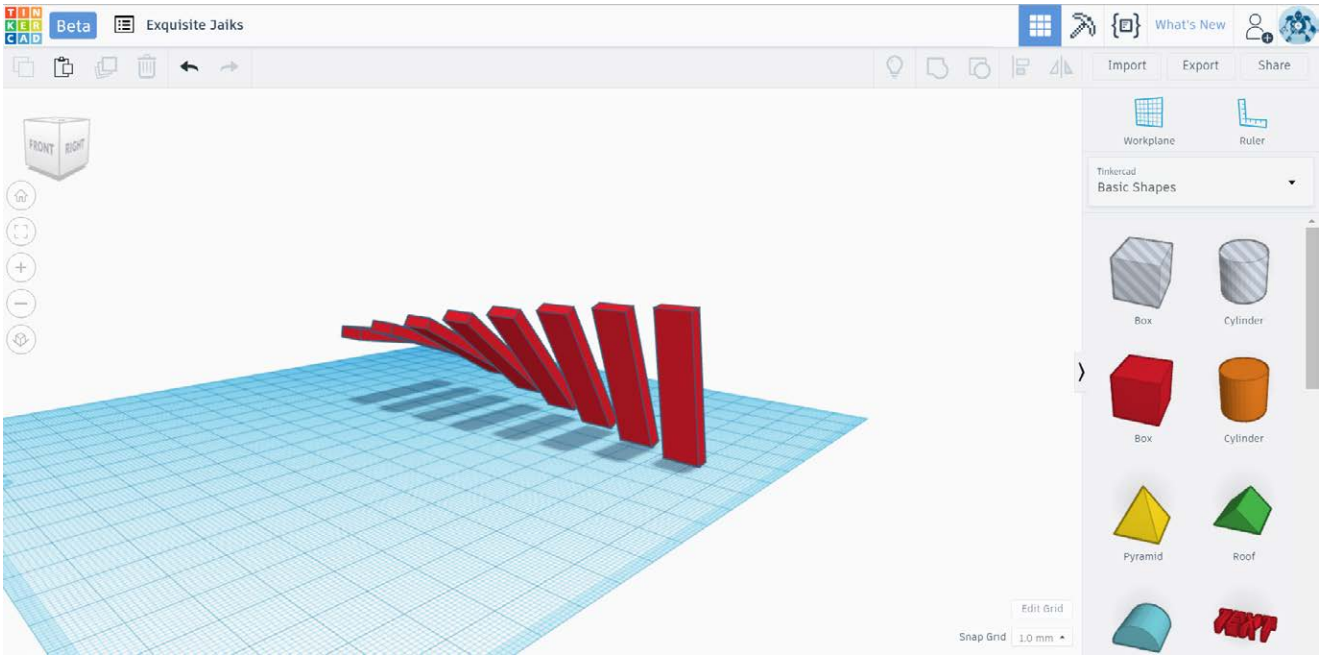
CAD to 3D Print

We now want to rotate each box to a different angle.

- Click on the first box you drew to select it. Rotate your view so that you are looking directly at the thin face.

- You will notice a double ended arrow, which allows you to rotate shapes. Click on the arrow and then click again in the white box that says 0 degrees. Then type in -10 and press enter on your keyboard.

- Repeat this step for the remaining boxes. But each time you move along, rotate the box by an extra 10 degrees. You will rotate the second box by -20 degrees, the third by -30 degrees and so on.



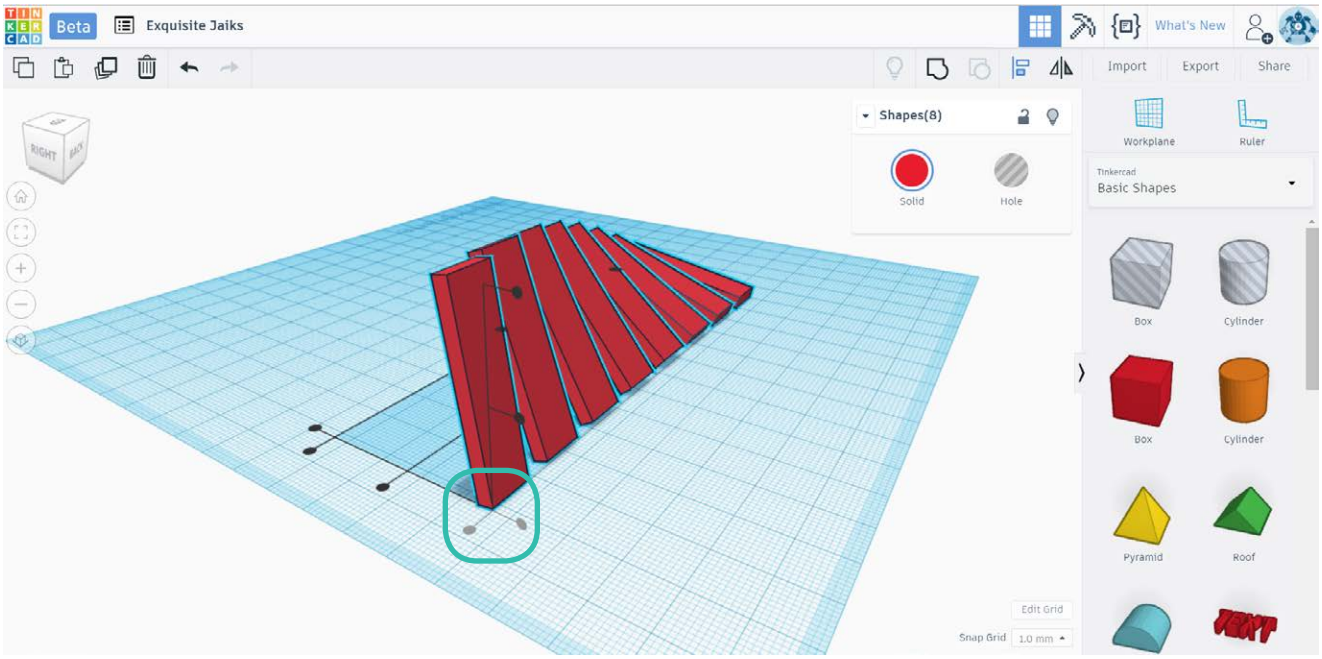
060 Align and Group

CAD to 3D Print

Some of our boxes look like they are floating! Let's align them.

- Now highlight everything in your model by clicking in your workspace and dragging a selection box over everything. Rotate around to a view similar to that in the below image. Click the align tool and you will see a series a black circles.
- Look for the circles that correspond to the ones in the below image that have a green box around them. Click both of these circles to align the boxes.

- Highlight everything again and click the group tool to make all your boxes a single component.



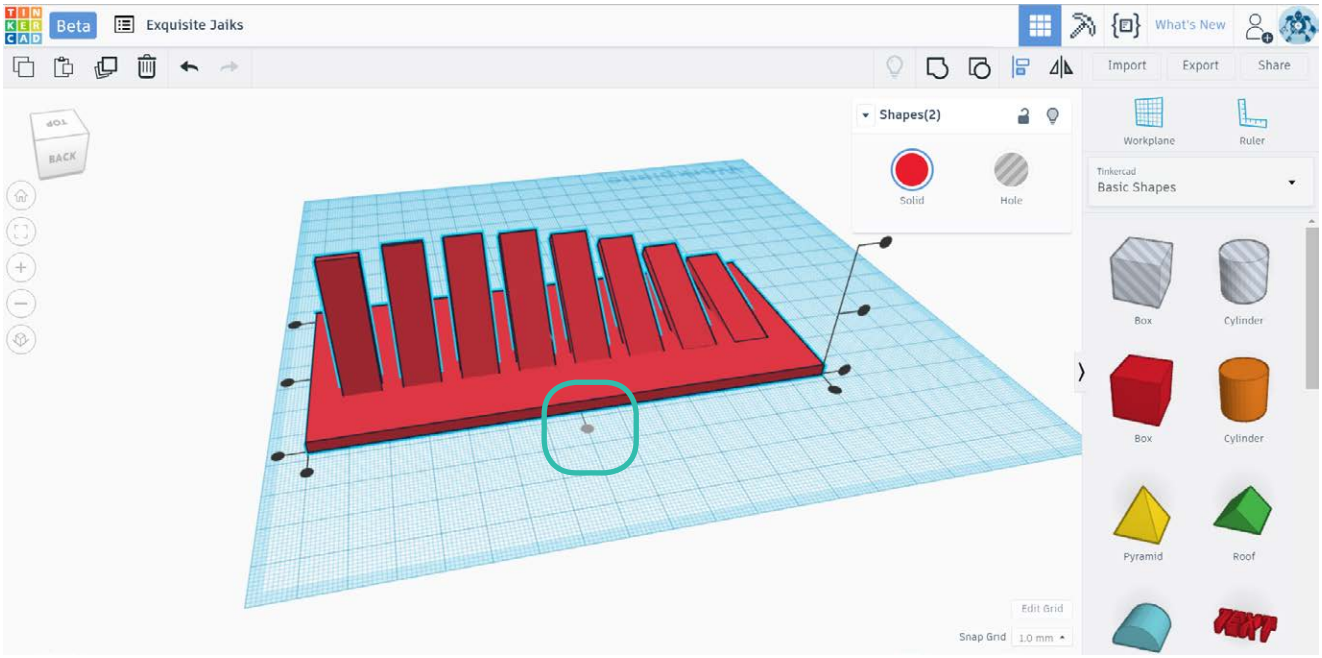
061 Create a Base

CAD to 3D Print

Let's make a base for our boxes.

- Drag another box from the basic shapes menu into the workspace. Give it a length of 140mm, width of 60mm and a height of 3mm.

- Click and drag the base to move it to a similar position as shown in the image below. Select everything in the workspace and click the align tool. Click the black circle that is highlighted in the below image to make sure the boxes are central to the base.



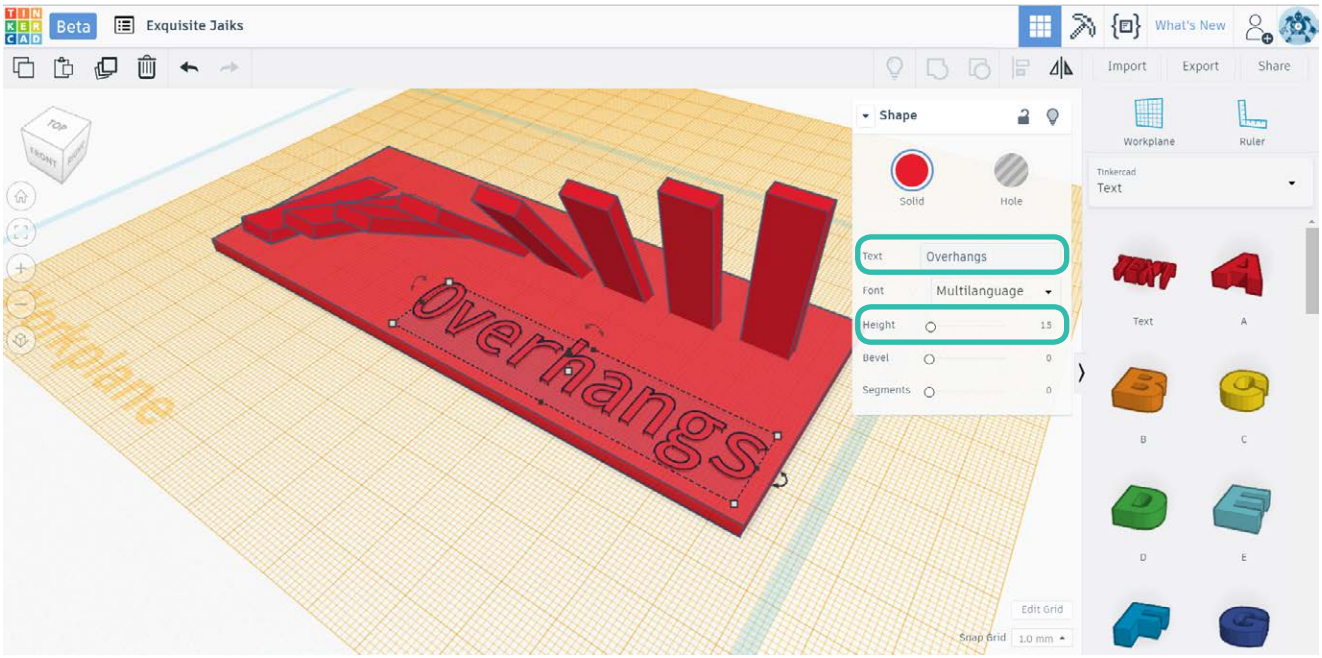
062 Insert Text

CAD to 3D Print

Now we are going to give our model a text label.

- Click the workplane tool and then click again on the top surface of your base. This will allow you to draw directly on to this surface rather than the ground plane.

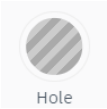
- On the right of your screen click the box where it says basic shapes. This will open a drop down menu. Click text.
- Drag and drop the shape that says Text onto the top surface. In the Shape menu you can amend the text. Amend the text to say ‘Overhangs’.
- Amend the size of the text by holding down shift on your keyboard and dragging one of the white boxes at the corner of the shape. Resize and position it at a similar place as per the below image.
- Click the white box in the middle of the text and amend the height to 1.5mm.



063 Embed Text

CAD to 3D Print

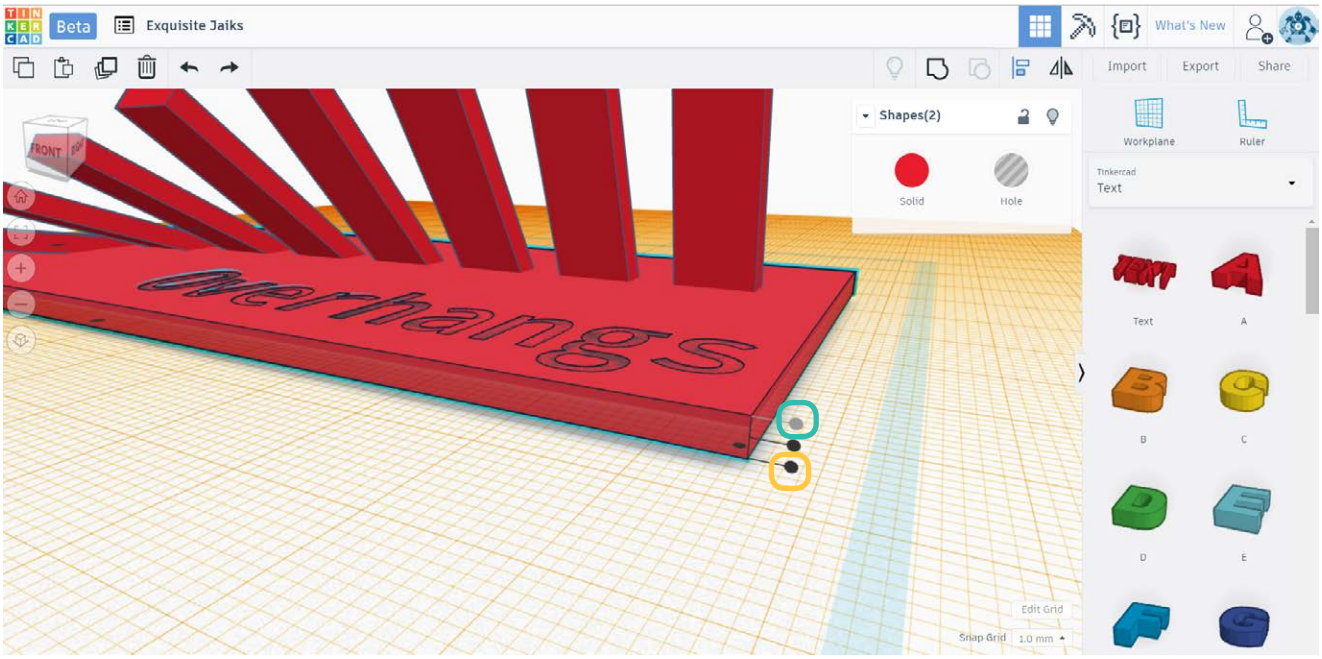
Let's embed the text into our base!



- Click on the 'Overhangs' text in your workspace to select it. In the shapes menu, click hole.

- Select your text and the base and click the align tool.
- Click the circle as highlighted in yellow in the below image. Then click the circle as highlighted in green in the below image. You will see that your text is aligned with the top surface of the base.

- To embed the text all you have to do is select everything in your workspace and click group. Notice the text has now become a hole in the base?



064 Label Boxes

CAD to 3D Print

Let's label each box to remind us of their overhang angle. Instead of making a hole in the base, these labels will protrude from the base.

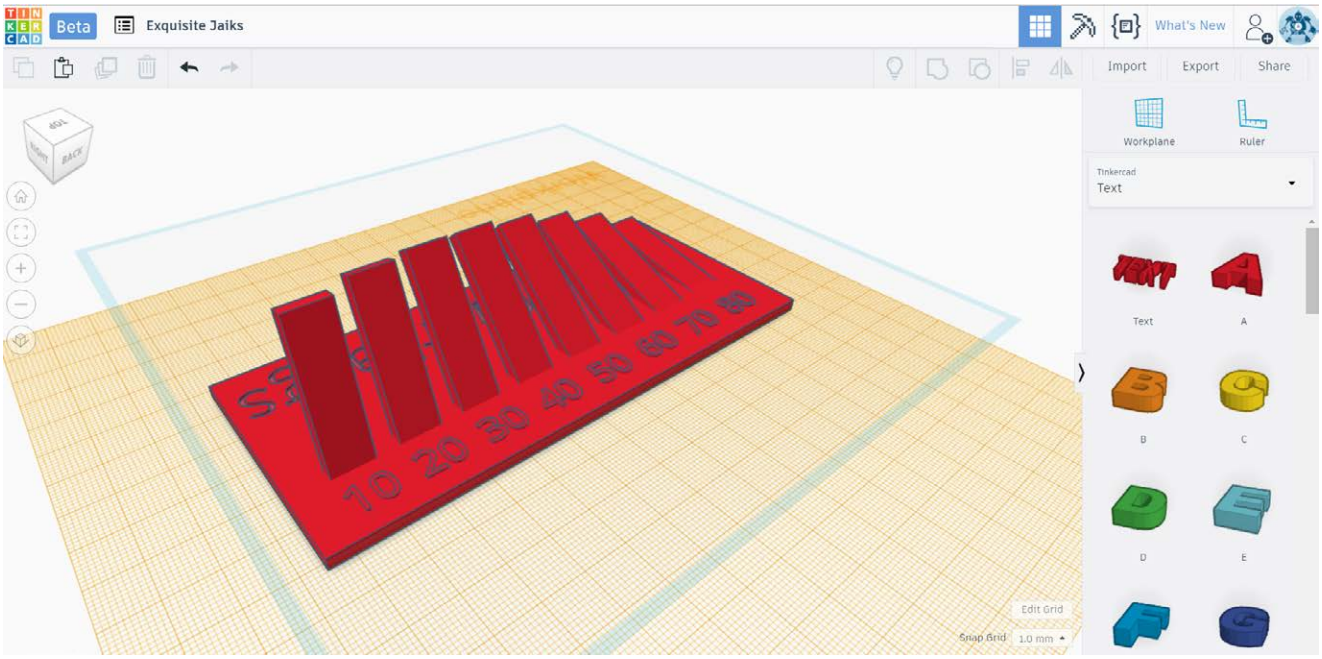
- Drag and drop the 'Text' shape onto the top surface of the base next to where you drew your very first box.

- Click the double ended arrow to rotate the text. Type in 180 in the degrees box and press enter on your keyboard.

- Change the text to '10' in the shapes menu and resize it so it is approximately the same width as the box. Next, click the white box in the middle of the text and give it a height of 1.5mm.

- Click the duplicate tool and then move the copied version over so it is approximately central to the next box. Now keep clicking duplicate until each box has a label.

- Go through each label and change the text in the shapes menu to match the angle its rotated by. The labels should be 10, 20, 30, 40, 50, 60, 70 and 80.



065 Export your Model

CAD to 3D Print

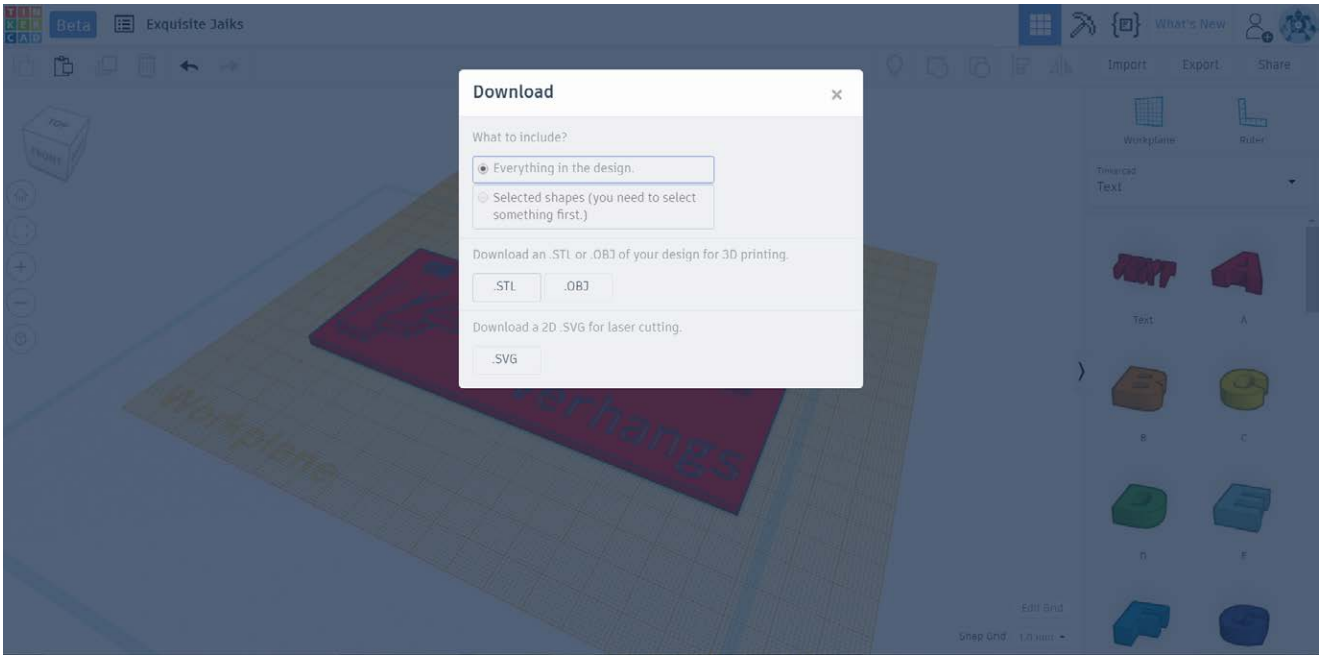
The final step is to combine all shapes into one solid, watertight model then export it as an STL.

- Select everything by dragging a box over all shapes in your workspace. Then click group.

- In the top right menu click export. Once there, click STL and save the file somewhere you will be able to find it easily.

- At the top of the screen you can see the name of your drawing. Tinkercad automatically gives it a name (usually something strange sounding) but you can click on it and change it to something more suitable. All designs are automatically saved in the cloud to your Tinkercad account.

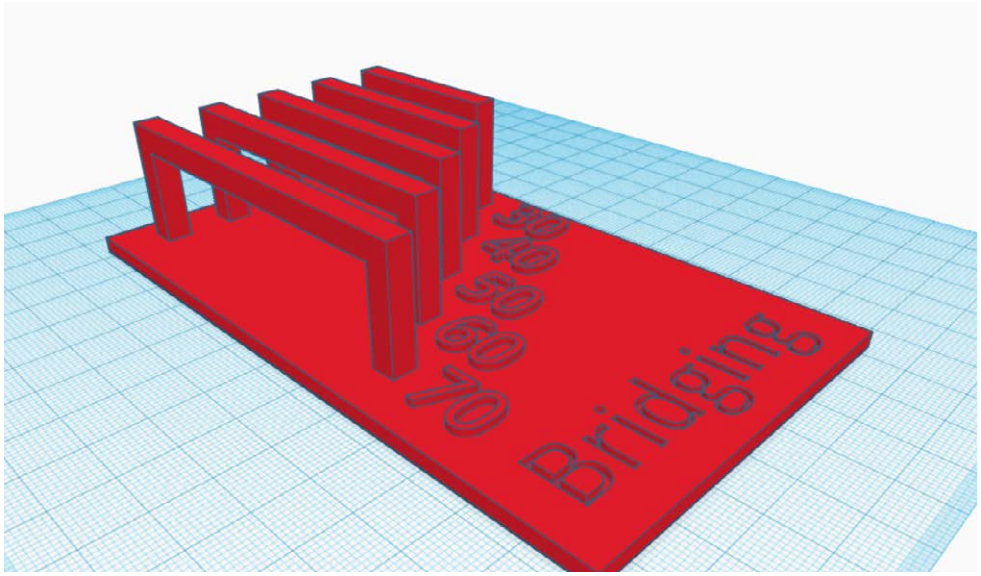
Well done! You've now completed the first visual aid model!



066

CAD to 3D Print

Design a ‘Bridging’ Model



The above image shows the second model we are going to be designing - the bridging model. When 3D printed the various bridging distances will have different surface finishes.

You can use the 3D print as a visual aid in the classroom to teach your students about bridging.

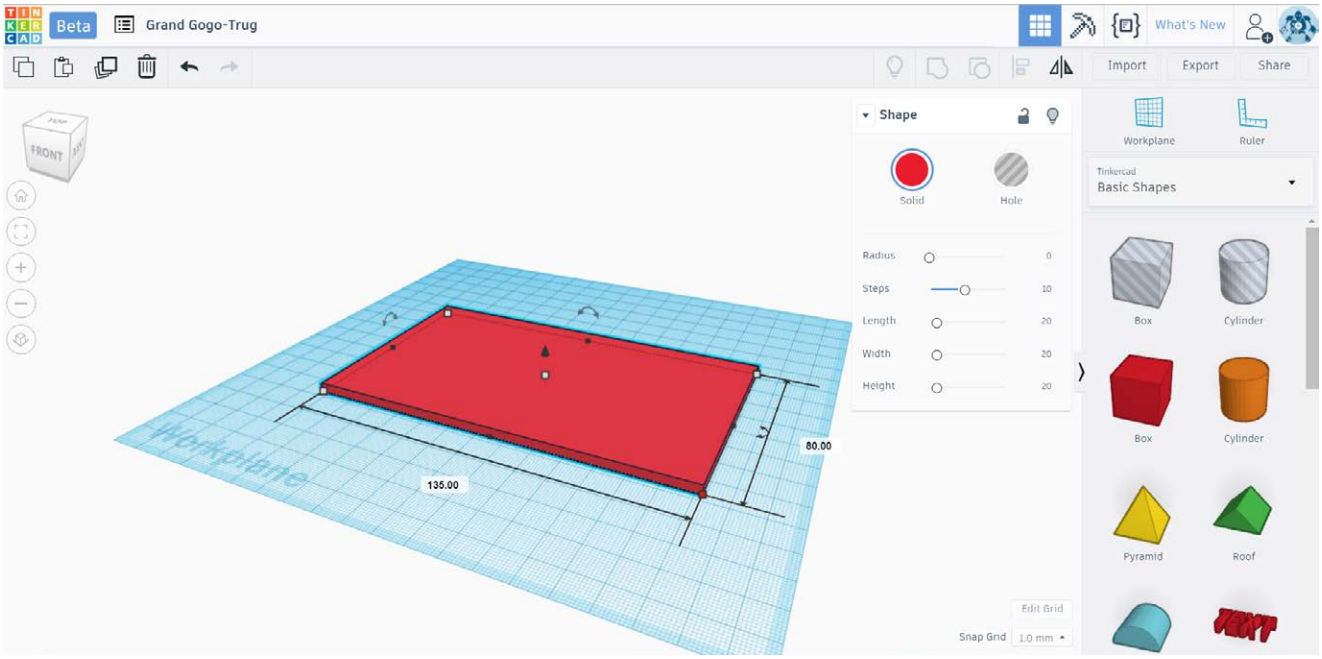
Begin by creating a new design in Tinkercad. If you are within an existing design, click the ‘My designs’ icon at the top left of the screen and select ‘New Design’.

067 Create a Base

CAD to 3D Print

For this model we are going to start by creating a base.

- Use the basic shapes menu on the right of the screen to drag a box onto your workplane.
- Click on one of the white squares at the bottom corner of the box to see its dimensions. Click in the white dimension boxes and give it a length of 135mm and a width of 80mm. Refer to the image below for guidance.
- There is another white square at the top of the box, this represents the height of the box. Click this white box and give it a dimension of 3mm.



068 Draw the First Bridge

CAD to 3D Print

Let's draw our first bridge!

- Click the workplane tool and then click again on the top surface of your base.

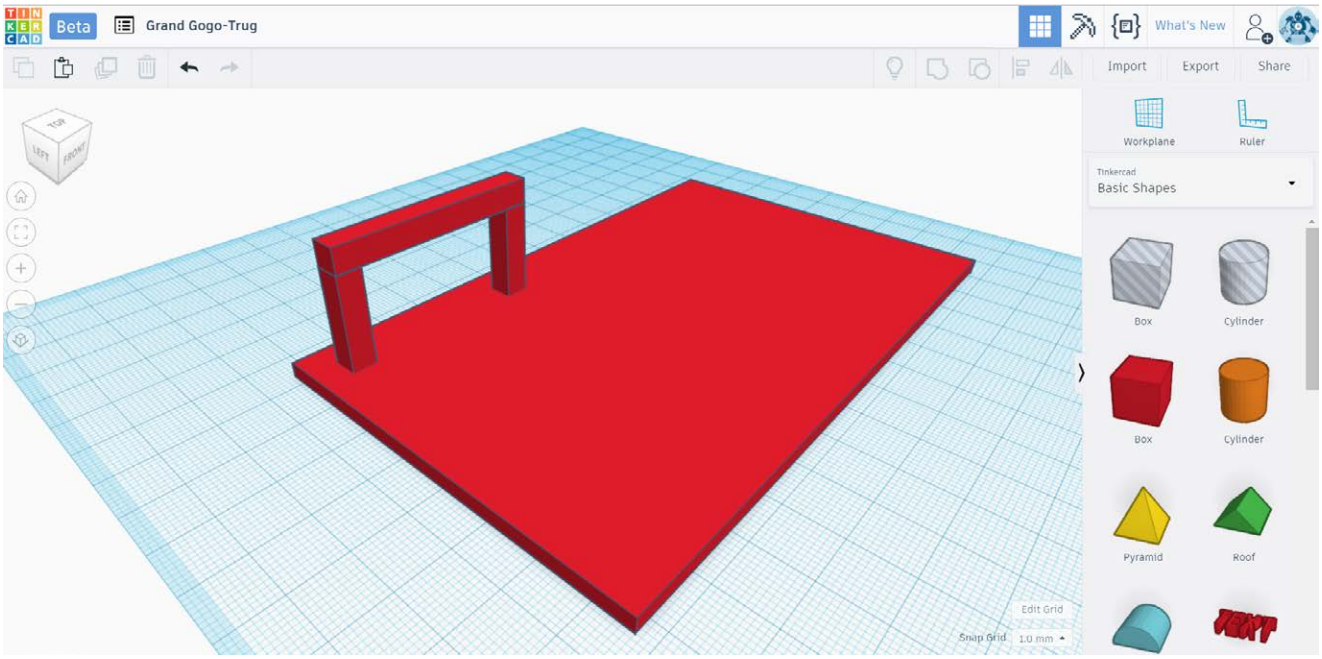
- Drag and drop a box shape onto the top left area of your base (see below image). Give it a length and width of 5mm and a height of 20mm.

- Click the duplicate tool to make another box. Move the box to the right and release it when the dimension box says 35mm. This means the distance inbetween your boxes is 30mm.

- Select the workplane tool and click on the top surface of either one of the boxes you just drew.

- Drag another box into your workspace. Then click and drag the white squares at the corners of box so that it sits flush on top of your first 2 boxes.

- Click the white square in the middle of the box and give the box a height of 5mm.



069 Draw another 4 Bridges

CAD to 3D Print

Now we are going to create an additional 4 bridges.

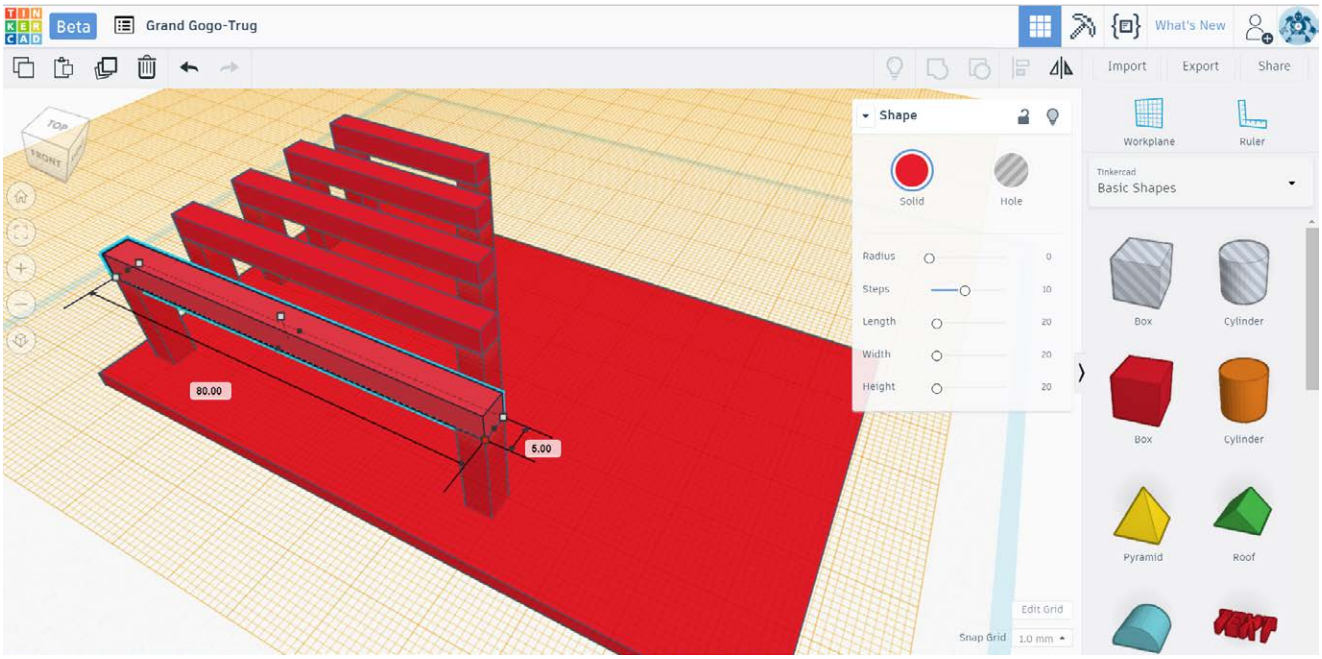
- Hold down shift on your keyboard and click the 3 boxes that represent your first bridge. This will select them all.

- Click the duplicate tool. Then move your copied bridge down until the dimension box says 15mm. Click duplicate 3 more times so that you have 5 bridges in total.

- The first bridge you created has a distance of 30mm between the vertical boxes. Locate the next bridge and move the vertical box on the right to the right by an additional 10mm, making the distance between the vertical boxes 40mm.

- Click on the horizontal box that bridges across the two vertical boxes. Drag one of the white boxes in the bottom corner of the shape across so that the horizontal box sits flush on top of the vertical box you have moved.

- Repeat this step for the remaining bridges, increasing the distance by 10mm each time so your model looks like the below.



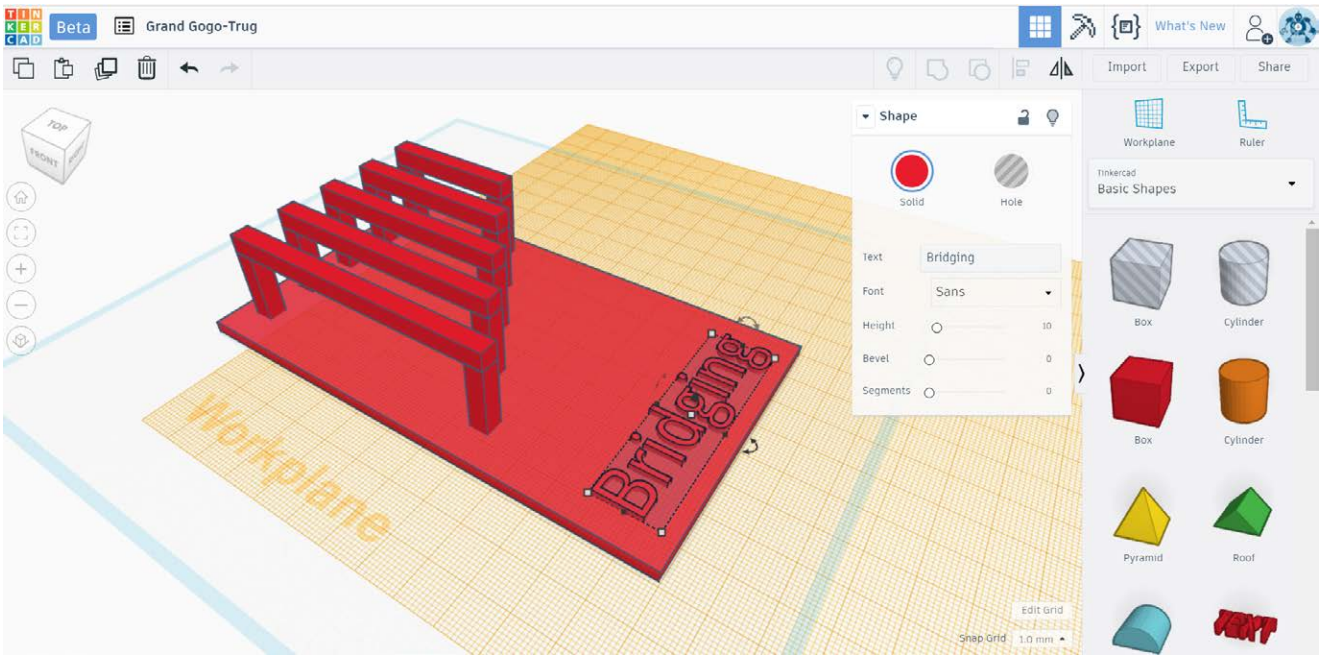
070 Insert Text

CAD to 3D Print

Now we are going to give our model a text label.

- Click the workplane tool and then click again on the top surface of your base. This will allow you to draw directly on to this surface rather than the ground plane.

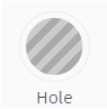
- On the right of your screen click the box where it says basic shapes. This will open a drop down menu. Click text.
- Drag and drop the shape that says Text onto the top surface. In the Shape menu you can amend the text. Amend the text to say 'Bridging'. Click and drag the double ended arrow to rotate the text like the below image.
- Amend the size of the text by holding down shift on your keyboard and dragging one of the white boxes at the corner of the shape. Resize and position it at a similar place as per the below image.
- Click the white box in the middle of the text and amend the height to 1.5mm.



071 Embed Text

CAD to 3D Print

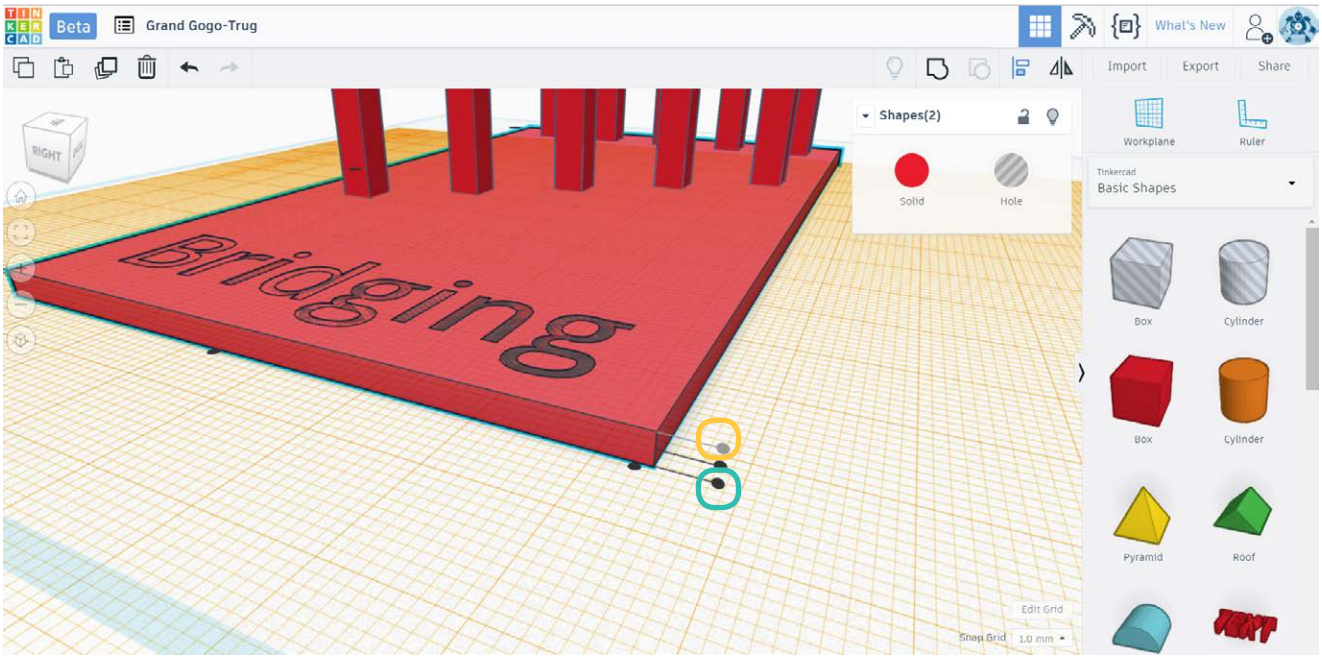
Let's embed the text into our base!



- Click on the 'Bridging' text in your workspace to select it. In the shapes menu, click hole.

- Select your text and the base and click the align tool.
- Click the bottom black circle as highlighted in green in the below image. You will see your text disappear as it is aligned with the bottom of the base. Now click on the top black circle as highlighted in yellow on the below image.

- To embed the text all you have to do is select everything in your workspace and click group. Notice the text has now become a hole in the base?



072 Label Bridges

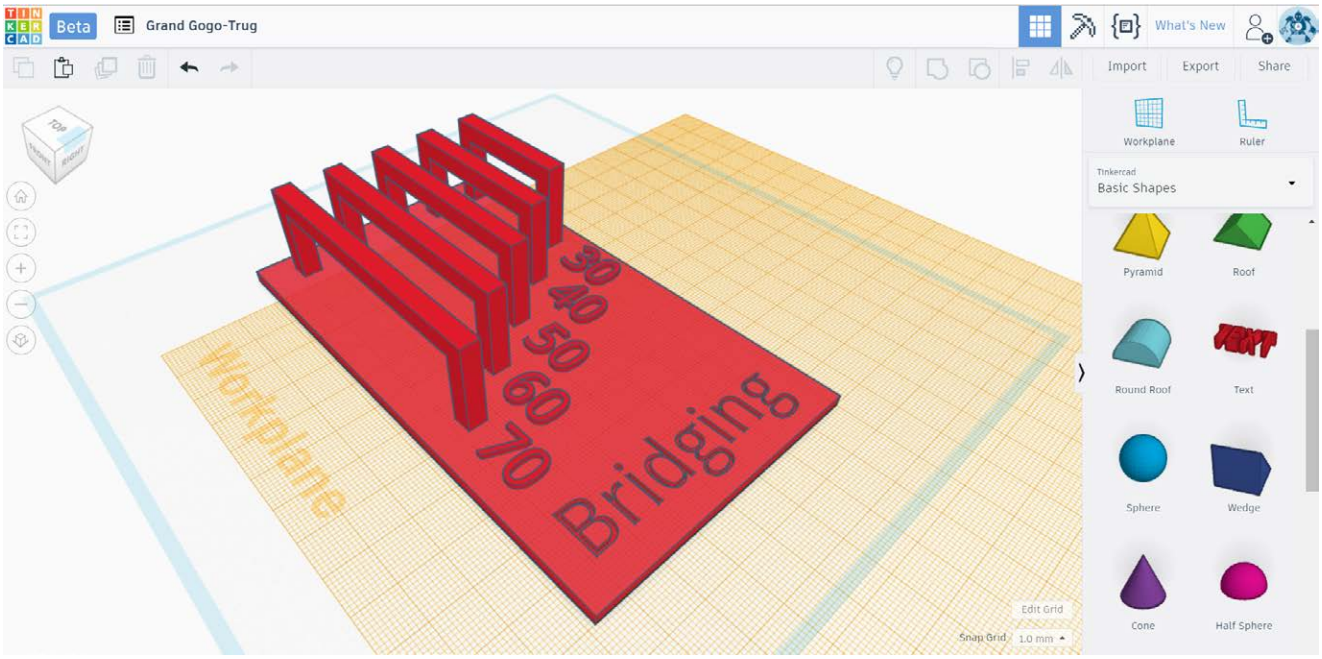
CAD to 3D Print

Let's label each bridge to remind us of their bridging distance.

- With the workplane still on the top of the base, drag and drop the 'Text' shape onto the top surface of the base next to where you drew your very first bridge.
- Change the text to '30' in the shapes menu and resize it so it is approximately the same size as shown in the below image. Next, click the white box in the middle of the text and give it a height of 1.5mm.

- Click the duplicate tool and then move the copied version over so it is next to the next bridge. Repeat this until each box has a label.
- Go through each label and change the text in the shapes menu to match the bridging distance. The labels should be 30, 40, 50, 60 and 70.

- Select everything in your model and click group.



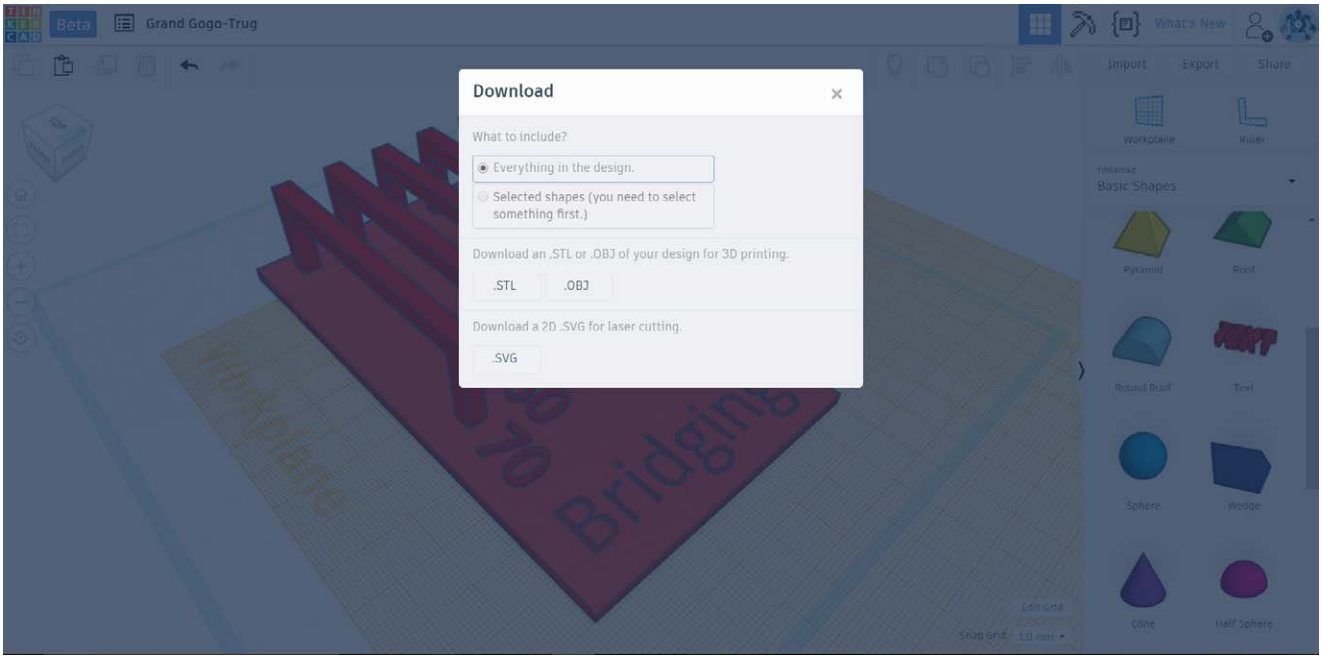
073 Export your Model

CAD to 3D Print

The final step is to export as an STL for 3D printing.

- In the top right menu click export. Once there, click STL and save the file somewhere you will be able to find it easily.
- At the top of the screen you can see the name of your drawing. Tinkercad automatically gives it a name (usually something strange sounding) but you can click on it and change it to something more suitable. All designs are automatically saved in the cloud to your Tinkercad account.

Well done! You've now completed the second visual aid model, one more to go!



Support Model

The above image shows the last model we are going to be designing - the support model. When 3D printed with support structure enabled in your slicing software, the model will have a layer of support material that assists the overhanging features. You can use the 3D print as a visual aid in the classroom and show students how to physically remove the support material.

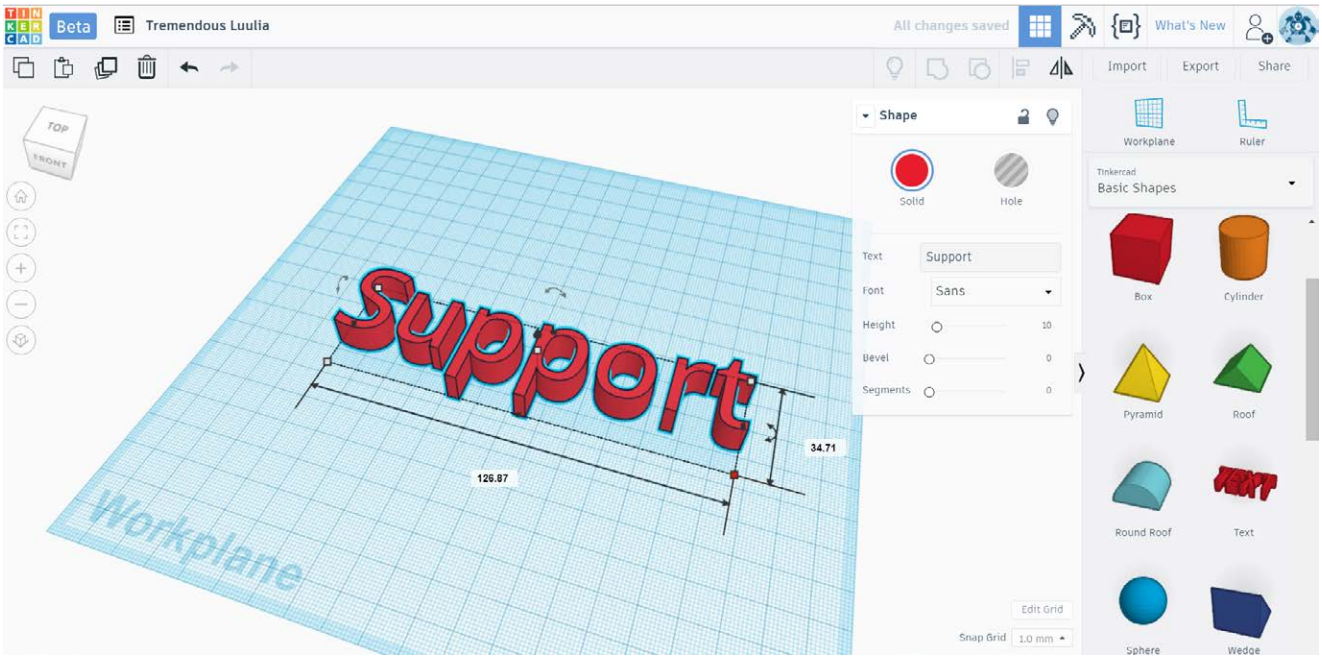
Begin by creating a new design in Tinkercad. If you are within an existing design, click the 'My designs' icon at the top left of the screen and select 'New Design'.

075 Insert Text

CAD to 3D Print

Let's begin by creating a text shape that says 'Support'.

- Drag and drop the shape that says Text into your workspace. In the Shape menu you can amend the text. Amend the text to say 'Support'.
- Amend the size of the text by holding down shift on your keyboard and dragging one of the white boxes at the corner of the shape. Resize and position it at a similar place as per the below image.
- Click the white box in the middle of the text and amend the height to 10mm.



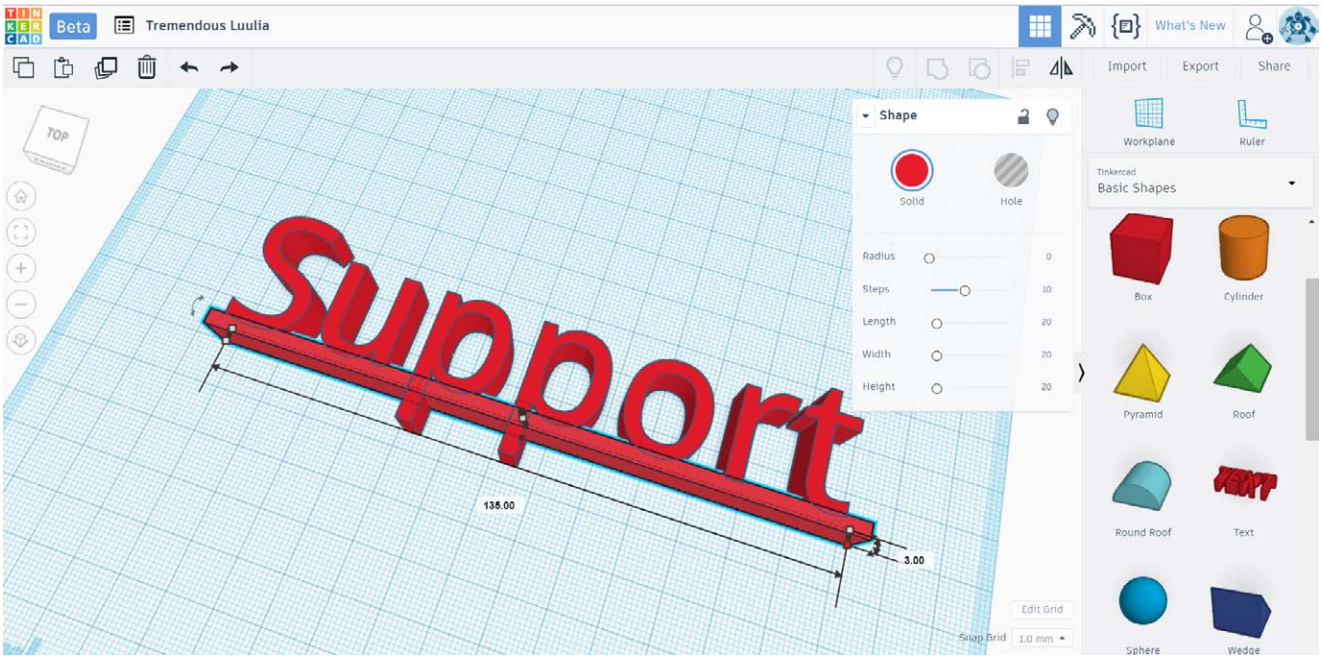
076 Draw a Box

CAD to 3D Print

We are now going to use a box to join up our text to be a single component.

- Use the basic shapes menu on the right of the screen to drag a box onto your workspace.
- There is a white square at the top of the box, this represents the height of the box. Click this white box and give it a height of 10mm.
- By clicking and dragging the white squares at the bottom corners of your box, manipulate the shape and position it so that it looks similar to the below image. Ensure that the box intersects each letter of the text.

- Select everything in your model and click the group tool.



077 Export your Model

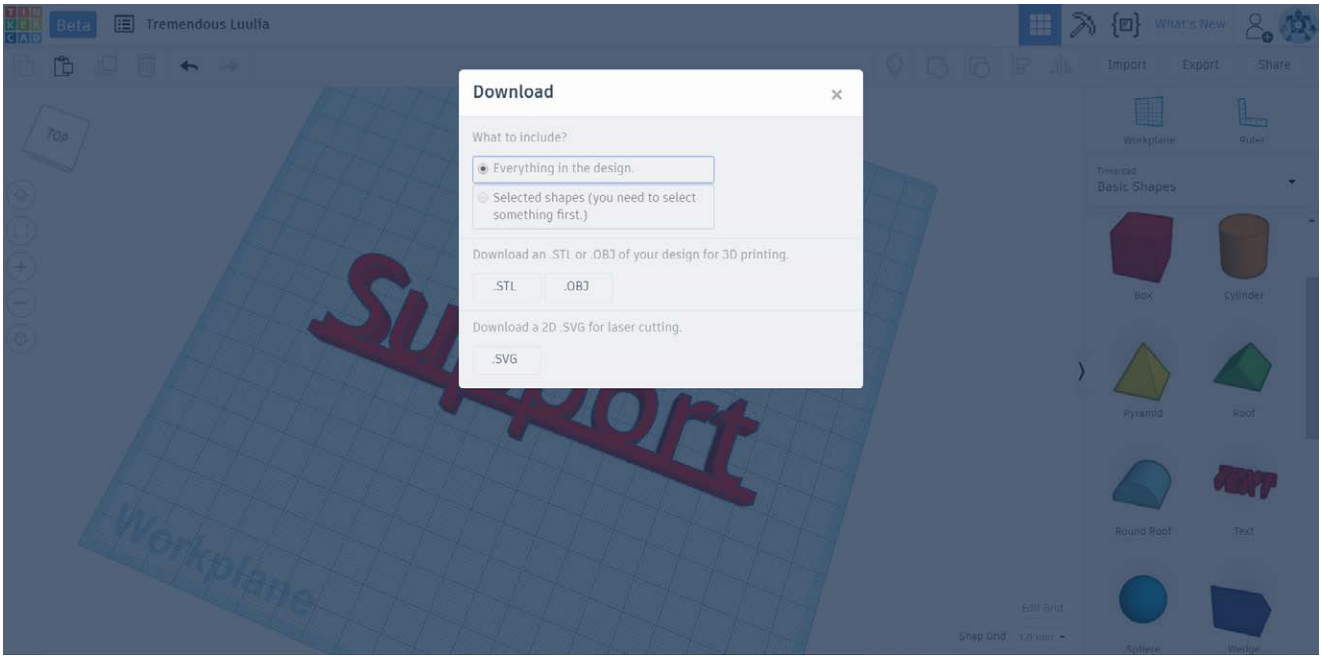
CAD to 3D Print

The final step is to export the model as an STL for 3D printing.

- In the top right menu click export. Once there, click STL and save the file somewhere you will be able to find it easily.
- At the top of the screen you can see the name of your drawing. Tinkercad automatically gives it a name (usually something strange sounding) but you can click on it and change it to something more suitable. All designs are automatically saved in the cloud to your Tinkercad account.

When you upload the STL to your slicer, we'll be rotating the model so that the bottom faces of the 'p' letters are on the build plate. This is not the optimal orientation for the model but we will print it like this to explore the support function.

Well done! You've now completed the last visual aid!



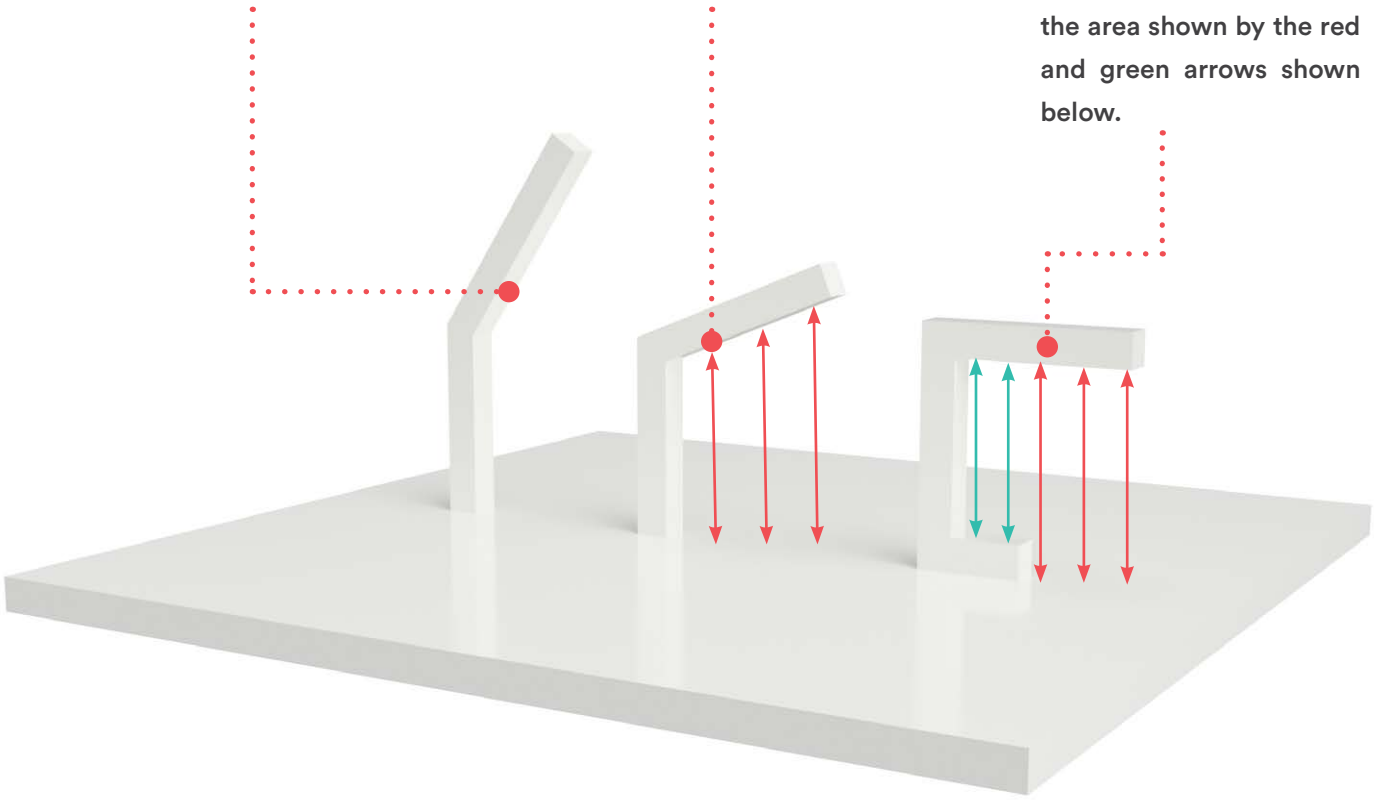
Support Material

Before we slice our models we are going to have a closer look at support structure. If you enable support structure in 3DStar, it will generate and print a temporary structure of lines underneath overhanging features. The temporary structure enables the printer to print steep overhangs and bridges but the surface quality when removed will not be completely smooth. The default setting in 3DStar means that support structure will be generated under overhangs that are larger than 50 degrees.

If 'Out' or 'Full' support was enabled in 3DStar, no support structure would be generated here because the overhanging angle is less than 50 degrees.

If 'Out' or 'Full' support was enabled for this model, support structure would be generated here because the overhanging angle is more than 50 degrees and all overhangs can be supported directly from the print bed.

If 'Out' support was enabled for this model, support material would be generated in the area shown by red arrows below. If 'Full' support was enabled, support material would be generated in the area shown by the red and green arrows shown below.

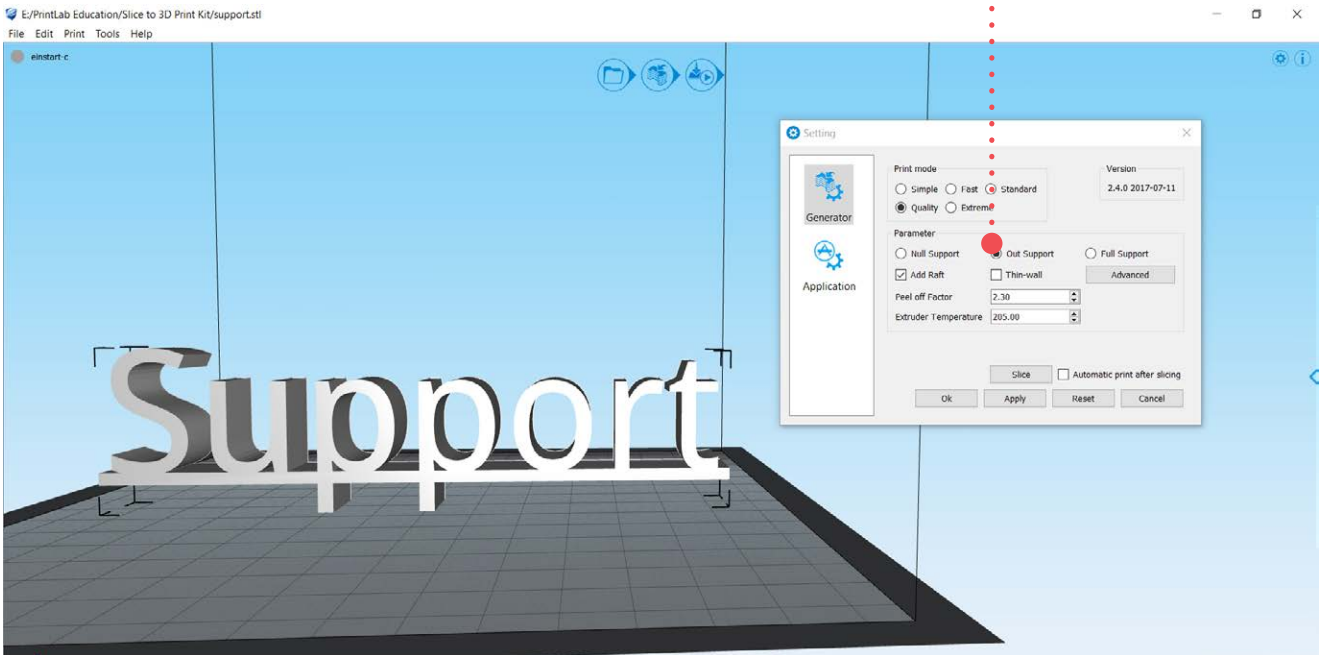


079 3D Printing the Visual Aids

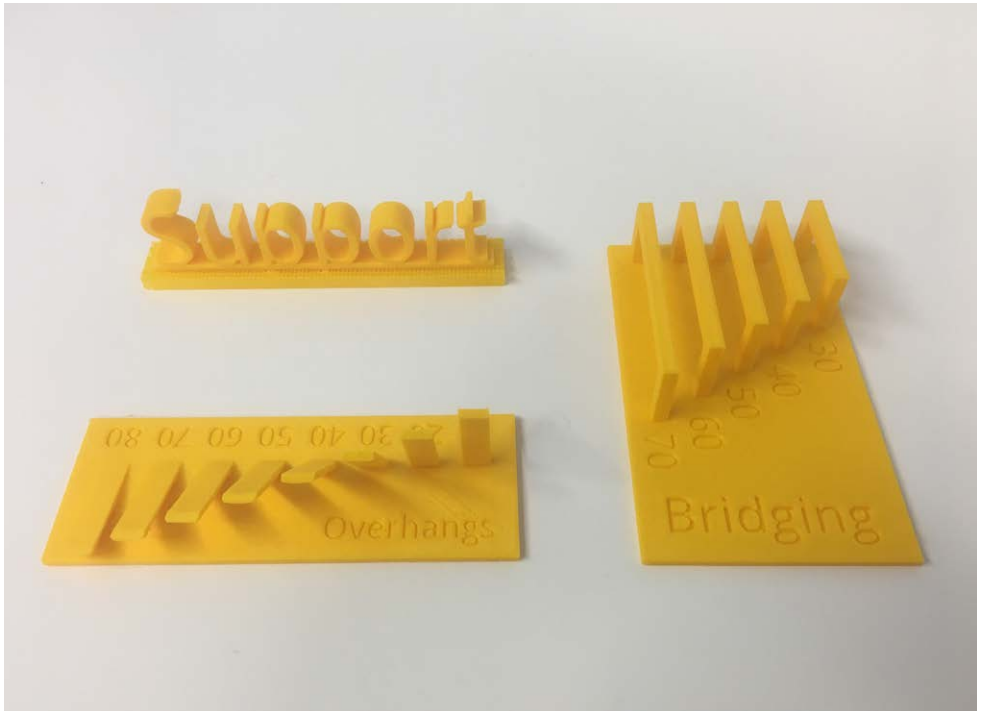
CAD to 3D Print

Print the overhangs and bridging models with the quality setting and see the below instructions to print the support model.

- When you open the support model in 3DStar, rotate it to the same orientation as the below image. This isn't the best way to print the model but that's ok because we are using the model to demonstrate support material.
- In the settings menu enable Out Support. This will generate support beneath the underline of the text.
- Ensure your raft is still enabled, then slice and print!



Analysing the Models



Your printed models should look similar to the above image. Here are some observations to make:

1. On the support model, look at the structure beneath the underline of the text. Squeeze it slightly and you will notice it is relatively fragile. Don't pull the support off just yet, we'll be doing this in front of students in your first 3D printing class!

2. On the overhangs model, look at each box and observe how the surface quality changes as the overhanging angle gets steeper. As you can see, it is very possible to print steep overhangs but the surface quality is compromised.

3. On the bridging model, look at how the longer the bridge, the poorer the surface quality. Similarly to overhangs, you can see that it is possible to bridge across large distances but the quality is also compromised.

Congratulations on completing the CAD to Print process! Let's now look at how 3D scanning can be used to obtain STL files for 3D printing.

6.

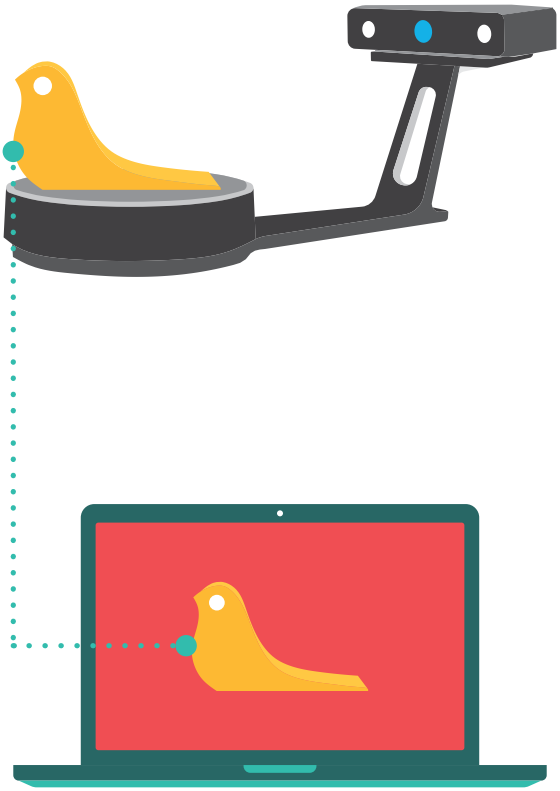
3D Scan to 3D Print

3D scanning can be an amazing way for educators to obtain STL files for 3D printing. Creating complex or organic geometries in CAD can take some time to learn, but with 3D scanning you can turn a real world object into a digital 3D model within minutes! You can either use a scanned model as a base and modify/add to it, or you can send it straight to the 3D printer. In this chapter we'll look at how to set up the EinScan-SE 3D scanner and you'll create your very own functional object for the classroom! If you come across any technical difficulties during this chapter, please refer to the troubleshooting section of the EinScan-SE User Manual. This is located on the PrintLab Education USB stick.


SHINING 3D
SHINING 3D
Ready to Print
SHINING 3D

About 3D Scanning

3D scanning is the process of collecting 3D data of an object's shape and appearance. A 3D scanner can turn physical objects into digital 3D models!



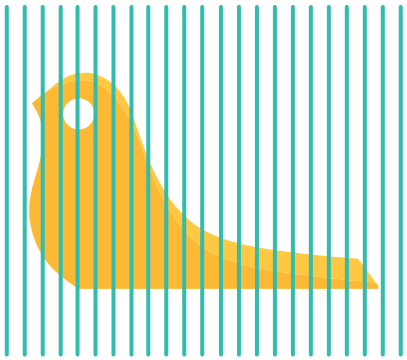
3D scanning opens up a world of opportunities that include:

- Preservation of artefacts
- Ability to reverse engineer products
- Ability to recreate models in a wide range of materials
- Accurate inspection of objects (e.g. precise measurements of distances and surfaces)
- Designing customised products (e.g. prosthetics that fit a patient perfectly)

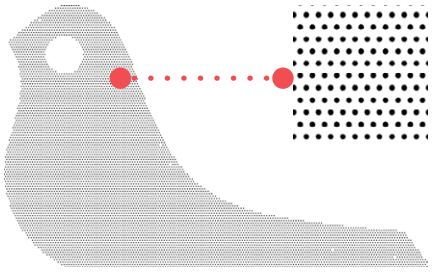
By introducing students to 3D scanning at such an early stage, you can easily obtain 3D files and further down the line you can develop lessons around editing 3D scans for functional applications.

How 3D Scanning Works

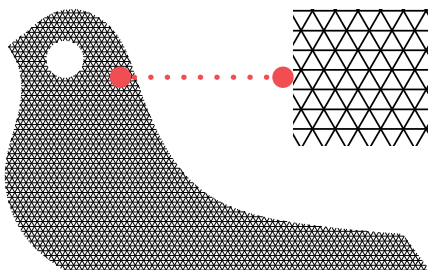
There are various types of 3D scanners - some use laser technology, some take photos around an object - but today we're going to look at Structured Light 3D Scanning. We believe that structured light 3D scanning is the most suitable for the classroom because it is a completely safe light source, as opposed to laser technology that can be harmful to the eyes.



1. Structured Light Scanners project a pattern onto an object. Built in cameras measure the edges of the pattern and through triangulation they can determine the angle and distance of the object from the 3D scanner.



2. This results in something called a point cloud. A point cloud is a set of 3D data points created by a 3D scanner. It cannot be 3D printed because there are no surfaces, only tiny dots in a 3 dimensional space.



3. Models need to be watertight to be 3D printed. Most 3D scanning software packages can easily convert a point cloud into a 3D printable STL file through the click of a button! The software will essentially join up all the dots in the point cloud to create a solid surface.

3D Scanning Applications

Museums

3D scanning is widely being used in museums. Perfectly identical, richly detailed, true-to-scale copies of an ancient artefact or a sculpture also represent an opportunity, not only to preserve but to teach and allow those interested to get hands-on without risking damage to a priceless item.

Medicine/Health

3D scanning enables the design and production of a prosthetic limb that is measured to a remarkable accuracy, meaning maximum comfort, mobility and reduction in pain. Coupled with 3D printing, this process is a fraction of the time and cost of traditionally used methods.

Engineering

Another area with huge potential for 3D scanning is engineering. The ability to scan any object and then use CAD for modification makes both reverse engineering and rapid prototyping an extremely streamlined process. Detailed measurements can be performed and investigation in to mechanical properties is simplified.

Science/Research

Researchers at Drexel University have recently begun 3D scanning and printing dinosaur fossils and building their very own scaled-down robotic replicas. The objective is to see how the dinosaurs bones interacted with one another to create movement and respond to environmental stresses.

Architecture

The ability to scan and analyse buildings in high detail makes 3D scanning a hugely attractive proposition when conducting architectural surveys. 3D scanning provides the user with extremely accurate measurements and the ability to fully utilise, visualise and modify data with CAD.

Design

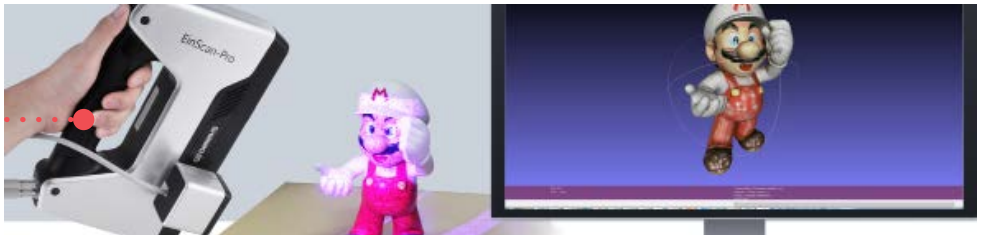
As we continue to design and develop more effective materials for a range of purposes, we commonly look to mimic natural materials for their superior properties, be it plant structures or even fossils. What better way to study these complex arrangements and create a new design than through scanning and studying in high resolution.

Full Body Scanning

Since no two human bodies are the exact same, what better subject to use when creating a unique 3D model. There are numerous services opening up around the world that enable the user to be 3D scanned and take home their very own 3D printed replica model of themselves.

Virtual Reality/Animation

Major games developers have been creating gaming characters with 3D scanning for some time, however as ease-of-use and affordability improves, more small-medium game and app developers can use 3D scanning to give gamers a better user experience.



3D Scanning in the Classroom

The Initial Value of 3D Scanning

Whilst students get to grips with CAD software, 3D scanning is an amazing way to easily obtain files for 3D printing. A popular option for educators is to run a series of hands-on activities where students create models out of clay or plasticine. These objects can then be placed onto a turntable 3D scanner that will give a 3D printable output (STL file). The STL files can then be uploaded straight on to your 3D printer's slicing software, where you can explore a range of options before 3D printing your students' creations.

There can be many lessons taught during this process, such as how obtaining a digital file of a design allows you to explore a variety of manufacturing techniques with different materials. For example, you may wish to create some versions in wood using CNC machinery and some models in plastic using a 3D printer.

Progressing 3D Scanning in the Classroom

As explained on the previous page, 3D scanning is great for obtaining 3D printable files, but its value goes much further than that. Once students become familiar with the 3D scanning process, you can introduce them to more advanced techniques that involve modifying 3D scans.

Take a look at the below image, which shows the pen you have previously printed. The pen was created by clay modelling the shell before 3D scanning it. CAD software was then used to edit the model so an ink cartridge can slot into the middle of the shell when 3D printed.

A lesson plan that we'll look into later enables students to create their own ergonomic 3D printed pens, designed uniquely to suit their grip. This exact same process of scan, edit, manufacture is widely being used in the product design industry. By introducing students to this process at an early stage, they can relate to real-world applications - something that is essential to prepare them for their future careers.

Meet the EinScan-SE

We are now going to set up the EinScan-SE, but first of all here is some general information. The EinScan-SE is the next generation of desktop 3D scanning. It has been designed so that even non-technical users can use it without difficulty. The EinScan-SE is the perfect companion for the classroom, simply point and click to turn physical objects into digital models. Let's take a look at some of the features of the EinScan-SE:

Fast Scanning

The EinScan-SE is capable of scanning at a speed of 8 seconds/scan. This means that when using the turntable mode, it takes just 2 minutes for a full 360 degree scan.

Fine Details

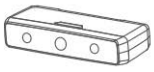
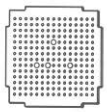
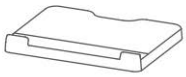
Using innovative structured light technology, the EinScan-SE can scan details up to an amazing accuracy of 0.1mm - 5 times more accurate than other scanners in the same price range.

3D Printer Compatibility

The EinScan-SE is a one-click scanning solution. The software automatically meshes scan data to create watertight 3D data that can be sent directly to the 3D printer.

Unboxing

Let's now go through the setup process. The instructions in this manual act as a quick guide to getting started. If you require further instruction, please refer to the EinScan-SE user manual provided on the PrintLab Education USB drive. Take out the contents of the box and make sure you have the below contents:

 Scanner Head	 Turntable	 Scanner Stand
 Scanner Bracket	 Calibration Board	 Calibration Holder
 Power Cord	 Power Adapter	 USB Cable A
 USB Cable B	 Quick Guide	

To run EinScan software you will need a computer with the following requirements:

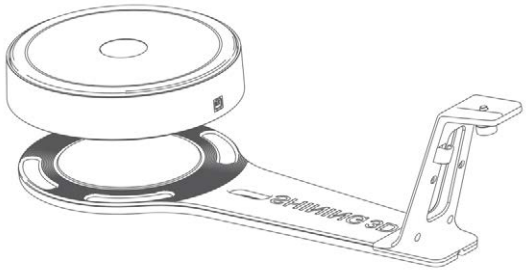
Operating System: Win7/8/10/64bit
Port: Minimum of 1 x USB 2.0 or 3.0
RAM: >8G
Graphics Card: NVIDIA Series (or equivalent)
Graphic Memory: >1G
CPU: i5 or higher

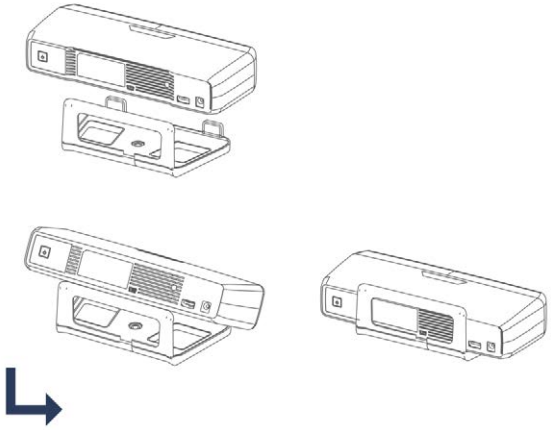
089 Scanner Assembly

3D Scan to 3D Print

1. Turntable Assembly

Place the turntable onto the scanner stand.



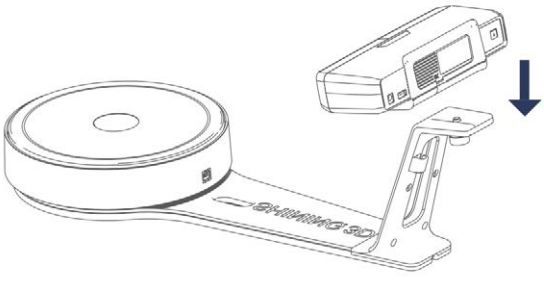


2. Scanner Head Assembly

Place the scanner head onto the bracket.

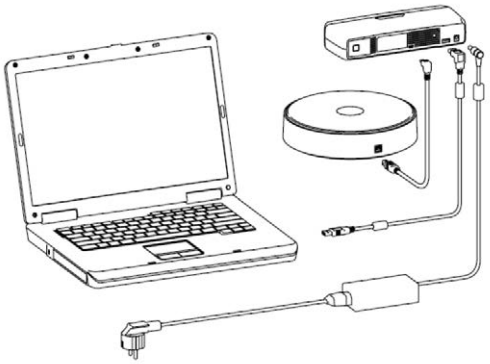
3.

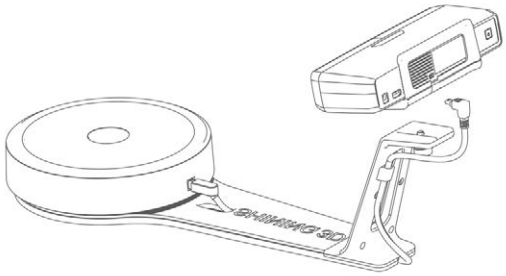
Screw the scanner into the socket on the stand



4. Computer Connection

Connect the USB cable into the back of the scanner and the computer's USB port.



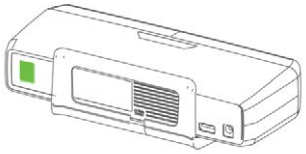


2. Scanner-Turntable Connection

Plug the USB cable in the stand into the back of the scanner and turntable.

6. Power Connection

Plug the power cord into the mains and back of the scanner. Press and hold the touch switch for 1 second to turn the scanner on.



Software Installation

1. Download Software

Download EinScan-SE software and user manual from www.einscan.com/software-download

2. Run Installer

Double click the downloaded setup file to run the installation wizard. Follow the installation instructions.

3. License Acquisition

During installation, you need to obtain a license file online to activate your scanner. Make sure the scanner is well connected and your computer is networked. Click 'Online Activation' when prompted.

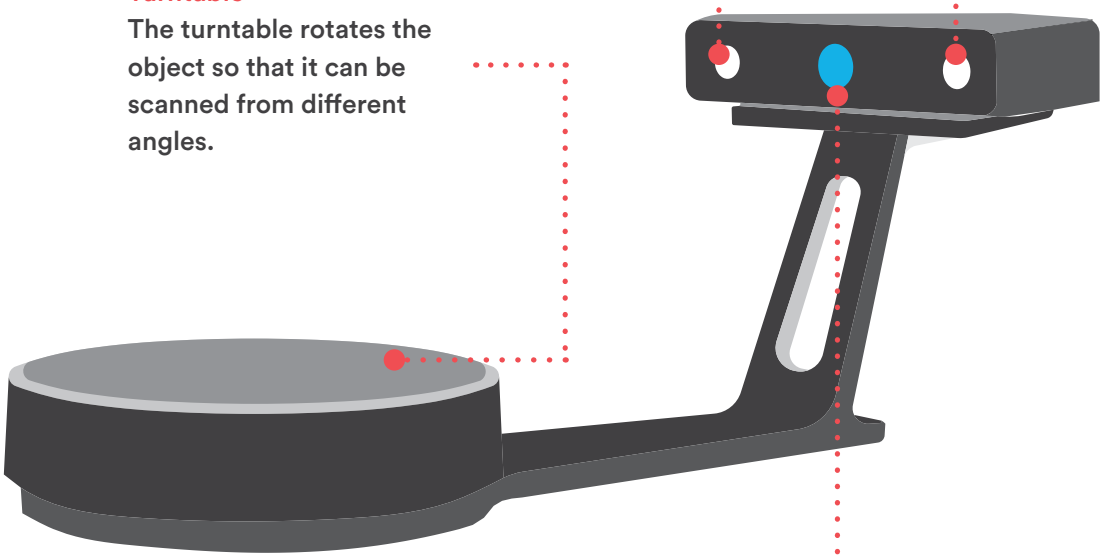
If the license acquisition fails using the online activation, contact your supplier to obtain a local activation code.

Elements of your 3D Scanner

Now that the scanner is set up and software has been installed, let's take a quick look at the elements of the EinScan-SE.

Cameras
The cameras measure the distance and angle of the patterns on the object.

Turntable
The turntable rotates the object so that it can be scanned from different angles.



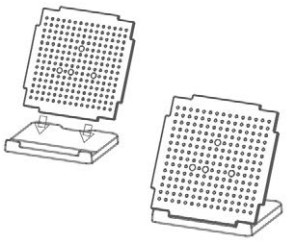
Projector
The projector is the part of the scanner that shines light and patterns on to the object.

Scanner Calibration

We are now going to run the calibration process. This short process adjusts and optimises the software and hardware to enable accurate scans. You should run calibration in the initial setup, if the scanner has been in transit with strong vibrations or if the scan quality/alignment appears incorrect.

1. Assemble Calibration Board

Insert the calibration board onto the board holder.



2. Place Calibration Board

Place the calibration board on the centre of the turntable facing the scanner head.

3. Run Calibration

When you open the software, select EinScan-SE and click Next. Then click the Calibration button and follow the on-screen instructions.

The board holder should remain still throughout the calibration process. If you struggle to keep the holder still, simply attach some blu-tack to the bottom of the holder and repeat the process.

Scanning Considerations

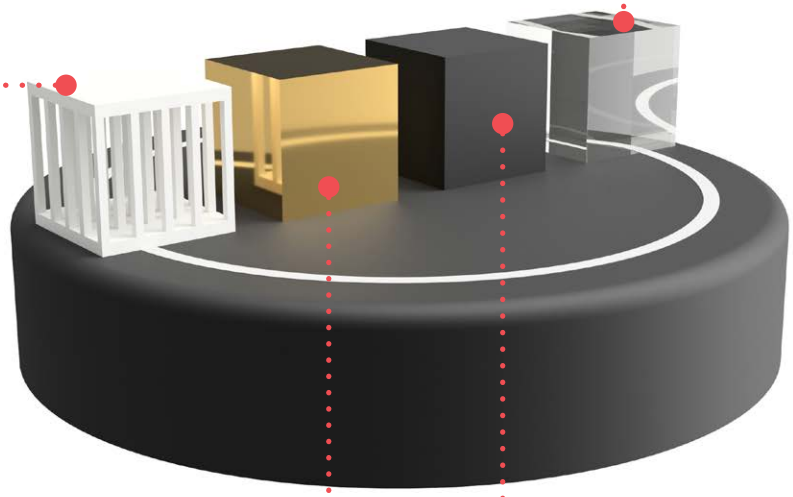
Before we start 3D scanning, it is important to understand that there are certain limitations with all light-based scanners. The below diagram shows different objects that may be difficult to scan:

Complex Internal Geometries

The projector and cameras must have a direct line of sight to the surface in order to record data from it. Therefore models with complex internal geometries or deep holes are difficult to scan.

Transparent/Translucent Objects

When the light and pattern from the projector hits a transparent or translucent object, it will pass through the surface. Therefore any data recorded by the cameras will be inaccurate. A common way to prepare models that are transparent/ translucent is to spray them with temporary white paint or cover them in white powder.



Shiny Objects

When the light and pattern from the projector hits a glossy surface, it will reflect - this also causes inaccuracies. Similarly to transparent objects, shiny objects can be prepared for 3D scanning by applying white paint or powder.

Very Dark/Black Objects

When the light and pattern from the projector hits a very dark surface, it will be absorbed. The scanner is unlikely to pick up much data from a black object. Again, they can be prepared with white paint or powder.

Selecting a Scan Object

We are now going to look at the process of creating a 3D scan on the EinScan-SE's turntable. Throughout the handbook we will be focusing on the Auto Scan (turntable) mode only. This allows you to scan objects from 30×30×30mm to 200×200×200mm. To scan larger objects you can mount the scanner head onto a tripod and use Fixed Scan mode (see EinScan-SE user manual).

First of all, you need to find a suitable object to scan. Ask yourself whether the object fits the following criteria. If it does, then it should be suitable for 3D scanning.

Object Checklist

- [ ] The object is larger than 30×30×30mm
- [ ] The object is smaller than 200×200×200mm
- [ ] The object is not glossy, transparent or black
- [ ] The object does not contain large holes
- [ ] The object is a single piece

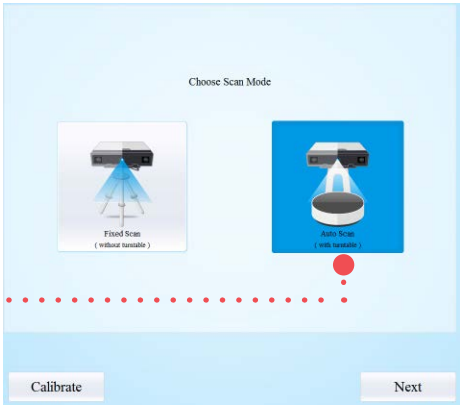
Here are some final 3D scanning tips:

- White coloured objects produce the best scanning results.
- If your object has small parts where it is black/very dark, this should still be able to scan. The scanner may not pick up some of the black areas but when you mesh the object after scanning, it will close up any holes.
- Objects with extremely thin walls or fuzzy features like hair may struggle to scan.
- Place the scanner in a low-lit area away from natural light. For optimal results, place it in a dark area of the room.

The Scanning Process

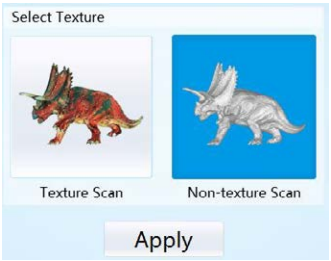
You should now have selected an object to scan! Go through the below instructions to create your first scan. Then experiment with other objects. Don't be afraid to try difficult objects, it may even be useful so you can learn more about the outcomes you achieve with different types of models.

1. In the software, once you have selected your scanner model, select Auto Scan and click Next.

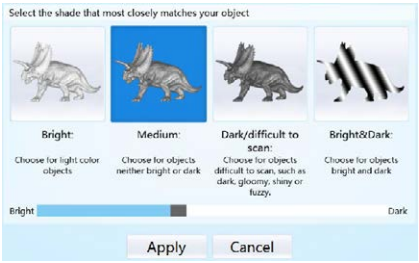


2. Click New Project, enter a relevant file name and then click Save in a relevant location (the default is desktop).

3. Select Non-texture Scan and click Apply. If you want to experiment with Texture scans, please see the EinScan-SE user manual.

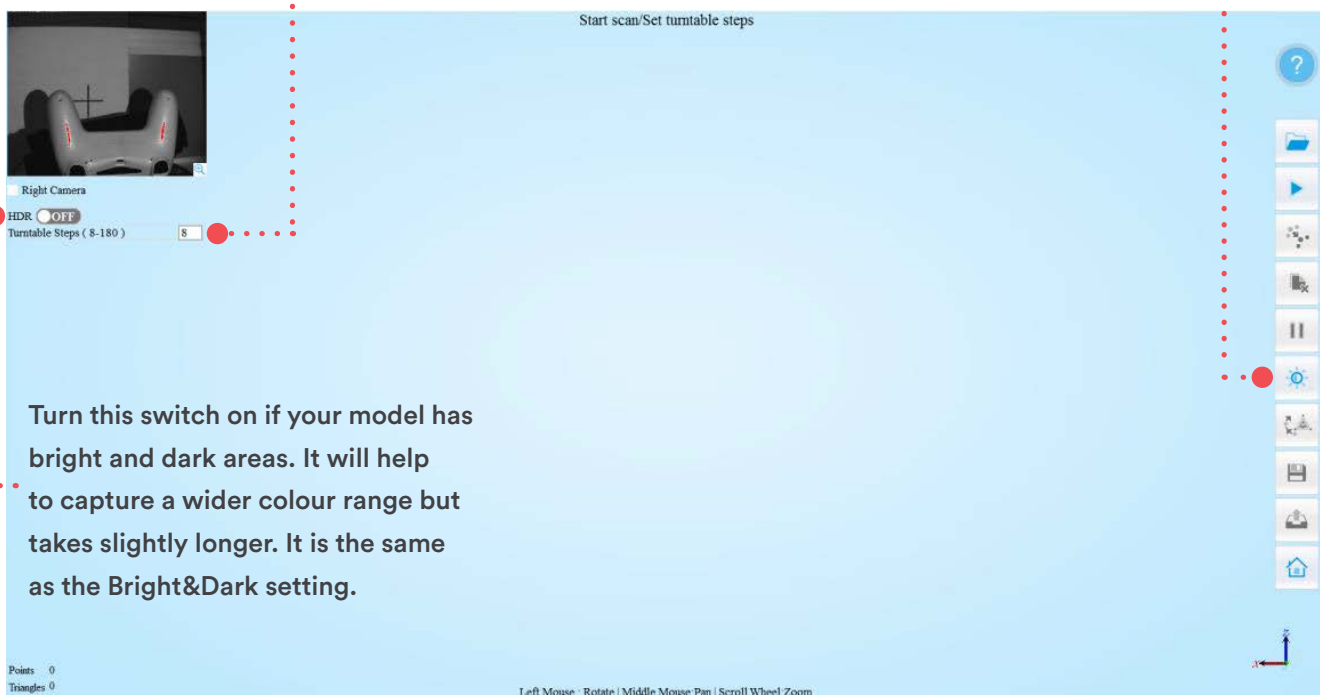


4. Place your object in the middle of the turntable. You will be prompted to choose a brightness setting. Take a look at your model on the screen, it should be in view of the cameras shown within the software. Adjust the bright/dark slider accordingly until you can see your model clearly but it has little/no red highlights. The red highlights are areas of overexposure. If your model is both bright and dark, select the Bright&Dark option. Click Apply when you have chosen the correct setting.



5. Once you have entered the scanning interface, you can also amend the brightness setting by clicking the Brightness icon.

You can also change the number of scans to run in a 360 rotation (turntable steps). The default is set to 8 but you can increase this to capture more data.



Turn this switch on if your model has bright and dark areas. It will help to capture a wider colour range but takes slightly longer. It is the same as the Bright&Dark setting.

6. To start the scan, click the Start Scan button.

7. Observe how the scanner projects a pattern onto the model and how it rotates to different positions until it has done a complete 360 degree scan. As each scan is made, you will see a preview of your model appear! The software automatically stitches the individual scans together, so you don't have to. You can zoom in and out by scrolling your mouse wheel. To orbit around your model, left click and drag your mouse. To pan across your model, hold down the mouse wheel whilst dragging the mouse.

8. After 2 minutes your scan will be complete and you have the options to accept or delete the scan. There are also some editing tools that allow you to delete unwanted parts of the scan. Here's how to operate them:

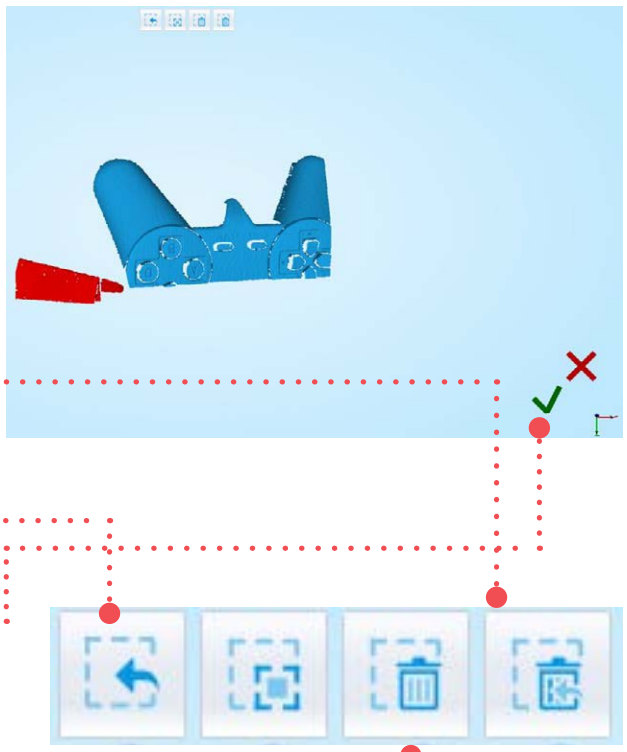
To select unwanted data press Ctrl+left mouse button and drag a loop around the unwanted points. The selected points will be highlighted in red.

To delete the points press the Delete icon.

You can press the Undo button to go back a step.

To deselect all highlighted points, click the Deselect icon.

Once you have completed editing, click the Tick.



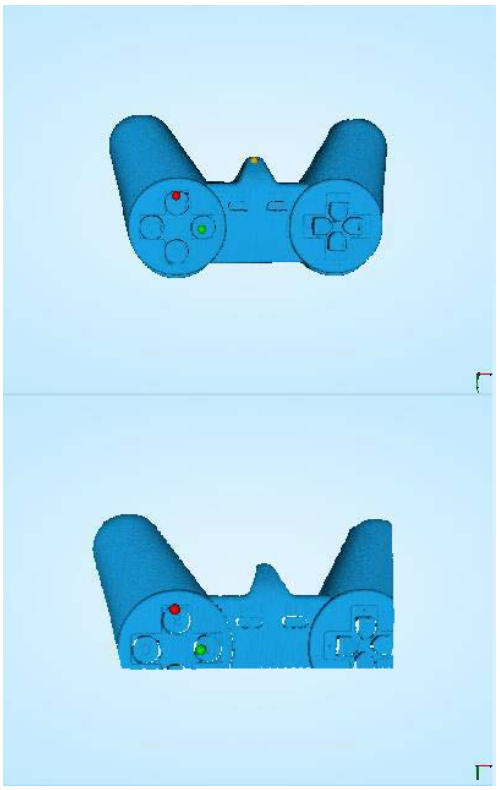
Additional Scans

Depending on the shape of your model and the orientation it was scanned at, you may want to run an additional scan after rotating your object to a different angle on the turntable. The automatic alignment features of the EinScan-SE make this extremely easy.

Once you have accepted your initial scan, simply rotate your object on the turntable and press the Start Scan button again. A second scan will be generated and once you click the tick to accept, both scans will automatically mesh together. Give this a try with your model!

Manual Alignment

If automatic alignment fails, you can also align 2 scans manually. To do this click the Align button. 2 Screens will appear showing both the separate scans. Rotate both models and find a common scanned area. Hold down Shift and Left Click on a point in one of the scans. Hold down Shift and click the same point in the second window. Repeat this for 2 additional points (space them out if possible). Once 3 points are selected, the manual alignment will take place.



You can rotate your object on the turntable and run as many scans as required. Don't worry too much if every single part of your model has not been scanned because the software's meshing feature will patch up any small holes. If you are not happy with the current scan, you can press the Delete button to revert back to the previous scan.

Meshing

Once you are happy with your scan, you now need to mesh it into a solid object so it can be 3D printed. EinScan's software will automatically create a watertight model ready for 3D printing. Follow the below steps to mesh your model.

1. Click the Mesh icon.

2. Click Watertight Model.

3. You will then be prompted to select the level of detail required. You may be tempted to always select High Detail, but for 3D printing in the classroom we actually recommend Medium or Low Detail. This is because it will generate a manageable file size and when 3D printed, you will not notice much difference between a High Detail and Low detail model.

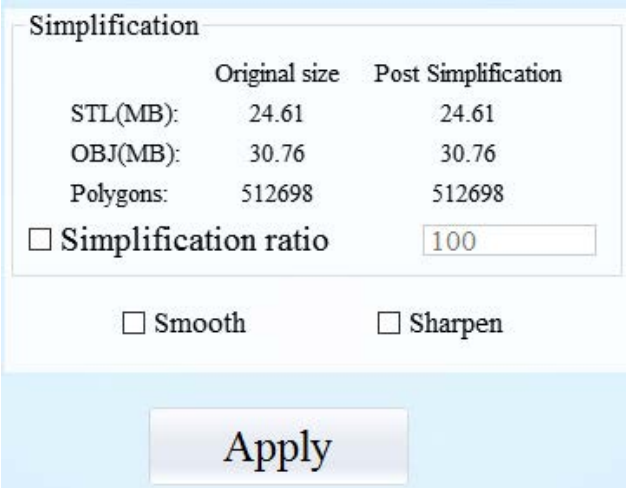
101 Simplification

3D Scan to 3D Print

When your scan has been meshed, a simplification window will appear. This allows you to do a range of functions.

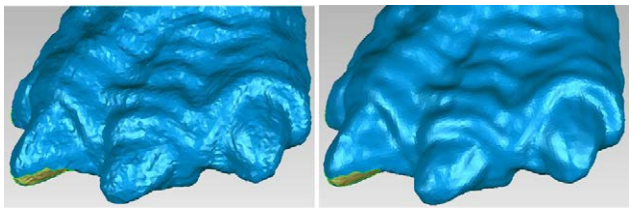
Simplification

You can reduce the file size of your model by entering a % for the simplification ratio. Try typing some numbers in and watch how the post simplification STL file size changes. Ideally, you want your model to be between 10-20MB for 3D printing so adjust accordingly.



Smooth

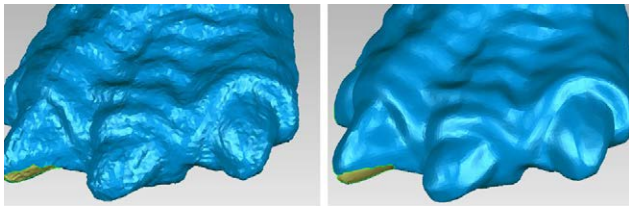
The image on the right shows the before and after effects if the smooth box is checked.



Before After

Sharpen

The image on the right shows the before and after effects if the sharpen box is checked.



Before After

Once you have chosen your simplification settings, click Apply. Then click the Save icon to save your model as a STL file. When prompted about scale, keep the scaling ratio at 100 if you want the model the same size as the scanned object. Once saved click the Home icon to go back to the homepage.

Sculpt, Scan, Print Exercise

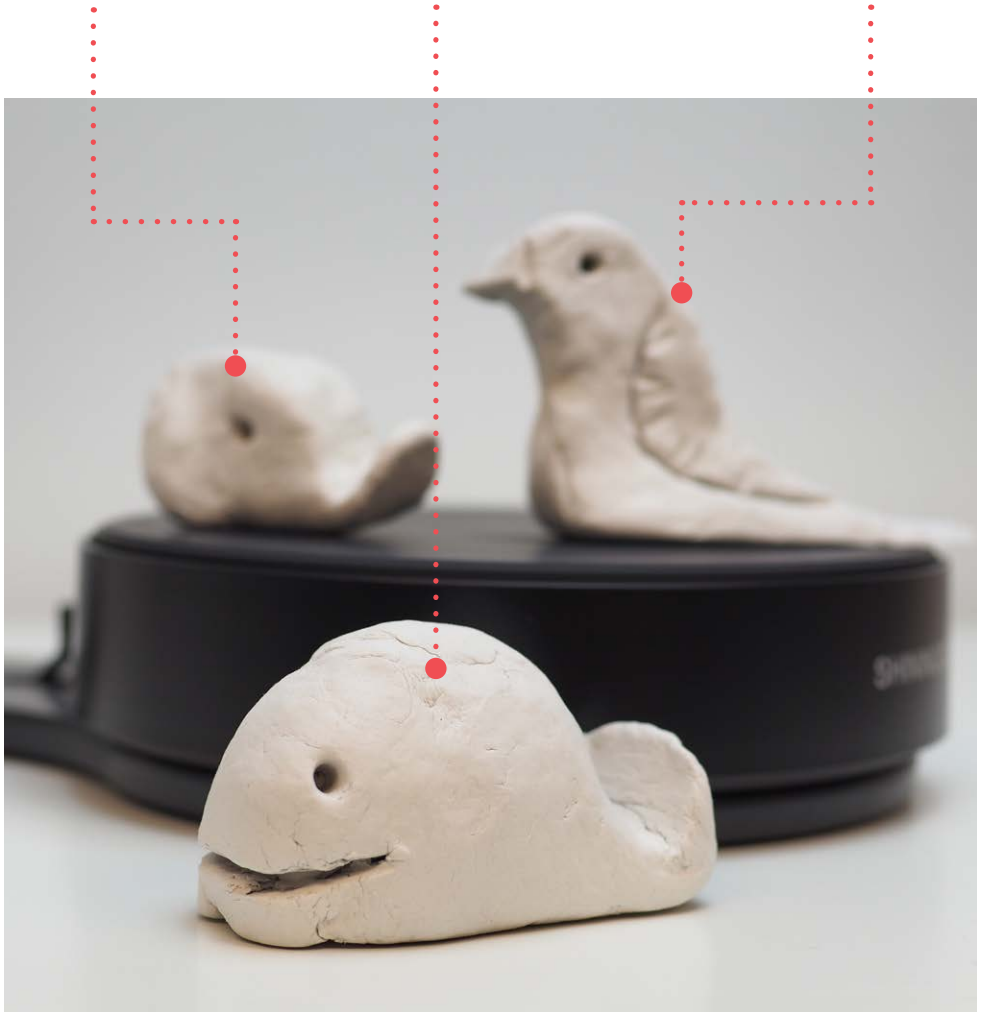
After experimenting with a range of objects, let's now create your own original design! For this exercise, use white air-drying clay or something similar. Take a look around your classroom and think of an object that you might want to 3D print. Some ideas include a doorstop, coat hook, tablet holder, desk organiser, cable tidy etc.

Start by sculpting your object and keep in mind the scanning considerations that you have learnt in this chapter. Here are some animal-themed creations we made:

Coat hook

Tablet holder

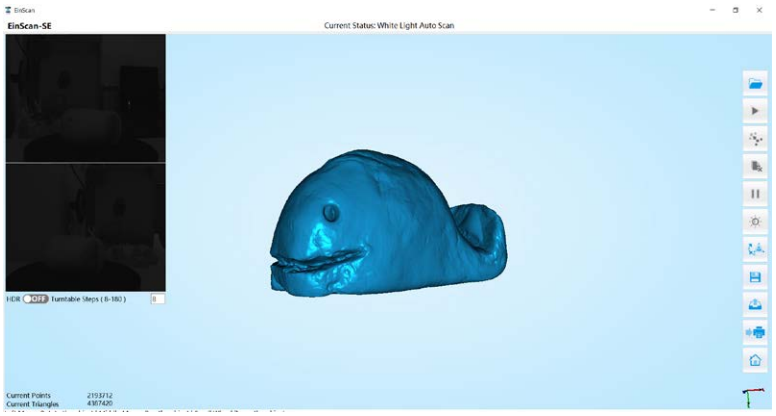
Door stop



Scan your Classroom Object

When your model is completed and dry, place it in the centre of the turntable and begin the scanning process.

Rotate your object and run another scan if necessary to capture all the details, then mesh your model to make it 3D printable.



When meshing, don't forget to simplify your model so that the STL is between 10-20MB. This will make it a manageable file size for 3D printing.

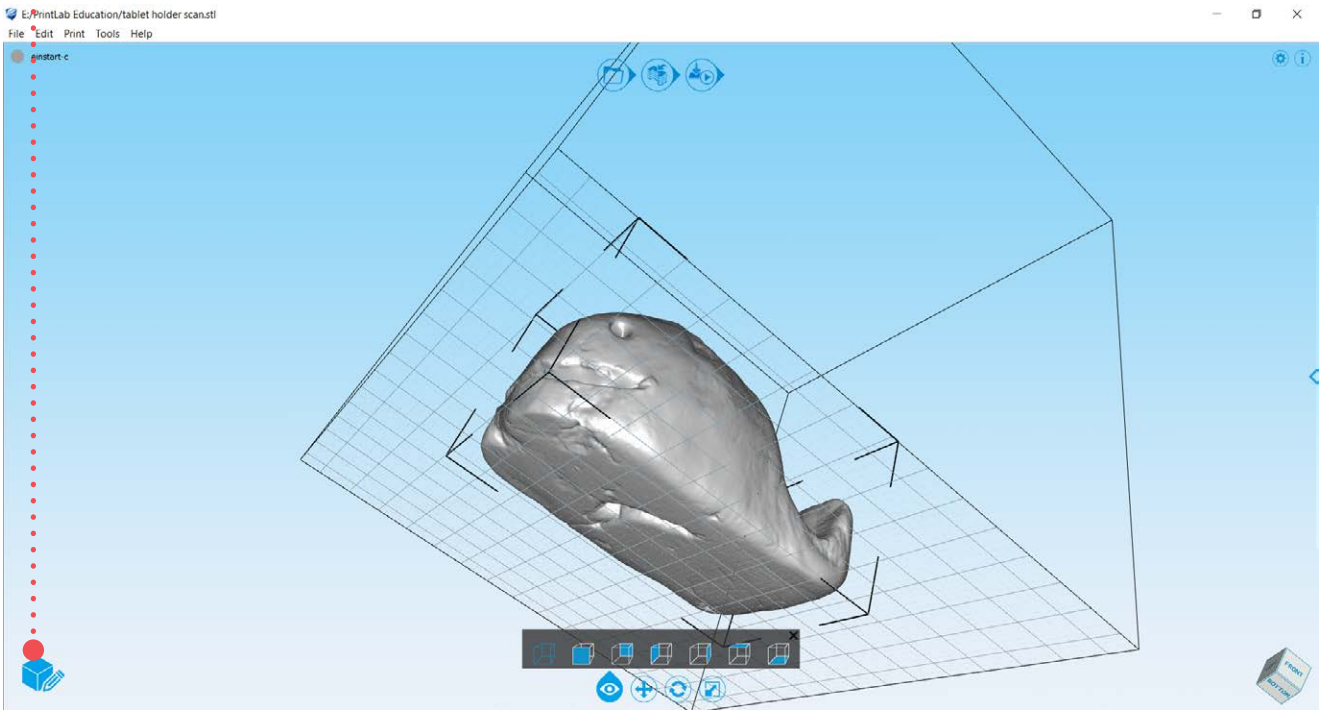
Once meshed, don't forget to save the model as an STL file! We'll now look at the process of uploading your model into 3DStar for 3D printing.

Slice your Classroom Object

Open your STL in 3DStar. Rotate and position it to an optimal position on the print bed. To ensure your print adheres to the print bed, it is best to have a flat surface on the bottom. Your scan may not be completely flat like our example shown below.

There is a cutting feature available in 3DStar that allows us to create a flat plane cut. We will be using this to slice a small part off the bottom of the model to make it completely flat.

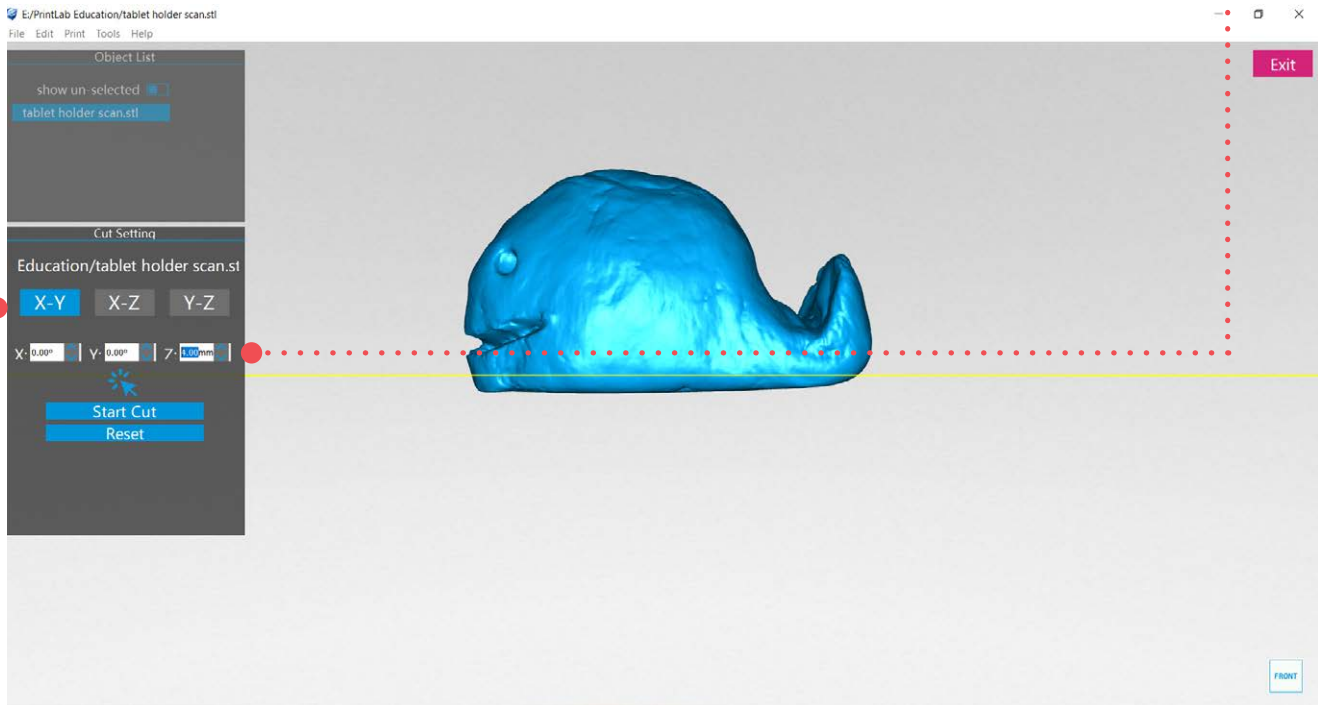
The feature is in the Advanced Edit mode. To enter this, click the icon at the bottom left of your screen.



- In the Advanced Edit Mode, click the Cut button.
- You will then see a yellow plane appear, this is your cutting plane. In the cut setting menu you will see 3 buttons X-Y, X-Z and Y-Z. Click each of these and take note of how the plane changes to a different axis.

- Click the X-Y plane, then in the Z box below, click the arrows to move the cutting plane towards the bottom of the model as shown below. When it is in the correct position, click Start Cut and once processed click Save Result.

- Click the Switch Scene button to go back to the main screen. Now click on the top of your model and the bottom of your model. You will see that it is now 2 separate models.
- Click the bottom section of your model then press Delete on your keyboard. Move the cut model so it is flat on the print bed.
- The final step is to slice the model using the print mode of your choice to generate a GSD file for 3D printing.



Print your Classroom Object

Upload your GSD file to the EinStart-C and begin the printing process.

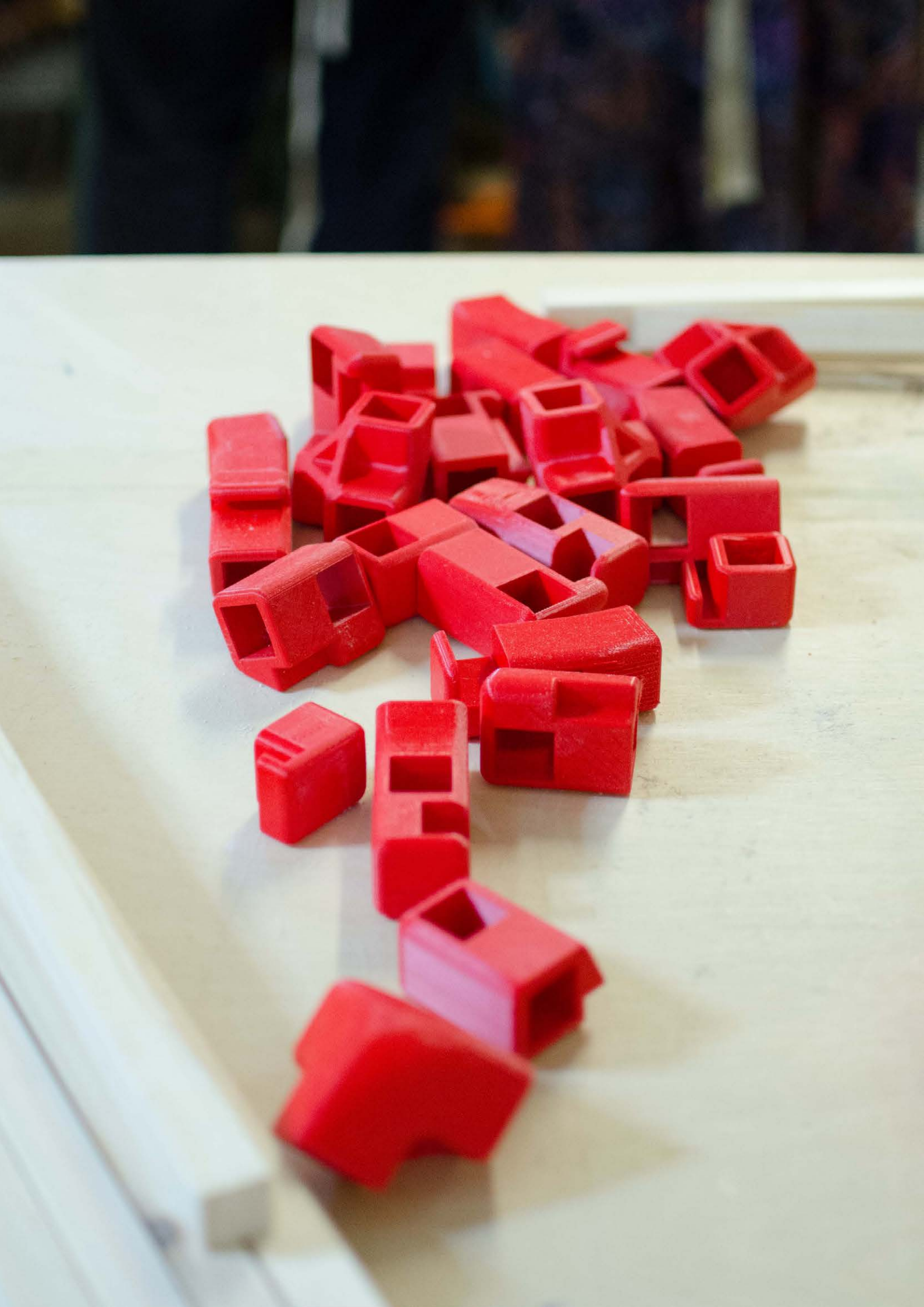
Combining sculpting, 3D scanning and 3D printing is a great way to create organic shaped objects that may be difficult to model in CAD software. Keep your clay model and 3D print in a safe place.

In your first 3D scanning lesson with your students, you will be introducing them to the same activity you have just done. At the end of the project, you will have a range of new classroom objects!

7.

Time and Cost Calculations

Two big considerations for integrating 3D printing in the classroom are time and cost. The 3D printing process can be very time consuming, depending on the size of models you print. Throughout this chapter you will go through activities in 3DStar to determine how long various prints take and how much they will cost. The printing information provided in 3DStar coupled with the price of your filament, gives you the details needed to calculate time and cost accurately.



Calculating Filament Costs

To work out the cost of a model or a series of models, we need to gather some details to find out how much 1g of filament costs. Answer the below questions, you can either write directly in this book or use a sheet of paper.

1. What is the weight of one of your filament reels in grams?

_____

2. What is the cost of one of your filament reels?

_____

The calculation to work out the cost of 1 gram of filament is:

cost of filament reel / weight of filament reel

e.g. If your filament costs $35 and the weight of filament is 750g, the cost of 1g of filament = $0.05.

3. What is your cost of 1g of filament?

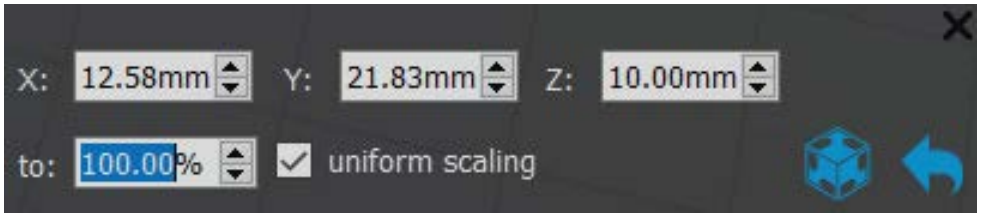
_____

Cost of a Small Model

Now you know the cost of 1g of filament, let's upload a model to 3DStar and experiment with various settings.

1. In the PrintLab Education USB stick, go to the Calculation folder and open cost.stl in 3DStar. Then click the Scale icon.

2. You will now see the Scale menu appear at the bottom.



3. The X, Y and Z values represent the size of the model uploaded. We'll keep them as they are at the moment but now you know roughly how big the model would be if it was printed.

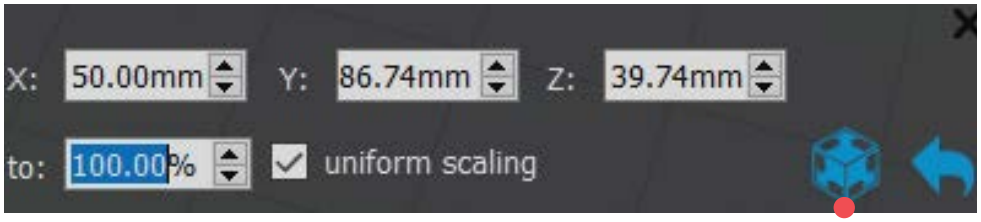
4. In the settings menu, select a Standard print mode and slice the model.

5. The printing information will appear and the top right icon states the mass of the filament it will use. Multiply this number by the cost/gram you worked out on the last page - this will be the material cost of this model!

Cost of a Large Model

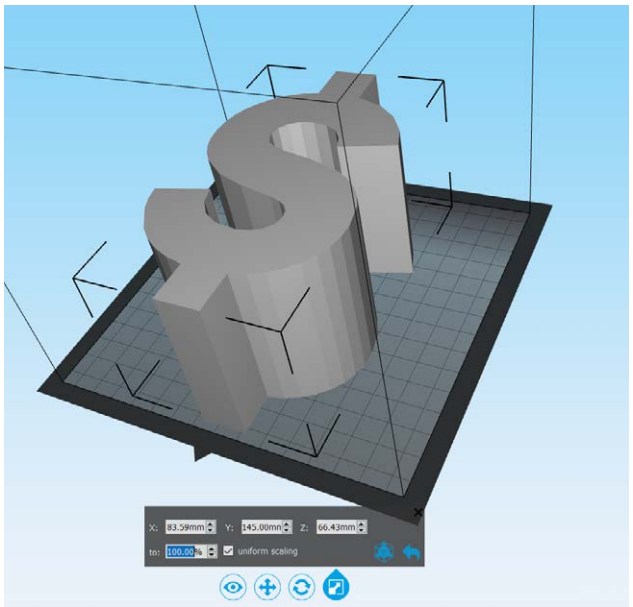
Go back into the Scale menu using the same cost.stl file. Let's explore the cost of the same model but this time we are going to enlarge it.

1. Try typing different values into the X, Y and Z boxes. Keep Uniform Scaling checked, otherwise this will only scale your model in 1 axis. Observe how your model changes size in the print preview area.



2. Click the to Maximum button. This will enlarge your model to the maximum size on the print bed.

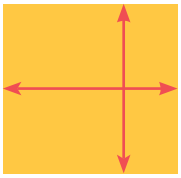
3. Slice the model using the standard setting again. Calculate the cost of this print as you did on the last page. You will notice a big difference in cost. If you want students to 3D print their own individual models, it is important to consider the cost of printing large models like this.



Classroom Tips for Costing

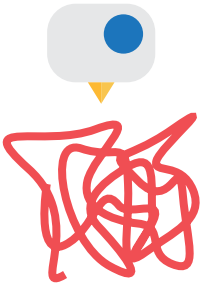
1. Keep a Log

It can be very helpful to keep a simple log of the amount of filament being used over a period of time. Take note of how the amount changes over time - is it increasing as more students gain access to the 3D printers? This will help you when budgeting for materials. In addition to the amount of filament, keep note of what specific type and colour of filament is being used. You may find that certain colours are more popular than others and you should therefore place your orders accordingly.



2. Set Design Criteria

Some students may be tempted to print their designs as big as possible! It's always good to set some design criteria, for example tell you students that their designs must fit within the dimensions 50×50×50mm. This also gets them thinking about real-world applications, where most designs have a set brief to follow.



3. Budget for Failed Prints

Although 3D printing has come a very long way in recent years, you will still come across failed prints. This isn't always to do with the hardware or materials - infact the majority of the time it may be that designs haven't been optimised for 3D printing. An example of this is if a student creates a design that has holes in the model, resulting in a failed print. When budgeting for materials, keep this in mind and include failed prints in your log.

4. Group Work

In addition to individual projects, encourage students to work in groups. This again relates to real-world applications because it is rare that architects or engineers will work on projects alone. By working in groups it reduces the amount of printing, but still engages each student in the design process.

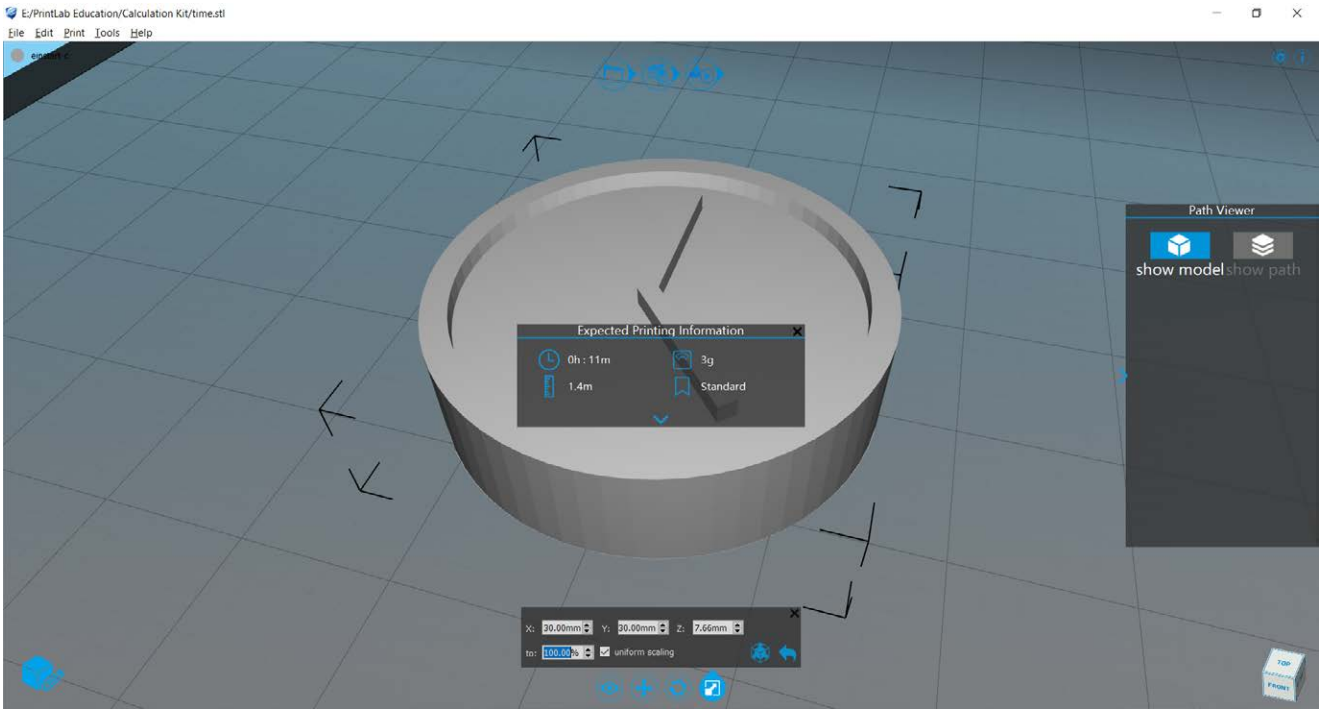
Print Time of Small Models

We are now going to run some similar exercises to look at how different sized models affect printing time. We are going to assume that we have 20 students working on individual projects. Each student needs to 3D print their own models.

1. In the PrintLab Education USB stick, go to the Calculation folder and open time.stl in 3DStar.

2. Go to the Scale menu and change the X value to 30mm. Then slice your model using Standard print mode.

3. Your estimated print time will be shown after slicing and it should be around 11 minutes. If 20 students printed a model of this size, that would equal 220 minutes of printing.



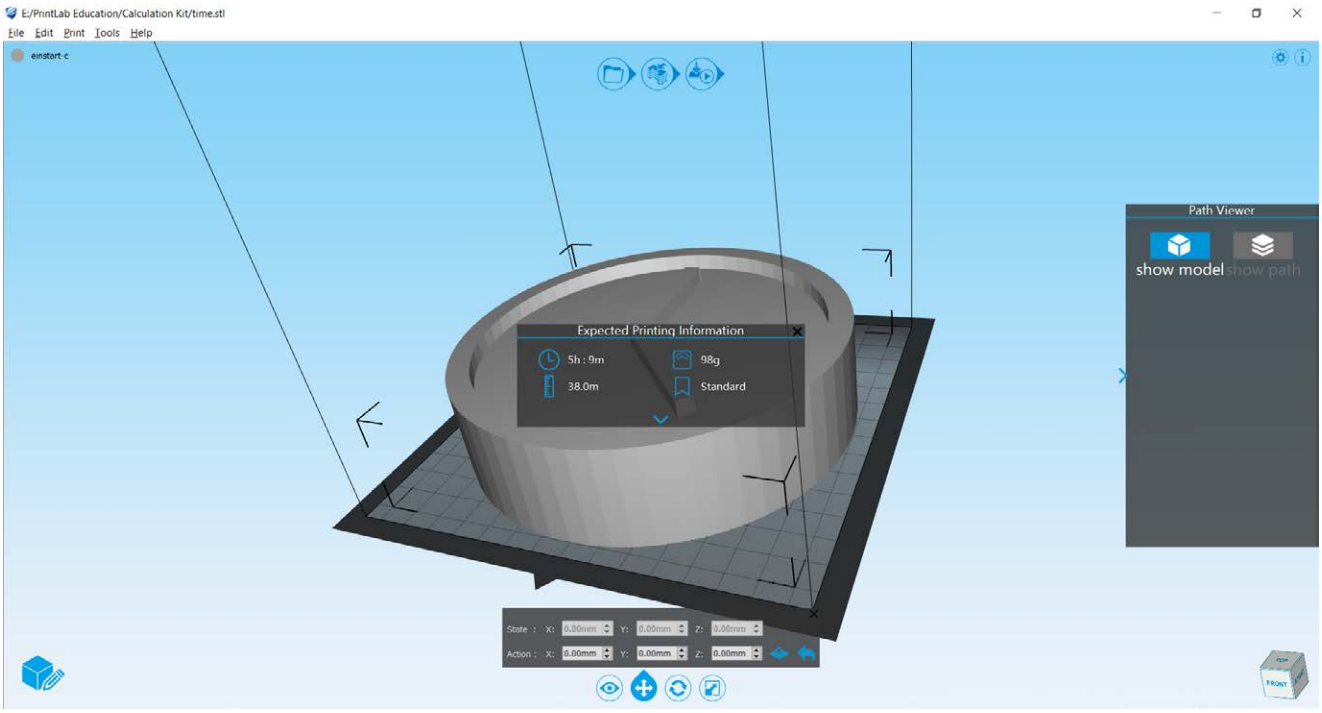
Print Time of Large Models

Using the same scenario of 20 students printing individual models, we are going to see how long it would take for 20 large prints.

1. Go back to the Scale menu and change the X value to 140mm.

2. Position your model in the centre of the print bed by using the toCenter function.

3. Now slice the model with the Standard print mode and you will notice that the estimated print time is over 5 hours. This means printing 20 models would take 100 hours.



Making Use of the Print Bed

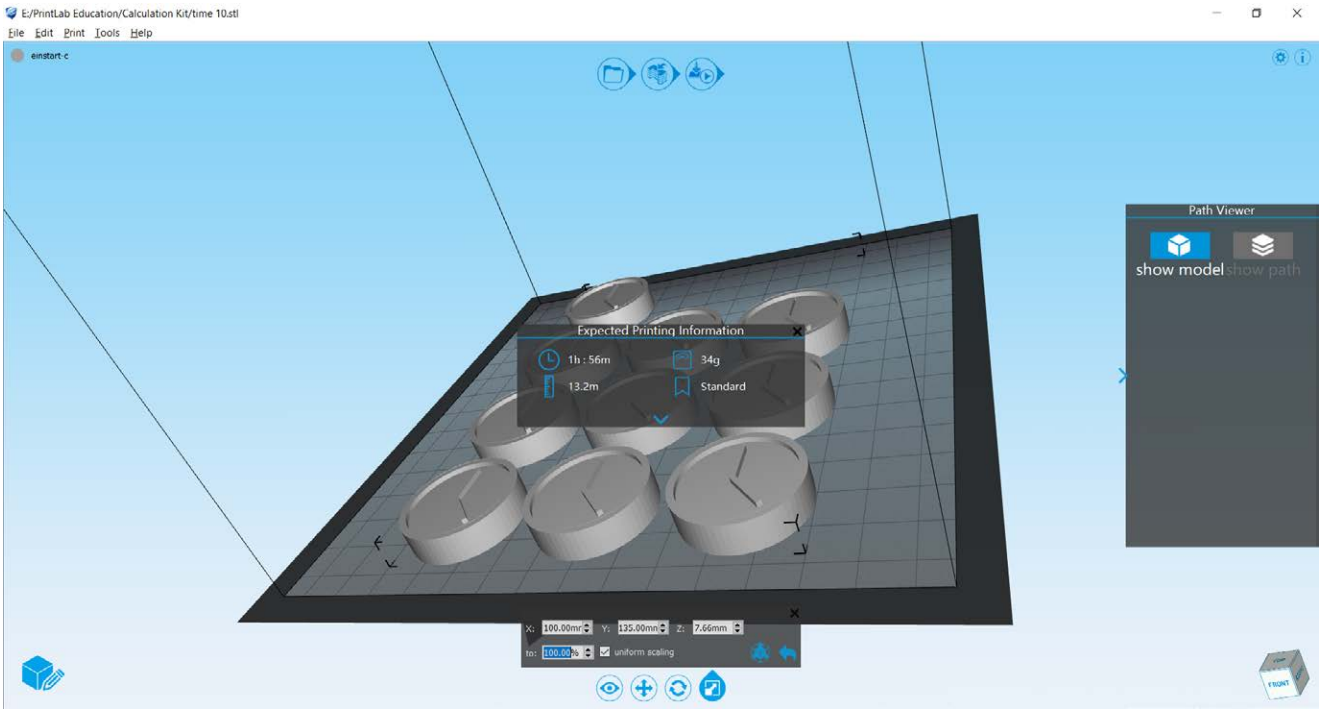
The EinStart-C's printable build volume is 153×153×153mm. You can print several models at once as long as the total area is within the build volume area. This may be one of the most useful features for the classroom and can save you a lot of time!

1. Go back to the Scale menu and resize the time.stl so that the X value is 30mm again.

2. Click on the model so that it is selected, then press Ctrl+C on your keyboard to copy the object. Press Ctrl+V to paste a second model.

3. Continue copying and pasting until you have 10 models on the print bed. Then slice with the Standard print mode.

4. You will notice that the estimated print time of all 10 models is still much less than a single print of the large model we previously slice. You could also set both your EinStart-C printers going at the same time, meaning the print time for 20 models would actually be less than 2 hours. Making use of the print bed also reduces the time required for starting many individual prints.



General Classroom Tips

It's nearly time to start teaching 3D printing classes! Here are some general tips to keep in mind:

1. Let students handle 3D printers

There's no better way to learn about 3D printing than to get hands-on. This especially applies to students! So make sure they have access to the printers - let them tinker and fix technical problems themselves.

2. Work together with students

Don't be afraid to admit to your students that you don't know everything about 3D printing. Work together with them in solving problems and keep your lessons open ended. What we mean by this is that although lessons should have set criteria and learning outcomes – there is a world of opportunity beyond this if you allow students some freedom to explore.

3. Don't isolate 3D printing

In modern day industry, it is rare that 3D printing is used as a tool on its own. It compliments other forms of design and manufacturing, such as laser cutting, CNC machining and 3D scanning, to enhance the outcome. Keep this in mind when planning your lessons and integrate 3D printing with core curriculum topics.

4. Be flexible and open to change

Something just as important as having a plan, is the need to be flexible and open to change. It is highly likely that the way you do things when you first begin your journey will be completely different to a year down the line. This is all part of the development process, so always try new techniques and keep an open mind.

8.

Teaching 3D Printing

The time has come to introduce 3D printing to your students. You should be proud of the training you have completed and you should be excited for the next steps. There is so much more to learn but you can be assured that if you have completed the activities in this handbook, then you are more than ready to teach 3D printing in the classroom. This chapter goes over the various curriculum included in the bundle. Each lesson has a full teacher's guide to support so remember to relax and enjoy inspiring the next generation!


THIS ITEM BELONGS TO
MAKERVERSITY DIY
TO ENSURE THAT EVERYONE CAN
MAKE THE MOST OF OUR WORKSHOPS,
PLEASE DO NOT REMOVE THIS ITEM.

Curriculum Overview

The PrintLab Education Bundle includes a whole range of curriculum to help you with the teaching process. Each lesson plan comes with everything you need, including a teachers guide giving step-by-step instructions and teaching tips. The curriculum has been developed by 3 brands, let's take a look at what's included:

Makerversity DIY Lesson Plans

Makerversity's simple and exciting lesson plans enable educators to incorporate making and hands-on activities into core curriculum subjects. From 3D printing sandtimers and greenhouses to making a webcam microscope, you'll be sure to find a suitable lesson to integrate into your existing curriculum. There are 10 Makerversity lesson plans included in the PrintLab Education Bundle, 6 of which involve 3D printing and 4 that involve other STEM activities.

Kideville Curriculum Kit

Kideville is a sustainable city design project, where much like in a game, each student is assigned a creative mission that takes them through a full design and project management process. The teacher curates this journey, which includes research, ideation, sketching, technical drawing, CAD modeling, 3D printing and presenting, keeping a balance of individual project development and group teamwork. The Kideville kit consists of 14 creative lesson plans including 20 instructional videos.

PrintLab Education Lesson Plans

Here at PrintLab we don't just bring together the world's best 3D printing curriculum, we also create our own lesson plans! We like to focus on projects that take students through the entire design to print process. Our first 5 lessons include 'Make your School Name in Braille' and 'Make an Ergonomic 3D Printed Pen' amongst others. We will also continue to support you with free lesson plans regularly. To be added to our mailing list, simply email hello@weareprintlab.com.

Introduction Lesson Plan

For your first 3D printing class we recommend the 'Introduction to 3D Printing' lesson by PrintLab. This can be found on the PrintLab Education USB stick under the Curriculum folder. In this lesson plan you will be using the visual aids that you designed and printed! They will be used to explain 3D printer settings as well as design considerations. Here's a quick overview of the lesson.

In this lesson you will introduce your students to the basic principles of 3D printing, how it works and how it can be used in various industries. The lesson involves context about 3D printing, physical demonstrations and a teamwork activity. The lesson lasts approximately 1 hour and can be incorporated into all STEM subjects . The material can be adapted for ages 7-15.

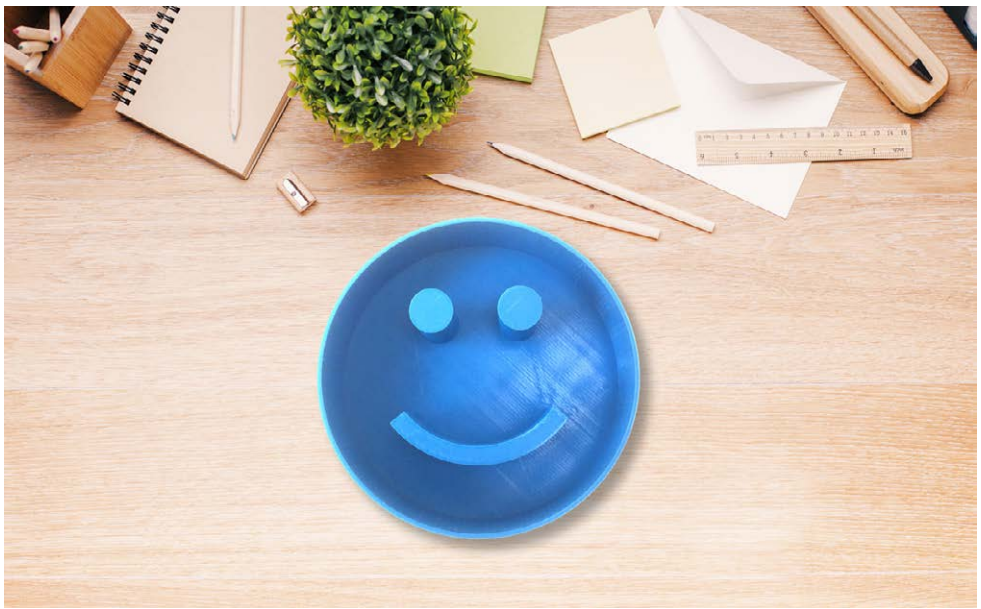
The process begins with a presentation and discussion session, where you will give an overview of 3D printing. At various points throughout the presentation you will physically demonstrate the 3D printing process and use printed models to explain various settings and parameters. In the second half of the lesson students will work in teams. Each team is given a different mission relating to a different industry. They will work collaboratively and sketch ideas about how they will use 3D printing in their business. The final stage of the lesson involves each team explaining their ideas to the rest of the class.

Make your own Cookie Cutter

The first lesson plan introduced students to 3D printing. In the next lesson plan we recommend the 'Make your own Cookie Cutter' class (also in the Curriculum folder of the PrintLab Education USB), which takes students through CAD software instructions to create a cookie cutter. It is important to introduce students to 3D modelling as early as possible because this is just as important as 3D printing itself!

This lesson is an introduction to Tinkercad, a free online, entry-level 3D modelling software. It explains the basic tools for building shapes and understanding three dimensional modelling. Explaining each of the tools methodically, the lesson engages pupils with each step to build their own simple and printable cookie cutter.

Make Your Own Cookie Cutter is a great one to try ahead of other curriculum such as the Kideville Kit, as it will set up pupils with a basic understanding of the key building tools and processes in order for them to start designing and building independently. The lesson can be incorporated into the study of maths, ICT, design technology, art or food technology.



Make Classroom Objects

At this stage you will have introduced students to 3D printing and taught them how to design a simple model in CAD. For the next lesson, we recommend the 'Make Classroom Objects' class, which involves 3D scanning, 3D printing and also introduces students to activities in slicing software.

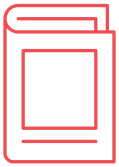
The lesson involves sketching, clay modelling, 3D scanning and 3D printing. The lesson is split up into 2 sessions lasting approximately 1 hour each and can be incorporated into the study of design technology, art and design, ICT and other STEM topics. The process begins with a short presentation and discussion session, where the teacher will give an overview and demonstration of 3D scanning technology. Students will then be introduced to their mission of creating a range of classroom objects such as door stops, desk organisers and coat hooks.

Following the presentation students will sketch out ideas in their workbook and design their clay models. At the end of session 1, students will vote for the best designs and these will be 3D scanned and 3D printed in session 2. Session 2 begins with a 3D scanning workshop where all the winning designs are turned into digital 3D models that can be 3D printed. By using instruction sheets included in this lesson pack, students will work in teams to go through the 3D scan to 3D print process. The final part of the lesson will involve starting the 3D prints.

The Next Steps

The curriculum we have introduced so far are great beginner lessons. Once these have been introduced, you and your students will be ready to take on the rest of the creative curriculum included in the bundle.

Before we introduce you to the rest of the curriculum, here are some considerations and tips on choosing and teaching your next 3D printing lessons:



1. Look at the Teacher's Guide

Each lesson plan comes with a teacher's guide that states the subject area the lesson is applicable to. In addition to this, the learning criteria and outcomes are stated. Take a good look at each lesson plan to determine where it fits in with your curriculum. You can also introduce other teachers in relevant subject areas to the lesson plan and the bundle products.

2. Consider After-School/Lunchtime Clubs

It might be that you come across an exciting lesson plan, but it does not meet the criteria of your subject area. In this case, consider running after-school or lunchtime clubs. This will also give your students time to explore, tinker and take control of their own learning.

3. Ask for Help and Support

If you are unsure about any of the curriculum materials or have any questions, do not hesitate to contact your bundle supplier. You can also contact us directly at hello@weareprintlab.com. We are always here to support you over a lifetime period.

The Kideville Kit

After completing the cookie cutter lesson, students should have learnt the basic principles of CAD design, which will prepare them for projects such as the Kideville Kit. The Kideville curriculum gives students more freedom to explore and design. It is a project that spans over 14 lessons, so there must be some careful planning in how you integrate the kit into your curriculum. Many teachers choose to use the kit as a design technology module over a term-long period.

Kit Contents

Kideville ocean board (70×50cm)
Teacher's handbook
14 x lesson plans
20 x instructional videos
Digital pack with 3D CAD files
Student packs (portfolios, brief cards, island tiles, houses)

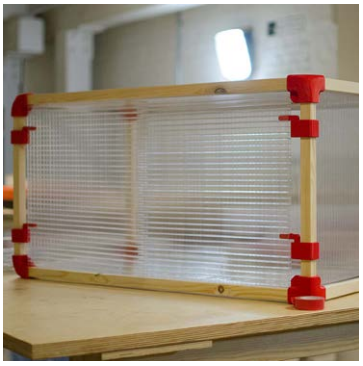
3D Print Kit Lessons

In this selection of lesson plans, there are ready-made STL files that you can 3D print prior to and during the classes. All lesson packs are available from the Curriculum folder on the PrintLab Education USB stick.

1. Build your own Sandtimer

This lesson uses bespoke, 3D printed components designed by Makerversity DIY, alongside everyday household items to enable children to produce a sandtimer. This is a great opportunity for pupils to hone fine motor skills through a simple hands on activity, whilst also practicing accuracy and measurement skills. The use of 3D printed components can open up discussion about production processes, materials and environmental or ethical implications of design.

2. Build your own Greenhouse



This lesson is a great way to engage pupils and pique their interest in natural sciences as well as manufacturing techniques. It empowers them in their learning environment by immersing them in the process of building a structure they can go on to use and explore with, an incredibly helpful lesson for many pupils. Using bespoke, 3D printed brackets designed by Makerversity DIY and basic, off the shelf materials, this lesson also encourages problem solving and team work.

3. Make your own Workshop Stool

This lesson empowers pupils in their learning environment by handing responsibility over to them to build the furniture they work from. Using bespoke, 3D printed brackets designed by Makerversity DIY and basic, off the shelf materials, this lesson encourages problem solving and team work. It can also be used to demonstrate a real life application of several scientific and mathematical topics, which can be incredibly helpful to many pupils.

4. Make your own Workbench

Similarly to the workshop stool, this lesson uses bespoke 3D printed brackets and off the shelf materials to create a workbench. Following the lessons, you can incorporate CAD design to see if your students can design additional features for your workbench.

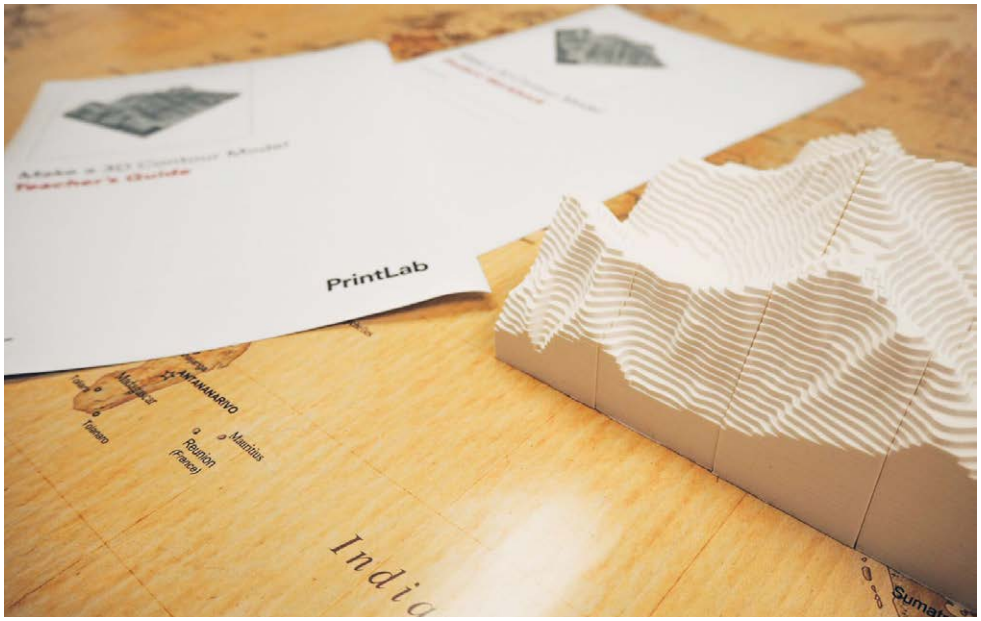
CAD to 3D Print Lessons

1. Design your own Pavilion

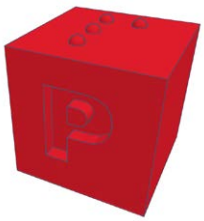
The students will go through a fast-forward design process that includes orthogonal 4-view drawing, basic 3D CAD modelling and 3D printing. By taking part in this process, they will be able to connect an analogue sketch to a digital 3D drawing and back to a physical 3D printed model, observing how their design changes and evolves between these stages. Students will learn design, drawing and CAD skills and will experience what it looks like to be a designer-architect.

2. Make a 3D Contour Model

In this lesson students will collaboratively design and 3D print a 1:50,000 scale model of Mount Everest and its surroundings. The lesson involves mathematical calculations along with CAD design tasks, mapping skills and 3D printing.



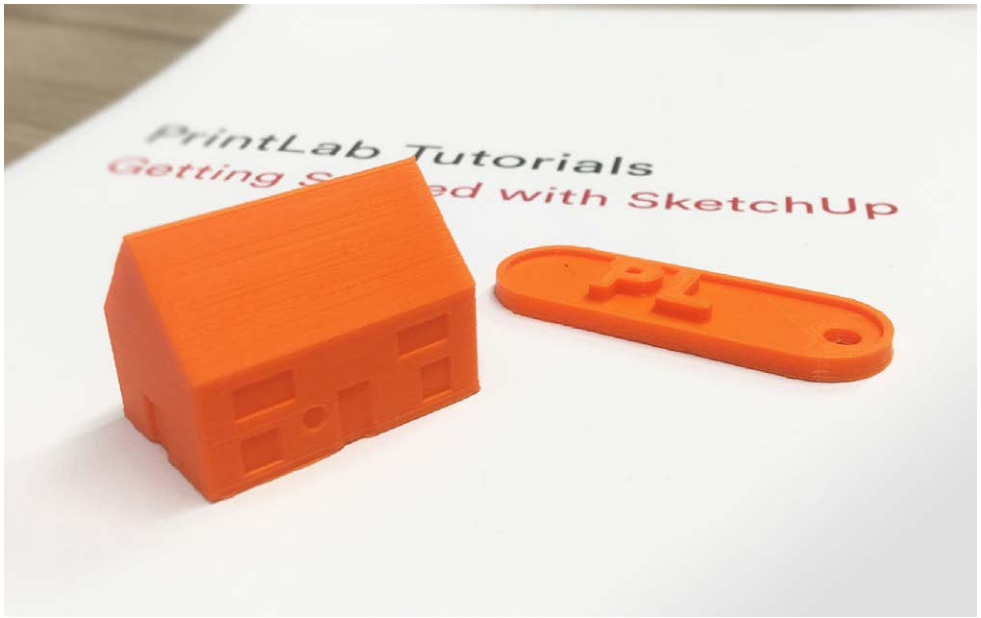
3. Make your School Name in Braille



In this lesson students will collaboratively design and 3D print their school name in braille. The lesson involves context about the written language braille along with mathematical calculations, CAD design and 3D printing. The final outcome will be a series of cube shaped braille models that can be placed/glued to a surface where it will be legible.

4. Getting Started with SketchUp for 3D Printing

This workbook can help both teachers and students get to grips with an alternative CAD software called SketchUp. The activities lead to students designing and printing their own house and keyring models.



3D Scan to 3D Print Lessons

1. Make an Ergonomic 3D Printed Pen

By combining traditional clay modelling with 3D scanning and 3D printing, we open up a whole range of opportunities in materials, customisation, production and digital archiving.

In this lesson students will go through the 3D scan to 3D print process to create an ergonomic pen. The lesson involves sketching, clay modelling, 3D scanning and 3D printing.

The lesson is split up into 3 sessions lasting approximately 1 hour each and can be incorporated into the study of design technology, art and design and ICT. The material can be adapted for ages 7-15.

Maker Lessons

1. Make your own measuring tape

This lesson provides a simple way to explain the concept of using units of measurement to record distance, as well as how to convert between different units of measurement. It enables them to practice accuracy and measurement skills, fractions, division and ratios, as well as encouraging their discussion of around systems of measurement and how to gauge what units are appropriate for different sized objects or distances.

2. Design your own wall graphics

This project will show you how to make an interactive wall graphic using the Touch Board and Electric Paint. Students can follow these easy instructions to learn how to cold solder and how sensors work. They will also use their creativity to create personal stories and narratives from visual images.

3. Design your own team uniform

Pupils will work in teams to develop their own logos which can then be applied to any garment, overalls, toolbelt using a heat press or iron. It aims to teach pupils to use hand drawing as a tool to communicate ideas and to develop these ideas using a combination of manual and digital tools. The printed toolbelts will afford pupils the opportunity to apply these skills practically and finish with a functioning and useful outcome.

4. Make your own microscope

This lesson is based around a simple hack of a cheap peripheral webcam which, using very basic workshop tools, can be turned into a digital microscope when connected to a laptop or USB enabled tablet. By dismantling an object, observing how it has been assembled and how these components work together, pupils will gain a deeper understanding of the material world around them and can use this curiosity to explore how things work and to invent for themselves.

9.

Skills Progression

The final chapter of this book talks about developing your skills as a teacher. A key skill that can truly open up a whole range of new opportunities is that of 3D modelling. By acquiring and developing skills in 3D modelling, you can pass your knowledge on to your students, allowing them to bring their most creative ideas to reality. There are 2 online courses included in the PrintLab Education Bundle that take you through in-depth exercises on 2 amazing free software packages, Fusion 360 and Meshmixer. We recommend that you go through the courses in your own time and at your own pace. They are very thorough and by the time you complete them, you'll have a whole new range of tools to introduce to your students.

About Fusion 360

Fusion 360 is free for educators and students. Create models that manufacturers around the world know how to build and run simulations on your models to see how they will react to real-world stresses. Create models driven by parameters, work on a model for a few hours, and go “back in time” to change one variable, and your model instantly updates with your new design choice. Create photo-realistic renderings and moving animations of your models to help people understand your product. Fusion 360 can do all of this and more!

An example of how Fusion 360 is being used in industry is the story of our partner Kidesign, who were successfully funded on Kickstarter for their recent project – The Densters. The Densters are a set of toy monsters that build blanket forts and dens, with a mission to enhance play and creativity within children. In addition to the amazing modelling tools Fusion has to offer, it was important for the Densters to be durable and able to resist a kid trying to pull their heads off! Using Fusion 360, weak points and tensile strength were tested within a few clicks, allowing Kidesign to optimize their design by finding out how best to improve the form of each toy.

Why Learn Fusion 360

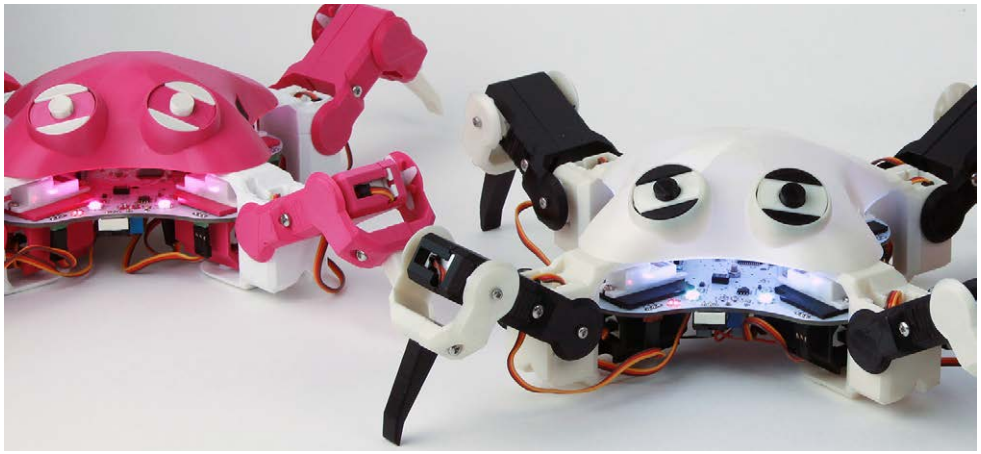
At this stage you may still be developing your skills in Tinkercad or SketchUp, so why are we introducing you to a brand new software? Let's take a look at some of the reasons why we are introducing you to Fusion 360.

1. We Recommend Learning a Range of Software

There are hundreds of design software packages available and we do recommend that teachers and students learn various different ones. There are various reasons for this but two key ones are firstly, some software packages are better at designing certain models than others. Secondly, different industries tend to use different software. For example architects may prefer SketchUp and engineers may prefer Fusion 360. By giving students skills in a range of packages, you can prepare them for the requirements of their future careers, whatever they may be.

2. It's a Professional Package with a User Friendly Interface

Fusion 360 is an advanced software package, but don't let that put you off. By going through the online course in the bundle, you will become a proficient designer in no time! Fusion 360 is used by industry professionals, so similarly to the previous point, you can train students in a software that may well be a requirement for their future career.



Fusion 360 Online Course

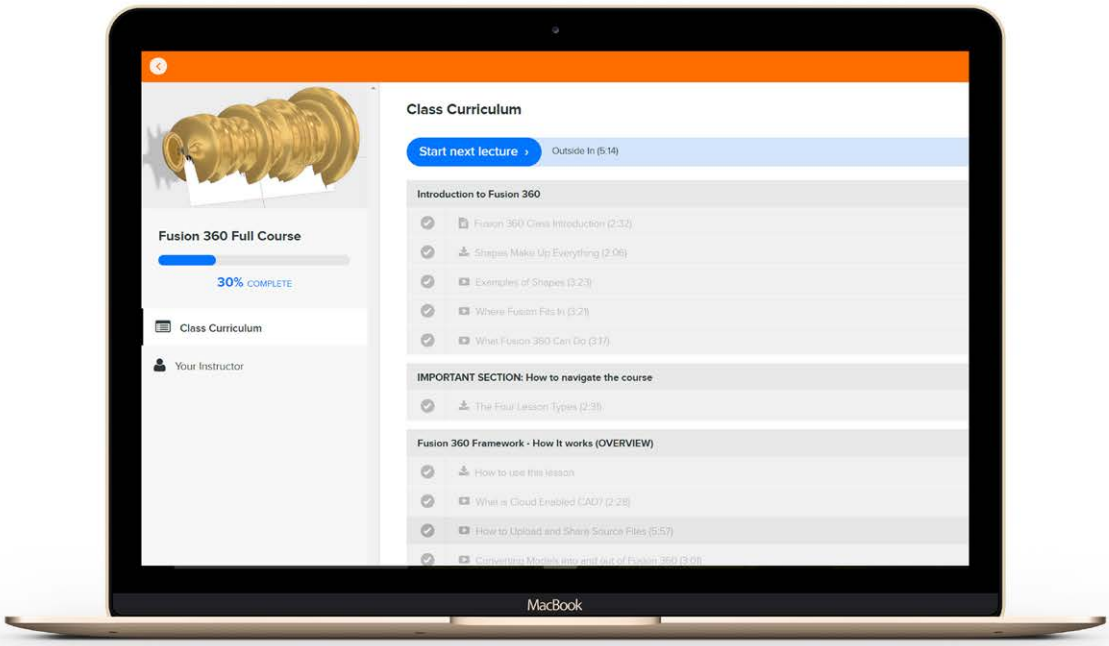
We're now going to tell you a little bit about the Fusion 360 online course provided on the PrintLab Education USB stick.

This course is an online, self-paced course by HoneyPoint3D that has over 15 hours of instruction, including a thorough reference section that gives short videos on every feature inside of Fusion 360. Get stuck on how to use the Revolve tool? Look it up in the reference sections and get back on your way. Want to learn strategies for how to approach design in Fusion 360 in the first place, the course has got that too!

Class Curriculum

Introduction to Fusion 360 (5 sections)
How to navigate the course (1 section)
Fusion 360 Framework - How it works (4 sections)
Understanding the Fusion 360 environment (11 sections)
Targeted Video Collection (7 sections)
Planning your Design (10 sections)
Sculpting something easy: Water Decanter (6 sections)
Introduction to Surface Modeling (8 sections)
Introduction to Sketching - Raspberry Pi Case (18 sections)
Fusion 360 and Meshes, an Expanding World (9 sections)
Model - Create (19 sections)
Reference: Model - Modify (19 sections)
Model - Sketch (25 sections)
Model - Construct (18 sections)
Model - Inspect (8 sections)
Model - Insert (6 sections)
Model - Make (2 sections)
Model - Add-Ins (3 sections)
Model - Select (2 sections)
Patch - Create (3 sections)
Patch - Modify (4 sections)
Model - Assemble (6 sections)
Simulation (1 section)

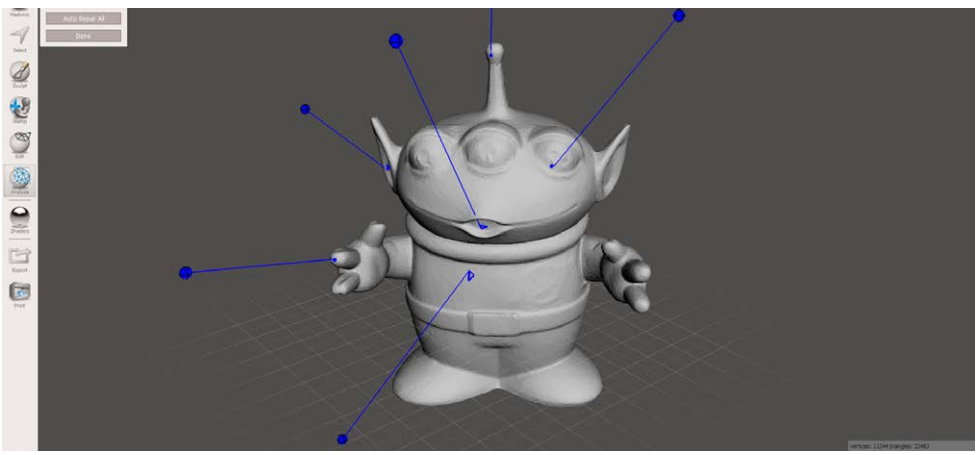
To access the course, load the PrintLab Education USB stick into your computer and navigate to Training Courses > Fusion 360 Online Course. Then click the activation link in the document or copy and paste it into your browser. This will take you to the online course enrolment.



About Meshmixer

Meshmixer is a free software that differs from Fusion 360. It is a sculpting tool that works with meshes. The simplest way to describe it is that it functions as if you are sculpting with digital clay. It is excellent for working with 3D scan data. You can edit and repair scans easily by using hundreds of functions. Additionally, it is optimised for 3D printing and has a range of tools for that too! Here are some key features:

Drag-and-Drop Mesh Mixing
3D Sculpting and Surface Stamping
Robust Convert-to-Solid for 3D printing
3D Patterns & Lattices
Hollowing (with escape holes!)
Branching Support Structures for 3D printing
Automatic Print Bed Orientation Optimization, Layout & Packing
Advanced selection tools including brushing, surface-lasso, and constraints
Remeshing and Mesh Simplification/Reducing
Mesh Smoothing and Free-Form Deformations
Hole Filling, Bridging, Boundary Zippering, and Auto-Repair
Plane Cuts, Mirroring, and Booleans
Extrusions, Offset Surfaces, and Project-to-Target-Surface
Interior Tubes & Channels
Precise 3D Positioning with Pivots
Automatic Alignment of Surfaces
3D Measurements
Stability & Thickness Analysis



Why Learn Meshmixer

1. You'll Require a Mesh-based Software for 3D Scans

You will have come across Meshmixer already if you have been through the ergonomic pen lesson. As you begin to explore 3D scanning further, you may want to teach your students advanced techniques to edit their scans. To do this, a mesh-based software is required. Tinkercad is great for creating designs for 3D printing but it does not have the functions or capabilities of Meshmixer when it comes to editing scans.

2. Meshmixer is Great for Organic Designs

As we have mentioned, using Meshmixer is like sculpting with digital clay. This means that you can achieve organic and textured models that cannot be created in packages such as Tinkercad and SketchUp. It is not a replacement for these programs, but an alternative for different types of models and a great companion for the EinScan-SE.

Below is an image of a sea shell candle holder. The shell was 3D scanned and edited in meshmixer so that a candle could slot into the shell.

Meshmixer Online Course

We're now going to tell you a little bit about the Meshmixer online course provided on the PrintLab Education USB stick.

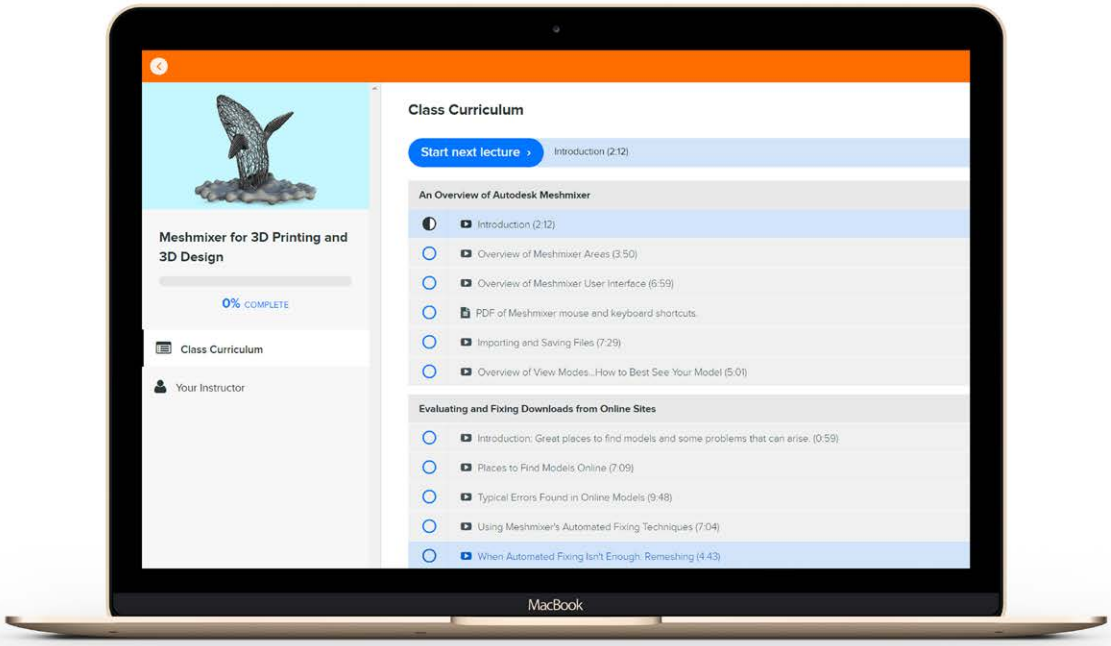
This class by HoneyPoint3D features 17+ hours of expert online video training, targeted videos explaining answers to specific questions, hidden tricks, multi-video modules that can be learned in order or by topic, 80+ meshmixer tools explained, 165+ total videos, answers to specific workflow questions and more!

You will learn how to create or upload your own CAD file and paint, create patterns, apply support material, sculpt, pull, twist, turn, add, delete, flatten, pitch, shrink, inflate, stencil, drag and drop, and/or mesh objects together. We will go over 80+ tools to unleash your creativity.

Class Curriculum

An Overview of Autodesk Meshmixer (6 sections)
Evaluating and Fixing Downloads from Online Sites (8 sections)
Working with Multiple Objects in Meshmixer (12 sections)
Polygonal Modeling vs. Prismatic Modeling: When To Use and What They Are (5 sections)
Sculpting with Digital Clay (17 sections)
Meshmixer's Support Structure Generation for 3D Printing (8 sections)
Creating and Fixing 3D Scans (11 sections)
Creating a 3D Model from a Photograph (6 sections)
Targeted Videos Collection (15 sections)
Reference Section: Sculpt Brush Modifiers (10 sections)
Reference Section: Volume Sculpt Brushes (12 sections)
Reference Section: Surface Sculpt Brushes (5 sections)
Reference Section: Edit Menu (17 sections)
Reference Section: Analysis Menu (11 sections)
Reference Section: Shaders Menu (1 section)
Reference Section: Select Menu (3 sections)
Reference Section: Select --> Edit Menu (17 sections)
Reference Section: Select --> Convert To Menu (1 section)
Reference Section: Select --> Deform Menu (1 section)
Reference Section: Select --> Modify Menu (1 section)

To access the course, load the PrintLab Education USB stick into your computer and navigate to Training Courses > Meshmixer Online Course. Then click the activation link in the document or copy and paste it into your browser. This will take you to the online course enrolment.



Progressing your Journey

At this stage you will have gained new knowledge and skills, but this is just the beginning! The 3D printing industry is young and ever-changing. There are various ways you can progress your journey and to keep up-to-date with the latest trends and pedagogy.

1. Attend Exhibitions

As the 3D printing industry continues to develop, more and more exhibitions are appearing around the world. Exhibitions are a great way to see new technologies first hand and you can ask exhibitors as many questions as you like.

2. Visit a Local Makerspace

Makerspaces are places where people come together to create! Makerspaces are equipped with the latest technology and best of all, they are accessible to the public. Why not contact your local makerspace and request a visit with your students. By doing this you'll get to see amazing creations and inventions that are sure to inspire your students.

3. Join an Online Community

Do some research online and find a community that suits you. There are many educators in your position looking for advice and looking to share their experiences with others.

4. Collaborate

Collaboration is one of the best ways to progress your journey. Whether it be sharing your skills with other teachers in your school or inviting other schools to look at your 3D printing lab, we highly recommend that you don't progress your journey alone!

We look forward to Supporting You

We hope you have found the handbook as a good starting point to integrating 3D printing into the curriculum.

As a brand we are always learning, always evolving and we will continue to support each school as best we can. If you have any feedback or require any assistance, don't hesitate to contact us - we and our partners around the world are here to support you.

We look forward to hearing from you and we highly recommend sharing this incredible journey with others!

Team PrintLab

Let’s inspire the next generation, together.

w: www.weareprintlab.com | e:hello@weareprintlab.com