THE EDUCATION FUND

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Engineering with 3-D Printing

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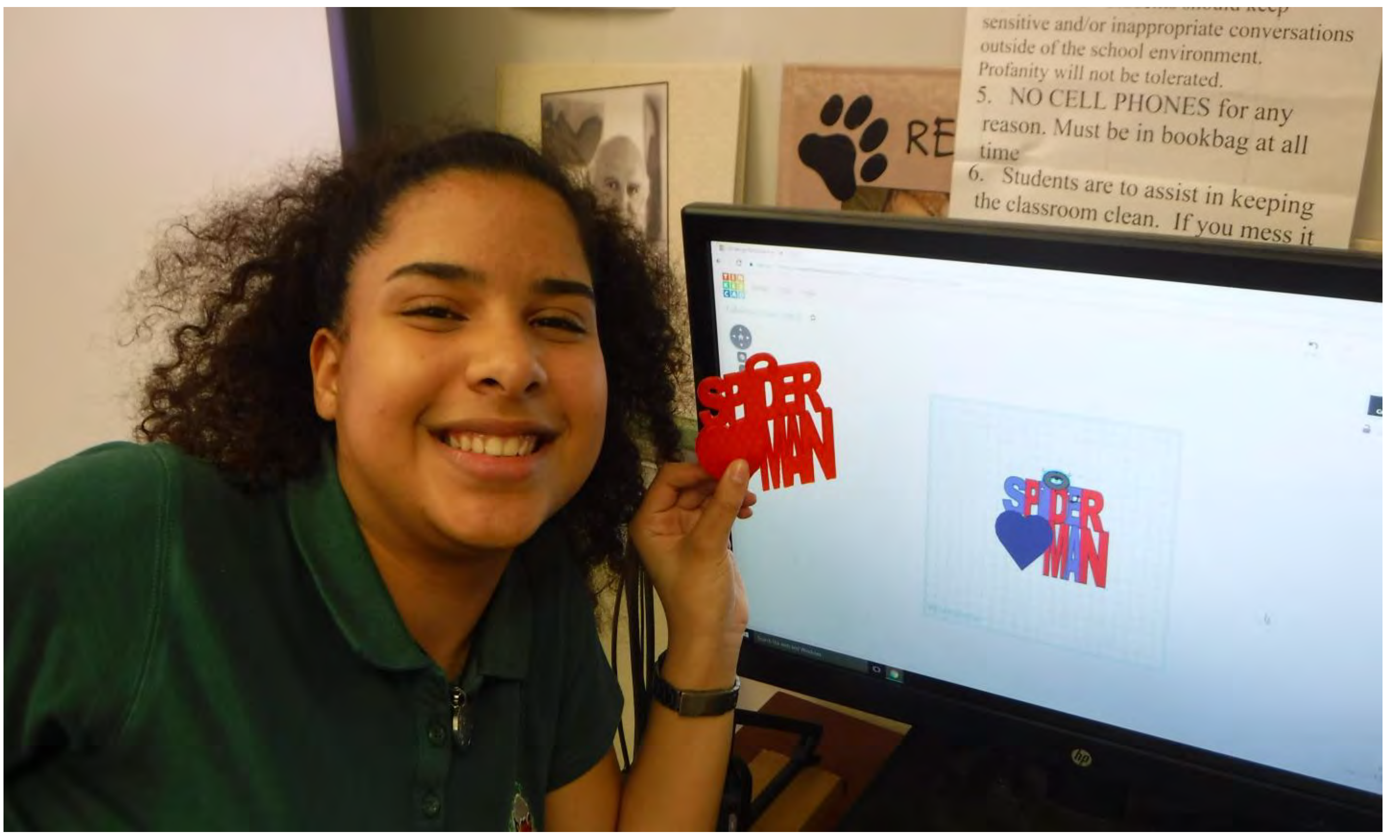


Dr. Suzanne Banas
sbanas@dadeschools.net

Are you ready for a 3-D Printer?

Do you even know all that it entails? If you are thinking about adding a 3-D printer to your curriculum, then this guide is for you!!!

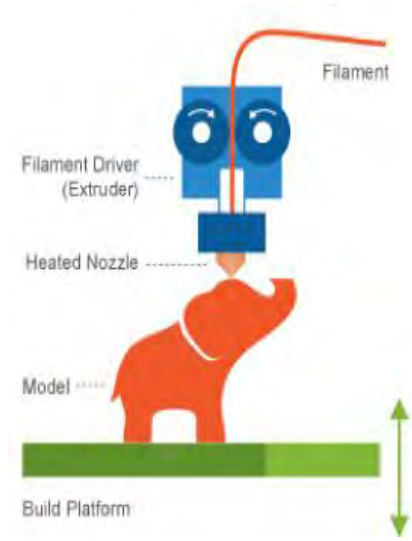
3D Printing?

FDM (Fused Deposition Modeling)

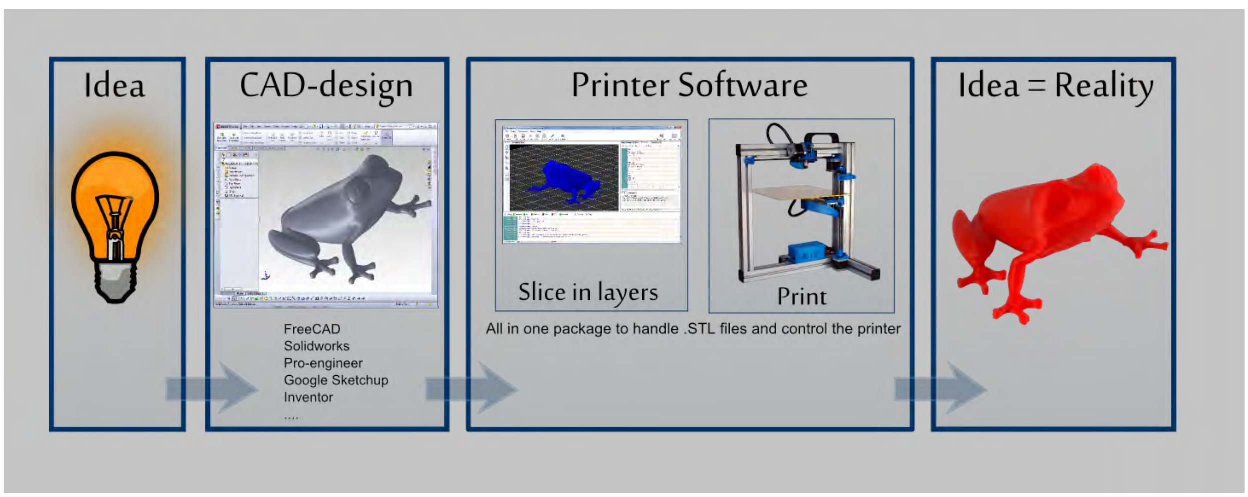
Plastics (ABS, PLA, Nylon, Polycarbonate, etc.)

Extrudes plastic wire aka "filament" into layers

Low Cost, Low Precision, Low Complexity, Multi-material



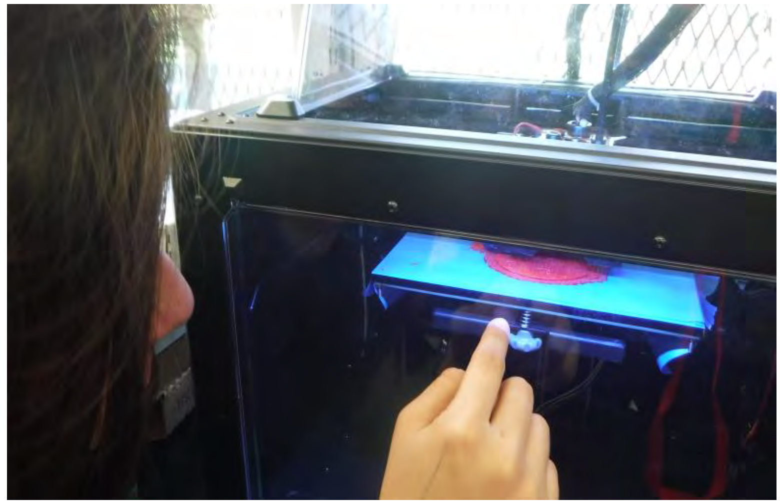
Process



There are several attributes you will need to know before you actually purchase the printer. While they are incredible tools, they are investments, and ill planning can make this into a nightmare, or at the very least, a dust collecting object in your classroom.

Printing Performance Attributes You Need To Know

File-to-Finished Part Speed



Every 3D printer has a different file-to-finished part speed, which takes into account build preparation, print speed, required post-processing, and optional finishing time.

Part Cost

In order to properly understand part cost estimates vendors, give you, it's important to know what has and has not been included to arrive at that quote.

Feature Detail Resolution

Hitting the right accuracy at the first print is essential when production batches involve various size, geometries, and types of parts.

Accuracy

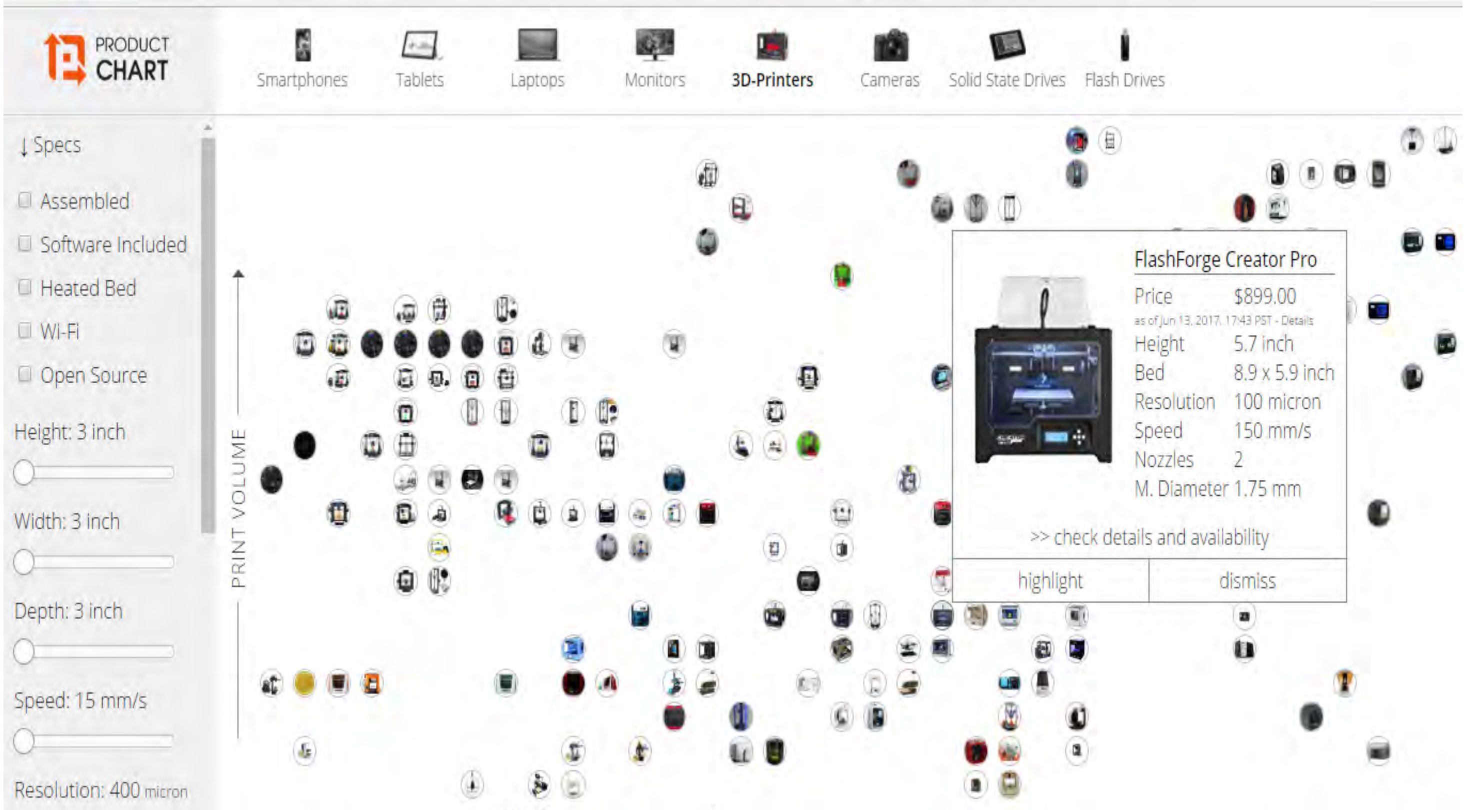
Accuracy claims by manufacturers are usually for specific measurement test parts and actual results will vary depending on part geometry, material shrinkage, part size and geometry, and precision and repeatability for production applications, so be sure to define your application accuracy requirements and test.

Material Properties

Understanding the intended applications and the needed material characteristics is important in selecting a 3D printer. Each technology has strengths and weaknesses that need to be factored in.

Print Capacity

Required print capacity for production is determined by a variety of criteria including the printer's ability to make the breadth of the parts you need to create.



This is a link to a comparison chart based on the attributes:

https://www.productchart.com/3d_printers/

Considerations:

Setup

When you unbox your printer, how long does the manufacturer say it will take to setup the printer for use. This means taking it out of the box, placing the filament into the printer, installing the software (if needed) and getting the printer actually ready for the first step, calibration. I know what you are saying "how hard can it be, I set up my printer up without help, it's a printer right?" The average time to set up a 3-D printer can be as little as 10 minutes or as much as half a day. The reason for this is quite simple, some printers are "some assembly required". For example, the FlashForge comes completely unassembled you have to put it together, and depending on your tech skill, it could take a half a day or more. Our tech guy took half a day, so adjust your time accordingly.

Once you have it assembled you will need to level the print bed which shouldn't take very long.

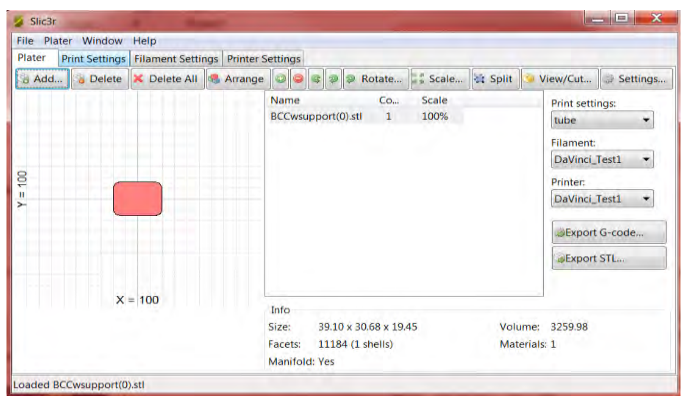
It’s usually placing it into its position and making sure it’s secure. Then putting the filament is next step. Depending on the printer, it may a simple process, or one that is quite irritating. In our research, we had one that had a button that said load filament, and it did it itself, while another one had to be fed until the print head caught it.

The final step in the process is placing any software the printer will need to work on your computer. The time on this will vary based on the internet connection, or if the software is on a disc, type and speed of your computer, you know the usual suspects. Once this is completed you are ready for one of the most important steps, CALIBRATION!

Calibration-

This is the most important step in getting your printer to work. FOLLOW THE MANUFACTURER'S INSTRUCTIONS!!! Failure to properly calibrate your printer, will invariably lead to poor performance by the printer, frustration by the user, and wasted time and filament. So remember calibrate, calibrate calibrate!!!!!

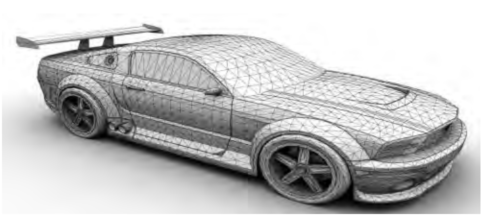
Slicing Software



Slicing
Generating Layers

- Slicing is the final step in preparing a print file
- STL files are used to generate layers for printing
- Scale, rotate, copy, and set print parameters

STL Files



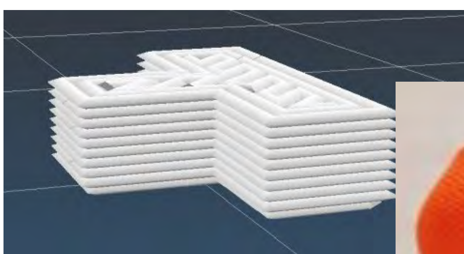
After a model is created, it is exported as a surface tessellation language (STL) file

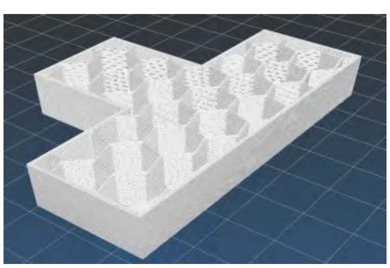
This binary code describes the triangulated surface by the vertices (x,y,z) and unit normal vector

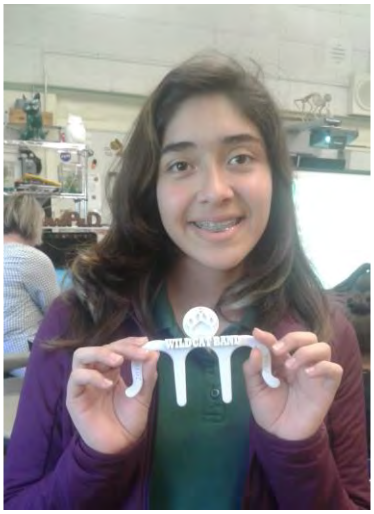
Slicing Parameters

Slicing allows for many parameters to be altered in the printing process, but the core functions include scaling, position, orientation, and duplication

• Print	• Filament	• Printer
• Layer thickness	• Diameter	• Bed Size
• Perimeters	• Extruder Temp	• Bed Center
• Solid layers bottom/top	• Heated Bed Temp	• Z Offset
• Infill type/density/angle	• Extrusion Multiplier	• Nozzle Diameter
• Speed	• Fan/cooling settings	• Retraction
• Skirt/Brim/Raft/Support	•	• Start/End G-code







Putting Together a Printing Tool Box

Before you start creating and printing you need to put together a toolbox to make the experience easier and more productive. Remember this is an investment in time, so be prepared to make it an effective one. Here is a list of the tools you will need to assemble. First you will need flat spatulas; you will want both a plastic and a metal one. This will aid you in getting the models off the print bed. This helps prevent breaking the models as they come off the and protects the print bed as well. Secondly you are going to need to procure is a good pair of wire cutters. I know what you are thinking "What would I need wire cutters when I'm printing in plastic?" Yes that is true, BUT no matter how good the printer every model has some raft or "string" hanging on the model. The wire cutters allow you to clean the model off giving it a professional look.

Next, you are going to need to get 6' blue painter's tape to cover the print bed to protect it. While some printers come with removable beds to help get the models of the tape provides extra protection from the model being removed from the print bed. It will increase the life of your print bed which in the long run saves you money. YAY

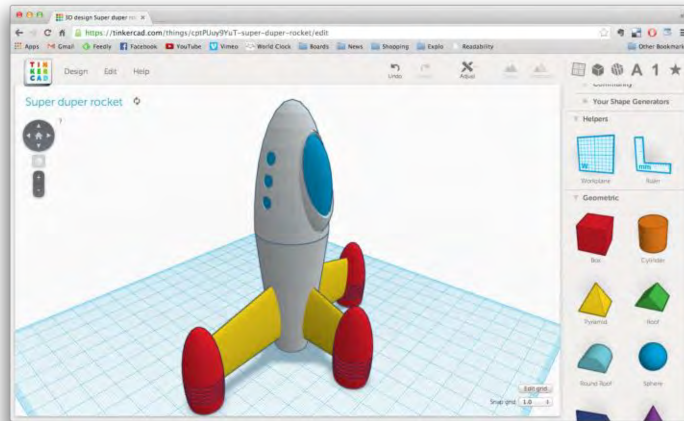
The next important thing you are going to need is sandpaper. Before you look at me like I'm crazy hear me out. The models you print may not come out smooth, but will have rough edges. These are not fun, especially if you are making things to use in the classroom. 100 grit is perfect for this. Sanding blocks work well too, just make sure it's 100 grit, don't go crazy!

While we are on cleaning up raft on the model, you also want to procure a nice file set. No we aren't doing our nails, but if you have articulated pieces like a hand, these are life savers. You will use a small file, for small areas and spaces, and a medium file for the bigger ones. Make sure your set has varied surfaces to make sure you always have the right tool for the job.

The remaining tools are quite self-explanatory. A small rubber mallet to help separate models when needed, a small plastic container to keep the tools in. You don't want to lose them, or not be able to find them when you need them. If your 3-D printer doesn't have to be slave to a computer but has a media port, then you will need an SD card to store your models on. If however, you have to slave to the printer, you will need a computer you can do without while printing models.

Creating things to print-

So now you are ready to print, but where do you find them?? The good news is that there are plenty of places to find pre-made models, or software to create your own. The bad news is that there are plenty of places to find pre-made models or software to create you own. Let's break this down, 3-D printers can create models to use in the classroom, or as a tool to allow students to prototype models and designs of their own. That is the first decision you will need to make. How do you intend to use the printer in your classroom? We will look at both ideas.

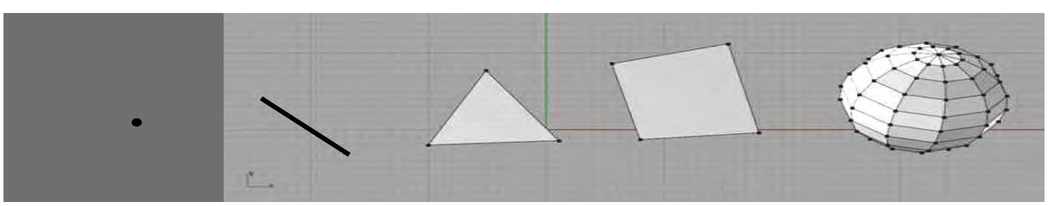


Polygonal Modeling

Representation/approximation of a 3D surface using polygons

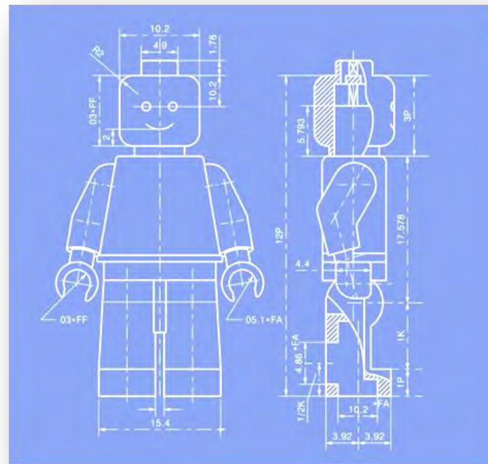
Aids in computer graphics rendering to reduce memory

Vertex/point → Edge/line → Surface/polygon → Mesh/solid



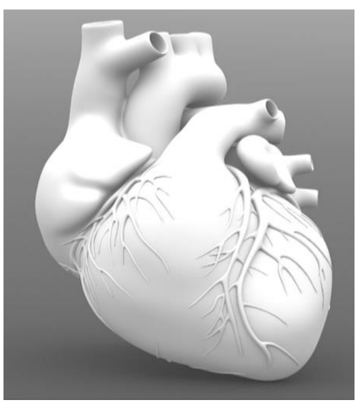
Mesh subdivision better approximates smooth surfaces by increasing mesh density

Parametric Modeling



- Defined by parameters, typically has flat surfaces, hard edges, less polygons
- Important tool to visualize & measure properties of objects before their physical creation
- Used by engineers, artists, architects, and many others

Organic Modeling

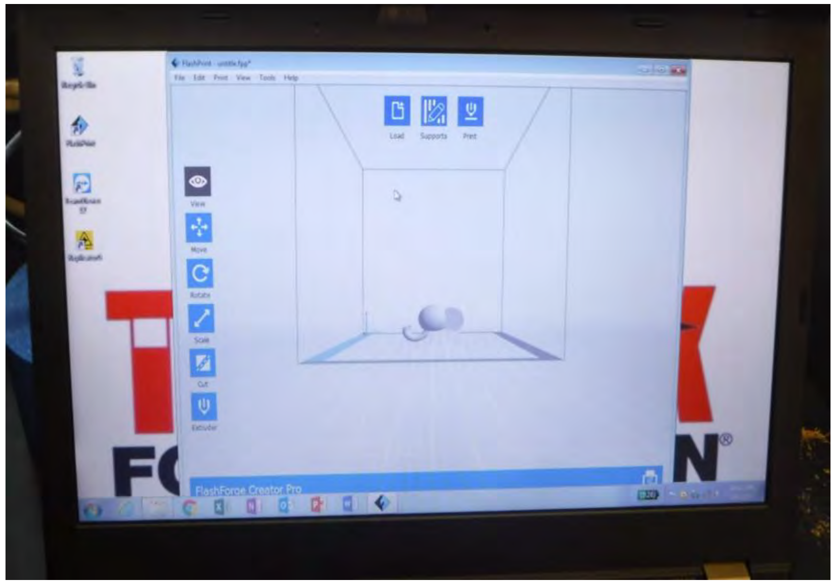


Typically used for real-world, biological, and/or complex shaped objects with many curved surfaces

Used by digital media, video game designers, artists, and many more

Creating models for the classroom.

If you are creating teaching models for your classroom, consults sites like thingiverse and tinkercad, or do a search for the model you will want to print. Pay close attention to the file type your printer needs to work with. There are file converters, but that's another story. Once you have selected and prepared the file, you will need to send it to your printer. Some printers have SD card ports, or USB, others may require the computer to be hardwired into the printer.



Modeling Software Companies

Parametric:

Dassault Systemes (Solidworks, Catia)

Autodesk Inc. (3ds Max, AutoCAD)

Organic

Autodesk Inc. (123D Catch, Maya, Meshmixer)

Pixologic (Zbrush, Sculptris)

Freeware

Tinkercad, Autodesk Inventor, Onshape, Sketchup

Modifying existing models.

In some cases you find a model or object that you want to modify to either fit your print bed, or individualize in some way. There are several programs that will do that and many of them are free. Check to make sure that your printer didn't come with its own software, but if not one that is probably the easiest to learn is a online program called tinkercad. Tinkercad has a large library to choose from and tools that easy to learn.

Now that you know what you are looking at comes the BIG question. Why do you want to do 3D printing? Rather than being neat, some models can be constructed out of paper, or even Legos. This is the biggest question you must answer before purchasing a 3D printer. Do you want to create models for the class, make manipulatives? Do you want the students to go through the Engineering Design Process, and create a prototype of their idea? As with any new technology there is the desire to get it just to "see" what it does, or to be the first on your block to have one. I suggest to soul search and decide what the endgame is and decide. If you decide it fits your class goals, then what I have said you will be of great use, if you have read all this and decide nope then hey you at least made an informed decision. (Those are rare today.)

As part of the science classroom, 3D printing can be **b**eneficial in science education by providing several aspects that can innovate education. 3D printing can provide teachers with 3D visual aids that they can use in their classroom in illustrating a hard to grasp. 3D printers make it easier for teachers to engage the interest of their students compared to just showing the pictorial representations of objects. Teachers can create a 3D model of the human heart, basic cell structure or geologic faults. Another aspect is that it can enhance hands-on learning and learning by doing. Using this 3D prototyping technology, students can produce realistic 3 dimensional mini-models. It provides more room for interactive class activities.

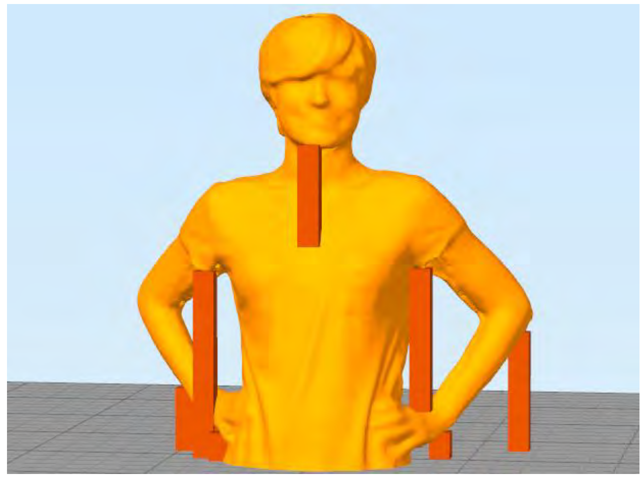
3-D printing is part of STEM. Since STEM should focus on real-world issues and problems; students can address real social, economic, and environmental problems and then seek solutions. STEM is guided by the engineering design process (EDP). 3D printing is becoming more important to the STEM curriculums. Giving students access to 3D printers turns them into thinkers, designers and builders — it is these kinds of activities that form the heart of education in the 21st century. Bringing 3D printing into the classroom exposes students to the same cutting-edge technologies they'll encounter in their careers. It gives them a jump-start on tomorrow's challenges. Tomorrow's engineers, designers and problem solvers deserve every tool available to build their future. 3D printing provides students with limitless creativity that they get to see, hold and test their ideas. The use of 3D printing in education is helping to nurture creativity and satisfy intellectual curiosity among students, thus preparing students for the real world. Introducing students to the world of 3D printing is a great way to get them excited about manufacturing and design. Students are able to see their ideas and creations come to life before their eyes in a very short period of time.

3D printing can provide teachers with visual aids that they can use in their classroom in illustrating a hard to grasp. 3D printers make it easier for teachers to engage the interest of their students compared to just showing the pictorial representations of objects. 3D printing is part of STEM. Since STEM should focus on real-world issues; students can address real social, economic, & environmental problems & then seek solutions. In Engineering Design Process, students define their problem, conduct a background research or students can try their own research-based ideas, & begin to develop multiple ideas for possible solutions. Students develop and create a prototypes, then test, evaluate, & redesign. Their focus is on taking different approaches, making mistakes, accepting and learning from them, and trying again and then developing solutions. 3D printing immerses students in hands-on inquiry and open-ended exploration. The students work is hands-on & in collaborative groups, & decisions about solutions are student-generated. They control their own ideas & design their own investigations. 3D printing argument STEM by applying rigorous math & science content, they also use technology in appropriate ways.

3D Scanning

Recreate existing objects shape and color in 3D through a type of probe

Used for prosthetics, digital archiving, aerospace, automotive parts, and more

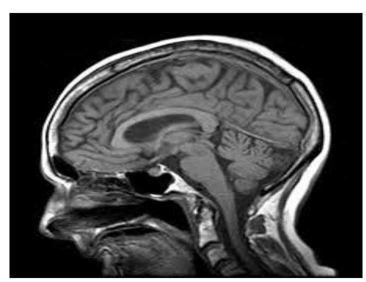


Scanning Technologies

Triangulation – uses a camera to view laser spot and calculate distance - good for short distances, resolution is 0.03-0.1 mm

Structured light – calculates distance based on distortion of light pattern - precision (5MP) and speed (40fps) advantage, can track motion

Computed Tomography (CT) – volumetric, uses z-stack of x-ray images - recreates exterior and interior of objects



Magnetic Resonance Imaging (MRI) – uses magnetic field and RF pulses - more contrast between body tissues

Project Idea

Objectives/Planned Outcomes

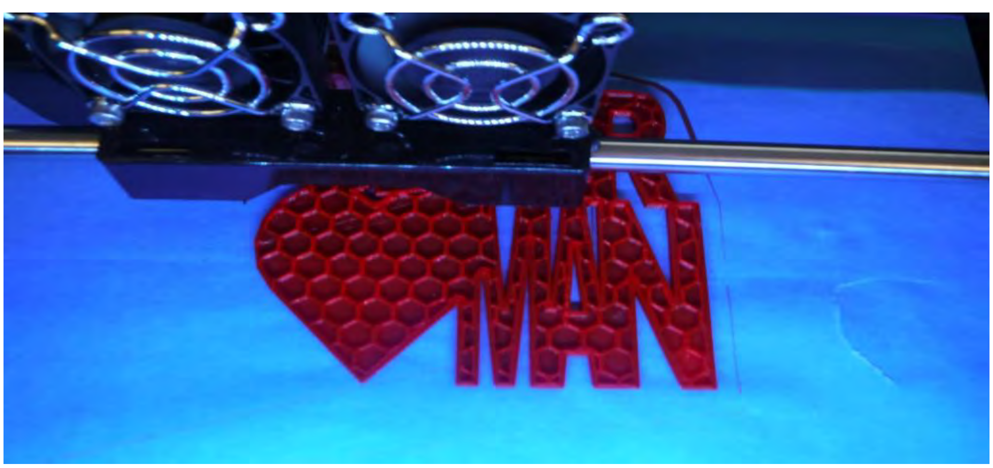
The academic needs include enhancement of academic skills, such as: reading, research, problem solving skills data analysis and communication skills. The 3D Designing Project is designed to create an engaging, interdisciplinary project that links schoolwork to real life.

The 3D Designing Project is designed to enable students to acquire skills in computer technology, the engineering design process, and word processing

- With other students in a small group, students developed, present their prototype.
- Students prepared and constructed an informational paper on their design
- Students interacted on the electronic network.
- Students accessed information from various data systems.
- Students located, interpreted, and applied information found to perform tasks.

The 3D Designing Project provides opportunities for students to develop necessary skills for effective critical thinking, problem solving, and decision-making in order to acquire the tools necessary for improved academic achievement.

- Students gathered information to answer questions and make conclusions from existing information.
- Working in a group, the students assimilated their information and discussed implications of their findings.
- Students applied various problem solving processes to the scientific method to create a real-world action plan.



Standards

SC.35.CS-CS.2.2Describe how computational thinking can be used to solve real life issues in science and engineering.

MAFS.912.G-MG.1.1 Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).

Methods/Strategies

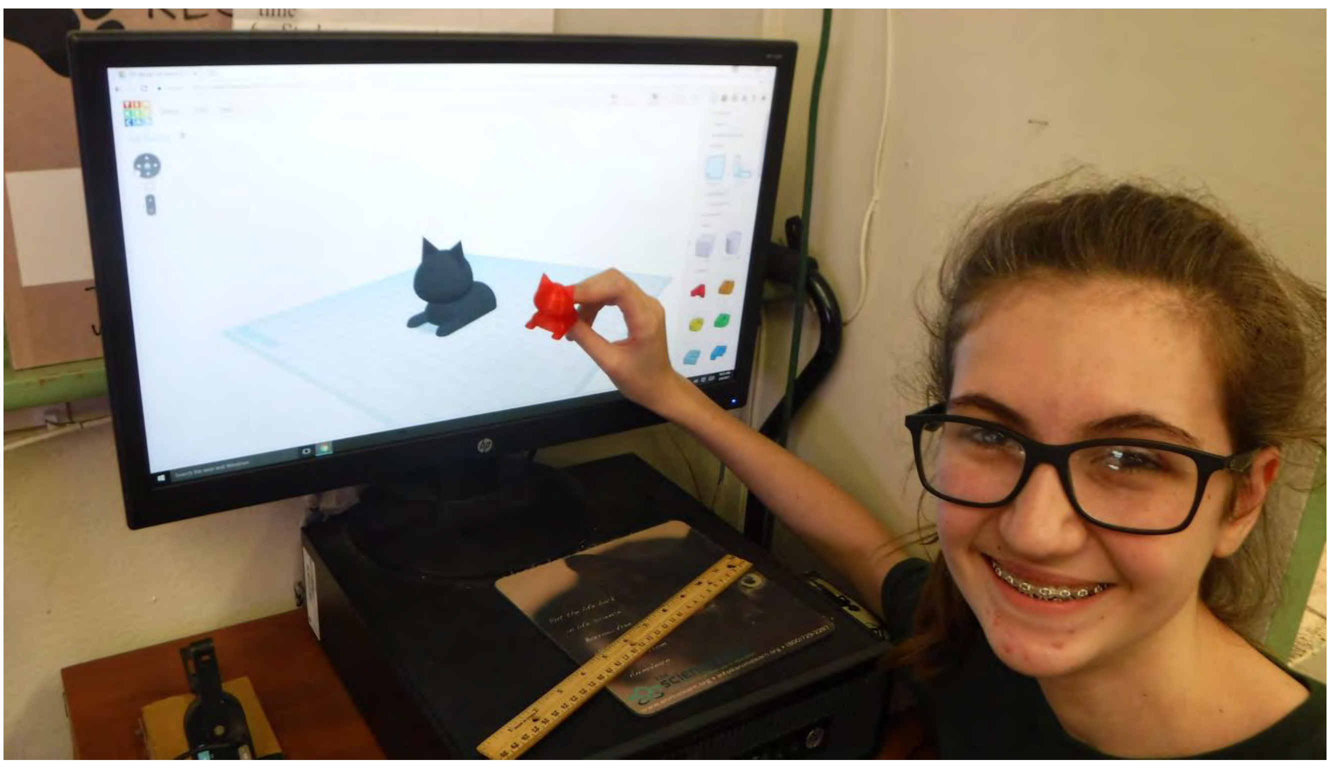
The Engineering Design Process provides a flexible process that takes students from identifying a problem—or a design challenge—to creating and/or developing a solution. In EDP, students define their problem, conduct a background research or students can try their own research-based ideas, and begin to develop multiple ideas for possible solutions. Students develop and create some prototypes, and then test, evaluate, and redesign their prototype. Their focus is on taking different approaches, making mistakes, accepting and learning from them, and trying again and then developing solutions. 3D printing immerses students in hands-on inquiry and open-ended exploration. The students work is hands-on & in collaborative groups, & decisions about solutions are student-generated. They control their own ideas & design their own investigations. 3D printing argument STEM by applying rigorous math & science content, they also use technology in appropriate ways. 3D printing is becoming more important to the STEM curriculums. Giving students access to 3D printers turns them into thinkers, designers and builders. Bringing 3D printing into the classroom exposes students to the same cutting-edge technologies they'll encounter in their careers. It gives them a jump-start on tomorrow's challenges. Tomorrow's engineers, designers & problem solvers deserve every tool available to build their future. 3D printing provides students with limitless creativity that they get to see, hold and test their ideas. The use of 3D printing in my class will assist to nurture creativity & satisfy intellectual curiosity among students. Students are able to see their ideas & creations come to life before their eyes in a very short period of time.

Time line

Each Friday the students will work on the Engineering Design Process

1. Learn about the Engineering Design Process
2. Practice using the Engineering Design Process

3. Students given a real world scenario to design a solution
4. Students begin to define their approach to the problem,
5. Conduct a background research
6. Students can try their own research-based ideas,
7. Begin to develop multiple ideas for possible solutions.
8. Develop and create some prototypes,
9. Develop and create some prototypes,
10. Then test,
11. evaluate,
12. redesign.
13. Present



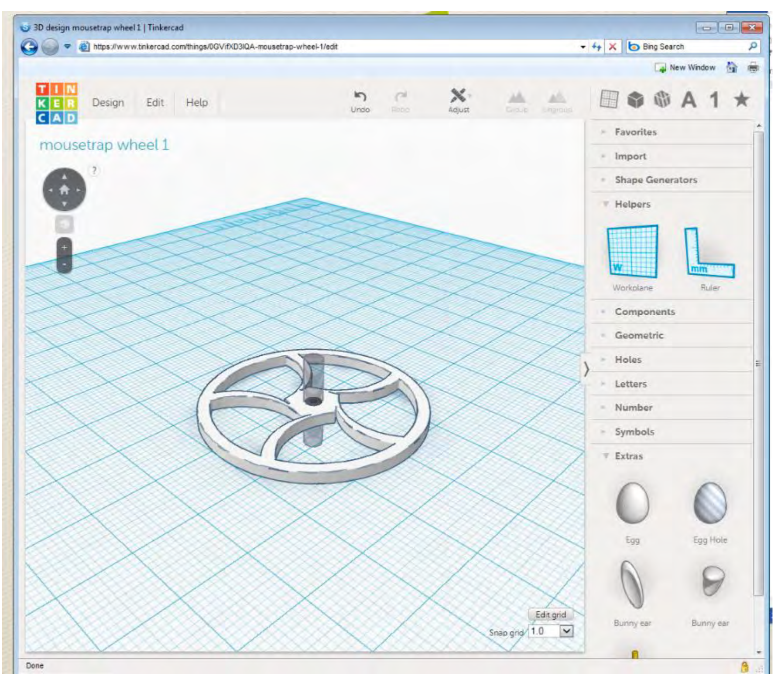
Tinkercad design your own or to modify an existing object

Get a free account, login

Clicking on "Waffle" takes you home

Search/ find an object, then "tinker this" is to edit. It will be put into you home work space

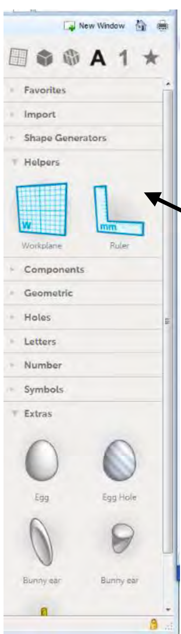
SCREENS AFTER OPENING A DESIGN/OBJECT or WORKSPACE



<u>Design</u>

New
Duplicate is to copy (*recommended to make a copy of original before making changes)
Save
Properties is to change the name of your design
Download for 3D printing .stl format is for most printers
(for Flashforge printer that uses .x3g file format you need to use replicator software to change format. Open in replicator and then change and save in .x3g format.)

<u>Orientation Bar</u>
up/down left right 'house' view location of entire workspace
'cube' fir view of selection
'+' zoom in '-' zoom out
right mouse button – hold to turn
scroll on mouse – to zoom
right mouse button and + key – to move



<u>SIDE BAR</u>

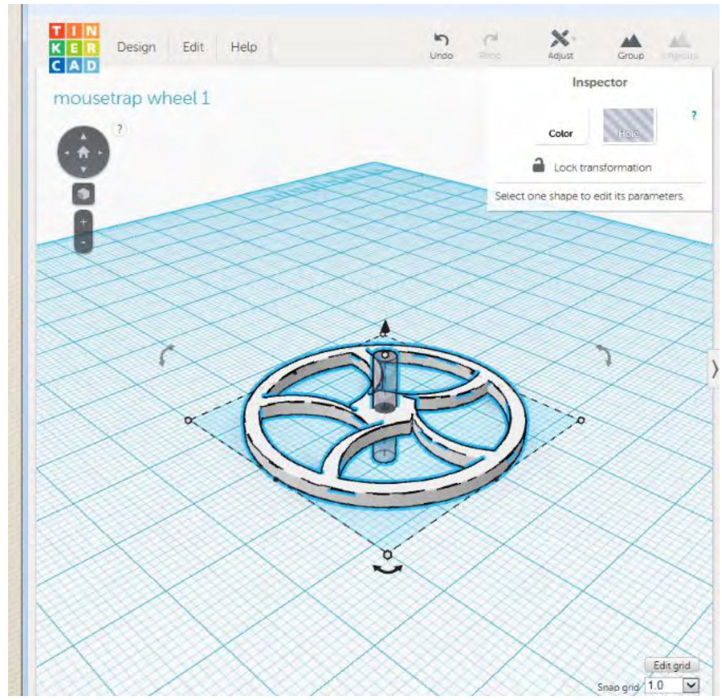
Favorites any shape or object that you use repeatedly can be saved here.
Import is to get objects from thingiverse or other stls
Shape Generators these are pre-made general shapes to use
Helpers
-workspace (drag and drop) this is what you do all your editing on, default ALWAYS work in workspace
-ruler (drag and drop) this is used to make specific dimensional changes or placement changes, by clicking on a number and it changes to red, it can be changed. Go back to workspace when done
Connectors pre-made objects
Geometric pre-made general shapes
Holes- pre-made holes can be resized (you can make any shape a 'hole')
Letter- pre-made letter objects/shapes
Number -pre-made number objects/shapes
Symbols-pre-made objects/shapes

When you click on object "Inspector" opens it show color of object which can be changed and any part of the object that is a 'hole'

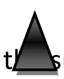
you can change any part of an object to a 'hole'

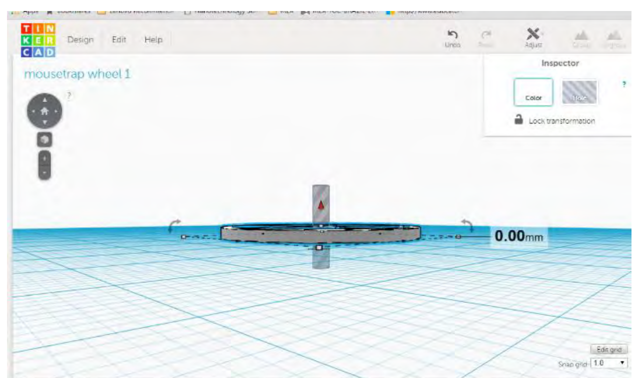
Clicking on the object, you can 'ungroup' various parts of an object shape, in this way individual parts can be changed

Shift click on each shape or pieces of the shape then 'group' them to be one piece. It will also show what the object will look like with the holes in it. You can view from different angles.



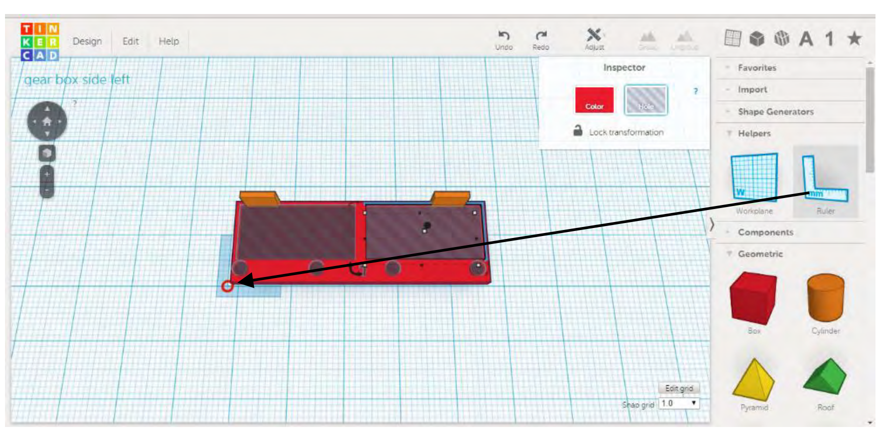
 Changes the view angle

 This changes the relationship (up/down) to the workspace plane . * Make sure the object is on the surface 0.0mm before printing

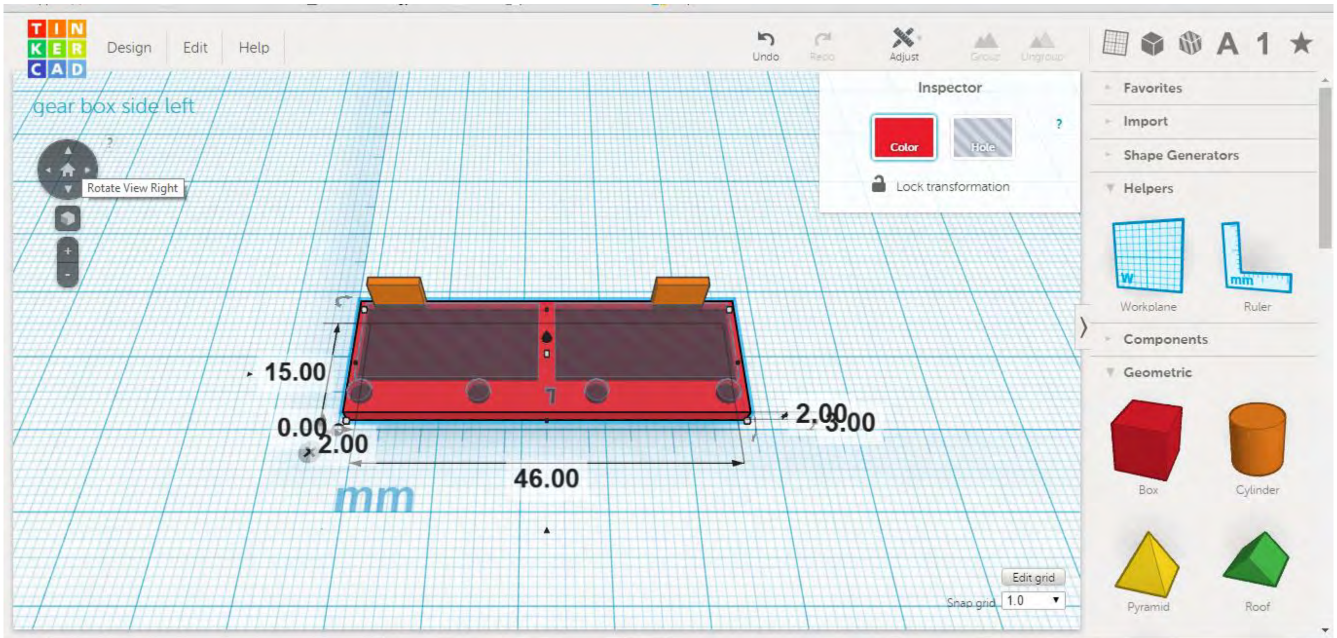


To change the dimensions of an object on the workspace

Drag ruler (from Helper Menu) to the workspace



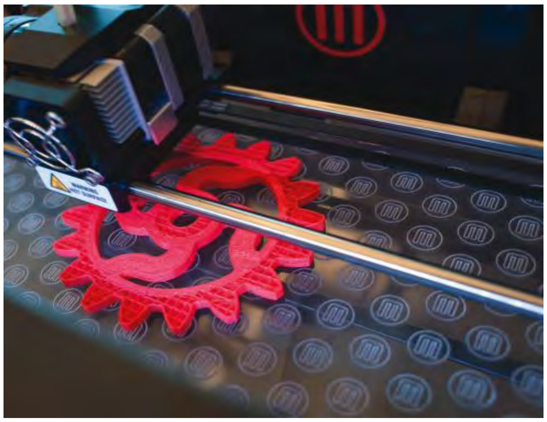
This is what the editable workspace looks like. Measurements all from center or ruler.



Clicking on each number, turning it red will allow you to change the value   Clicking on center of ruler will dismiss the ruler and back to workspace.

Benefits of 3D Printing

Parts can be made with low waste since the part is built “additively” instead of “subtractively”.



Increased Complexity

Parts with complex geometries can be made that are otherwise impossible to manufacture.

Mass Customization

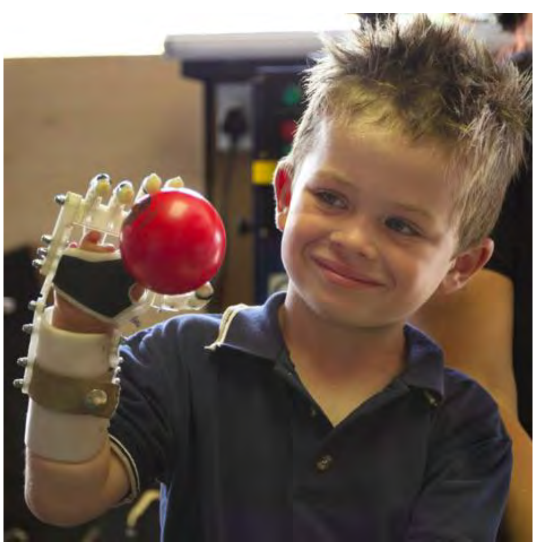
Custom parts made specific for the application, at no extra cost.

Applications

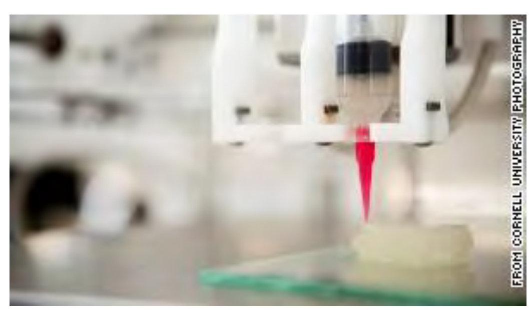
The future of manufacturing with 3D Printing is arguably bringing about a 3rd Industrial Revolution. The capabilities of these machine are endless, they will be utilized by every type of engineer, and will affect every industry.

SpaceX has a 3D printed engine chamber designed and built by students. 3D printing this part decreased the lead time by an order of magnitude

BioMedical Engineering - Prosthetics, Implants, Organs

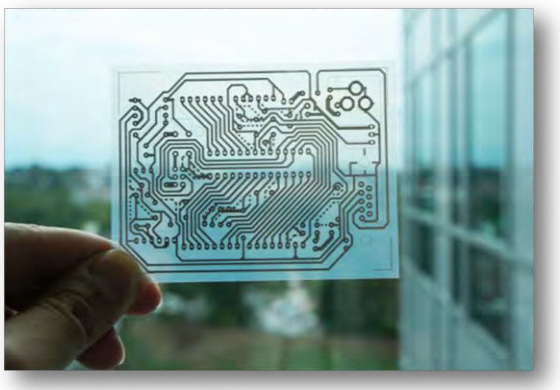


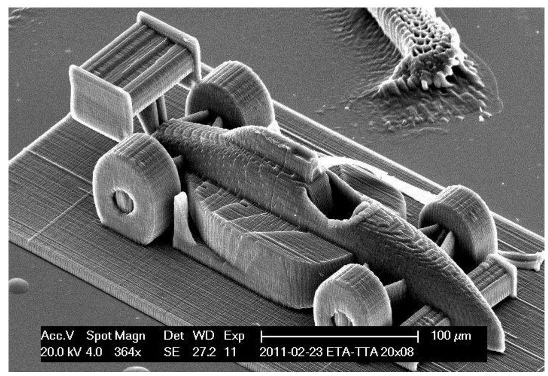
A 3D printer at Cornell University produces an artificial ear.



Mechanical Engineering - Aerospace, Auto, Product Design

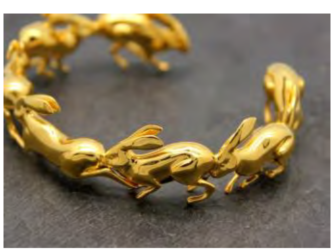
CSE/EE - Circuits + Nano Printing

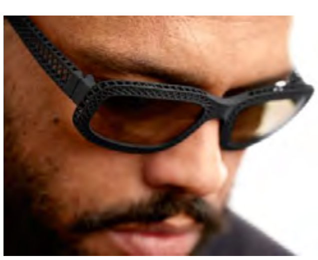




MSE - Material Research & Development

Fashion





Art & Creativity

Obama voice sculpture https://www.youtube.com/watch?v=PM-l05XusNU

Bears on stairs https://vimeo.com/91711011

3d printed food art

Chase Me - The first 3d printed short film https://vimeo.com/121352977

THE EDUCATION FUND

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All Miami-Dade County public school teachers, media specialists, counselors or assistant principals may request funds to implement any project idea, teaching strategy or project from the 2017 Idea EXPO workshops and/or curriculum ideas profiled annually in the ***Ideas with IMPACT*** catalogs from 1990 to the current year, 2017-18. Most catalogs can be viewed on The Education Fund's website at educationfund.org under the heading, "Publications."

- Open to all K-12 M-DCPS teachers, counselors, media specialists
- Quick and easy reporting requirements
- Grants range from $150 - $400
- Grant recipients recognized at an Awards Reception

To apply, you must contact the teacher who developed the idea before submitting your application. Contact can be made by attending a workshop given by the disseminator, communicating via email or telephone, by visiting the disseminator in their classroom, or by having the disseminator visit your classroom.

Project funds are to be spent within the current school year or an extension may be requested. An expense report with receipts is required by Friday, June 1, 2018.

APPLICATION DEADLINE:
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Apply online at educationfund.org

For more information, contact:

Edwina Lau, Program Director
305.558.4544, ext. 113
elau@educationfund.org

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