CLEAPSS Design and Technology

Futureminds

Tomorrow's world explored today

3D SPECIAL EDITION

3D SPECIAL 2020

CLEAPSS D&T e-newsletter

Welcome to the 3D special edition of *Futureminds*.

For those of you that have been with us since *Futureminds* Issue 1 you will know what a popular and valuable resource it has become.

To make it even more useful, for both existing and new readers, we have decided to republish articles that deal with a single subject so that the advice is contained in one easy to access document.

In this issue we are looking at the rapidly changing world of 3D printing. On each page you will see that we have included a reference to the issue in which it was first published and of course the text contains live links with even more information and useful contacts.

Over the coming months there will be further special editions dealing with:

- Food Technology
- Textiles
- Art
- an edition dedicated to the SmallPrint – our updates to H&S advice and guidance.

If you have any comments or would like to submit an article for *Futureminds*, contact CLEAPSS:

Dt@cleapss.org.uk or via Twitter: @cleapss_dt

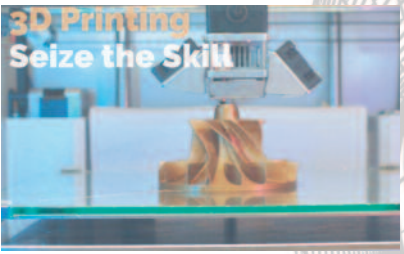
Happy reading!

Designing for 3D

By Dr Achilleas Sesis of 4Delta

3D Printing:
Not a Hype but a Technical Skill

3D printing is experiencing an, almost exponential growth, both in machine technology and printing materials. This serves as a catalyst for the simultaneous development in services and applications, where currently it has infiltrated almost every product-making activity of our societies. Some of the prototype ideas include printed culinary edibles, full-scale houses, components for the transport and manufacturing industry, wearable arts and medical parts. Perhaps an interesting fact is the affordability of this manufacturing tool, where current desktop system can be purchased for as low as few hundred pound (£).

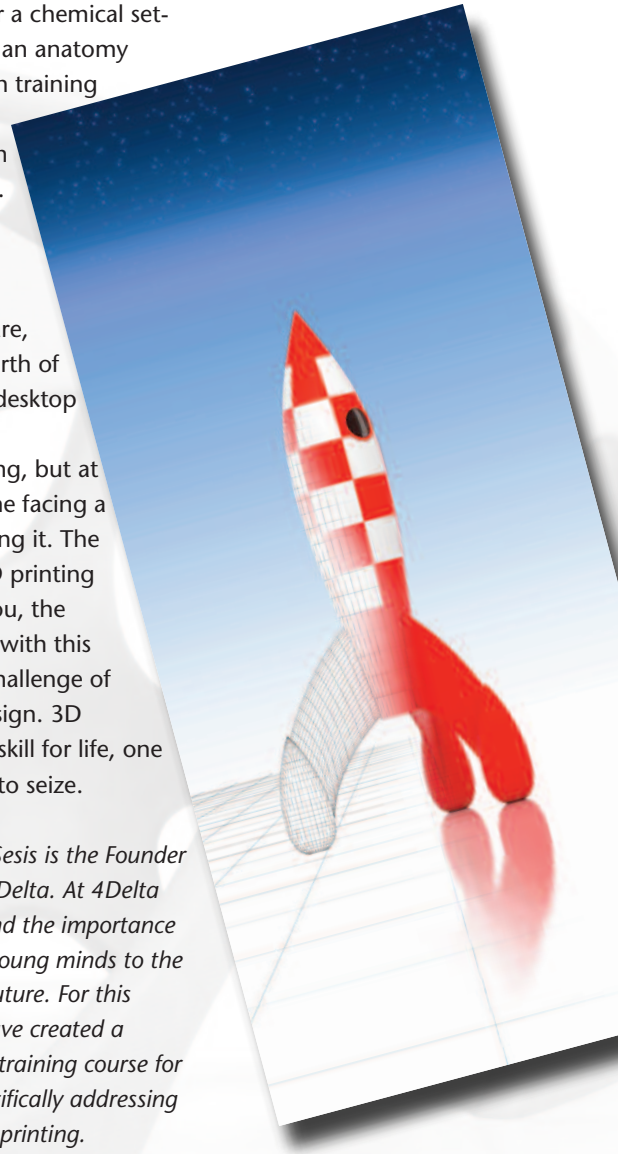


Desktop 3D printing, is now widely available in schools and typically used in homes by those for whom technology is a hobby. As a result numerous interactive websites have sprung up, offering designs to be readily printed. This is great, but I want you to take a step back and think. The beauty of 3D printing lies in the ability to design and build our own ideas. While the technology is rapidly moving, a fundamental element so often overseen is the ability to design. Essentially desktop 3D printing was pioneered to enable the creator within you and your students.

A fundamental prerequisite to be an independent 3D printing maker requires you to be a computer aided design (CAD) software user. This is a technical skill typically associated with product designers and all the types of engineering. Files produced through the use of those software are exported in a format that a 3D printer can understand. This basic requirement for the use of 3D printers has often been overshadowed by enthusiasm for their potential applications. As a result, we start seeing the first signs of nullifying its benefits, with perhaps the most visible being the repetition of printed parts. Does the image of another chess piece haunt you? Does this sound worrying? Unfortunately it should, if those first signs are left to become a trend then we are in danger of derailing the drive towards the creation of skilful pupils, a matter often discussed and brought to the top of the agenda in decision-making bodies. We must not forget one of the key principals of education is to create independent thinkers/makers, and as you strive to enhance the independent spirit of your pupil, why should you allow it to happen in this case?

More importantly and pertinent in education, where the boundaries between teaching topics can be easily bridged, 3D printing has the potential to go beyond the narrative of the Design and Technology curriculum. Students from all subjects can participate in the making of things, such as copies of archaeological artefacts for a history debate, wind tunnel test pieces for an aerodynamic project, part making for an electronics housing, props for an art performance, support structures for a chemical set-up, parts for an anatomy study or even training aid for students with impairments. The list is endless.

So here we are, seeing the birth of widespread desktop complex manufacturing, but at the same time facing a threat of losing it. The beauty of 3D printing lies within you, the creator, and with this comes the challenge of technical design. 3D printing is a skill for life, one for students to seize.



Dr Achilleas Sesis is the Founder and MD of 4Delta. At 4Delta we understand the importance of exposing young minds to the tools of the future. For this reason we have created a Cloud-based training course for students specifically addressing CAD and 3D printing.

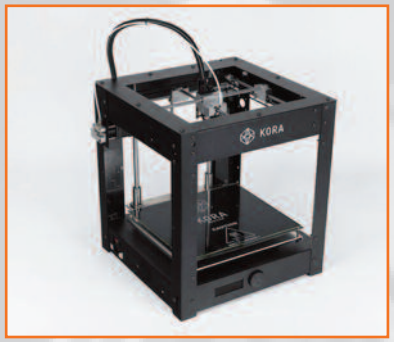
For more information please visit our website at:
http://www.4delta.co.uk
or email us at
education@4delta.co.uk

KORA 3D printers

by Dale Charnock

KORA was established in 2013 with the vision of becoming a world leading maker of advanced yet affordable 3D PRINTERS for creative people and businesses.

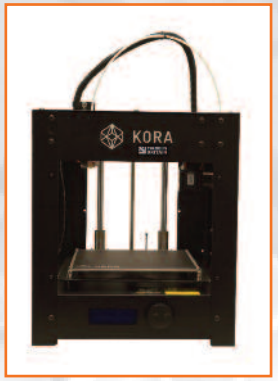
KORA
www.kora.co.uk



Our latest product, The Midi (the machine used at CLEAPSS) - is a professional desktop 3D Printer, designed and made in Great Britain for a world of workspaces.

Kora 3D Printers and Consumables has recognised the need within the Educational Sector to provide the highest quality, affordable but most importantly, safe 3D printers and accessories.

Working closely with Government agencies and alongside CLEAPSS, Kora can now offer a range of British manufactured 3D printers, these have been designed, built and tested in the UK to provide safe utilisation of most standard available 3D Printer filament types within the classroom, laboratory and business environments.



To encourage teachers and students to develop high level skills in this exciting new industry we have built a training centre at our premises in Leeds (opening in June 2016). It will provide teachers and students with the opportunity to gain a basic overview of 3D printing, learn a range of software applications and make items on KORA printers. We also plan to run more advanced training and offer an ongoing 'full hand-holding program' to improve confidence and knowledge of 3D printing. We will, at all times, impress upon users the importance of safe 3d printing in public environments.

The training facility will have access to 3D printers, IT facilities and a 'dirty' area for finishing prints.

Please email enquiries@kora.co.uk if you require further information.

MADE IN BRITAIN

3D printing and STEM education

By Phil Cotton

"I feel challenged as it is something new, and you can be creative." Quote from GCSE student when discussing 3D printing.

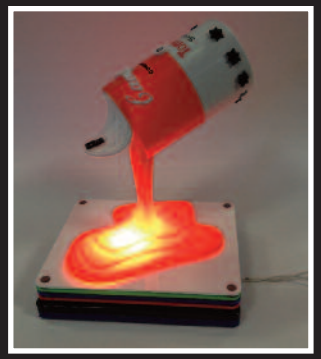
It's the first lesson with the 3D printer. You're out of your depth slightly. You've only had the printer one week with a few spare hours to try and figure out the machine. You're a novice in front of the class but you hold your nerve and demonstrate it anyway. Will it print first time or wont it, you're thinking? The printer starts to print, your class is fixated. Sink or swim time, sigh of relief, it worked. This was my first experience of teaching 3D printing to my students five years ago, and I have never looked back since, neither have my students.

The opportunity to embrace new technology in the classroom has never been more accessible. The current Design and Technology national curriculum includes the topic of 'new and emerging technologies'. The breadth of hardware and support available to meet this area is vast. From programmable components to 3D printing, students have never had it so good. For our students to compete in the ever-growing global economy, we must prepare them for jobs that possibly don't exist yet. The only way we can ensure that students achieve a world class education is by exposing them to the latest innovations such as 3D printing and the BBC microbit. This will allow them to keep pace with changing industries and prepare them for future careers.

If we look at 'additive manufacturing', or '3D printing' as it's more commonly known, my students have embraced the technology and run with it. The result is more challenging lessons and deeper learning opportunities. The technology naturally fuels students' creativity as they can design using 3D CAD, then it can usually be 3D printed. The technology encourages students to experiment and, ultimately, embrace an iterative design process which reflects a higher level of thinking. Rather than one episode of design and make, 3D printing encourages students to go back and re-design and then re-print, re-evaluate, and the process repeats. This models a more real life design and engineering experience. This experience is also reflected in students learning how to write code with programmable components. Very rarely will students write a correct line of code first time round. They must test out their code and then go back and re-write to ensure that they have achieved their intended objectives.

Where does this lead the future of technology education? There are ripe opportunities within education to tap into the 'future minds' of students. The support network is being led by National STEM centre in York with world-class teacher training courses being delivered to help UK students realise their potential in STEM education. Within a changing technological world, it is more important than ever to embrace new technologies in the classroom.

Phil Cotton is a National STEM centre accredited lead teacher of STEM. He has for the past 18 months delivered CPD courses at the National STEM Centre, on integrating 3D printing into the curriclum. He has simultaneously worked full time as a Design and Technology teacher at Ladybridge High School in Bolton. Phil has also worked with the University of Manchester delivering training for Initial Teacher Training on 3D printing in education and he has presented at regional STEMNET events and educational conferences.



3D Printing with GoPrint3D

by David Whitehouse

At GoPrint3D, we believe that 3D printing is the future of industry and manufacturing. Offering an unprecedented range of 3D printers and 3D printing solutions, we help people and organisations choose the right 3D printer for their needs.

GoPrint3D are able to offer impartial advice, and sell and hire 3D printers, we also offer a 3D printing service. For many multinationals, 3D business is one of the most important growth areas. And for many SMEs, desktop 3D printing has driven innovation and development.

In schools, 3D printing can change the way students learn, and in dental labs, it has revolutionised how orthodontic devices are made. Look elsewhere, and it's plain to see the impact desktop 3D printing has had on industry in such a short period of time.

For example, the 3D Jewellery Company (Facebook: Amy's 3D casts and jewellery) is a recipient of our 3D printing service. Amy creates beautiful 3D casts of children's hands, feet and fingerprints. These casts are made using a quick-setting mould, and 3D scanning is then used to map this. We then 3D print the models in our workshop using the Formlabs Form 2, 3D printer, rendering a fingerprint-perfect model for Amy's customers. For Amy and her company, our 3D printing service is a low-cost way to manufacture products.

Elsewhere, Metmachex Engineering use 3D printing to manufacture prototype swing arms and billet parts. These are printed using the Zortrax M200 3D printer, and if they are printed with a functional resin, they can be used for mechanical applications. We recommended and supplied the Zortrax M200, because it's a high-accuracy, high-output machine.

Another exciting project we worked on recently was for the Beyond Boundaries: Art by Email project, set up by the Yorkshire Sculpture Park. We supplied the Yorkshire Sculpture Park with a Zortrax M300 3D printer, so they could 3D print a sculpture submitted to them by artist Sahand Hesamiyan. The sculpture, named "Pardis", was inspired by mysticism and Islamic geometry. A beautiful, opaque white sculpture with interesting geometries, it printed successfully and formed part of the Yorkshire Sculpture Park's exhibition in March.

Beyond these projects, we provide customer service and support for customers who purchase a 3D printer through us. We are authorised by our partners (where applicable) to provide support, and in cases, warranty work, and our experienced team can help you to get the most out of 3D printing, whatever the application.

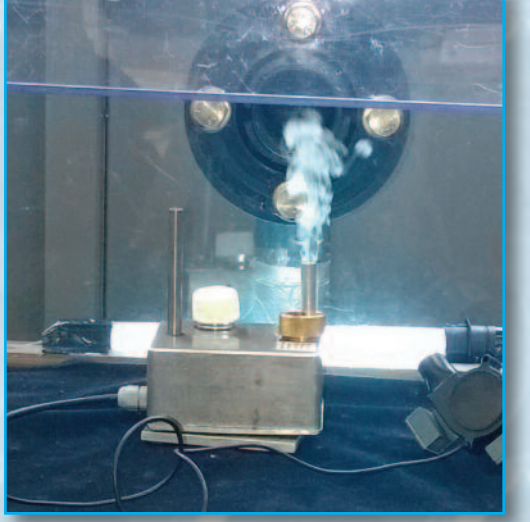
Some of our partners include Formlabs, Ultimaker, 3D Platform, Markforged, Leapfrog, MakerBot and Zortrax, and we are always looking for new partners to work with. From dual-extruder Fused Filament Fabrication 3D printers to Stereolithography 3D printers, which print from a tank of resin, we offer it all, and we're excited and proud to be part of such a diverse, high-growth industry that's showing enormous potential.

Here at CLEAPSS we have been doing lots of interesting things with our 3D printers, as you may have read earlier, or seen from our tweets. We have also been working on our new D&T website which now has project ideas, so if any of the methods mentioned in this article interest you, take a look at the new website for information related to the safe practices you need to bear in mind when developing a 3D printing project.

3D printing update

Over the past two years CLEAPSS has been working with the Health and Safety Executive (HSE) and others to test the emissions from desktop 3D printers which use plastic filament heated and extruded to create a 3-dimensional outcome on a build plate. Among the printers tested are several which are commonly seen in schools.

The results show that there are some serious health concerns in using these devices that need to be taken into consideration when assessing the risks for their use. The focus of these concerns has been on fumes and nanoparticles



Users of the Internet can find a range of conflicting reports on the safety of 3D printers. Some suggest that "3D printers are safe", others that there are significant safety issues in using particular materials. Most published reports concentrate on the fumes from the printing filament, rather than particle emission. There is a general agreement that PLA (Polylactic acid) produces 'safer' fumes when printing, as it does not contain some of the more harmful plastic components. ABS (Acrylonitrile butadiene styrene) is generally considered less safe because it gives off a range of chemicals when heated, including styrene, which are known to cause sensitisation and other harmful effects.

The HSE and CLEAPSS could find no reliable reports concerning emissions of nanoparticles. It is increasingly accepted that nanoparticles, such as those emitted by 3D printers and laser cutters, can be a significant health hazard, and effective controls should be put in place to protect the user. The HSE recommends a precautionary approach to risk management with control strategies aiming to reduce exposure to As Low As is Reasonably Practicable (ALARP).

Tests carried out at the Health and Safety Laboratory:

1. Pyrolysis Testing, mainly for fumes, small pieces of filament are burned and the exhaust gases are analysed

2. Emission Testing, mainly for particles, the 3D printers are placed in a wind tunnel and the exhaust gases are passed over a variety of sensors whilst the printer is working

Conclusions from the Pyrolysis Tests:

- Not all filaments are correctly labelled, one roll of filament was labelled PLA but was ABS, some filaments have no indication of their content i.e. ninjaflex, which was found to be polyurethane.
- All filaments give off fumes when heated, some containing hazardous products such as styrene, and isocyanates, which should be controlled under COSHH regulations.
- The colour can affect the emissions, both in quantity and content.
- Some batches of filament can differ from identically-labelled filament from the same supplier.
- Emissions increase during the heating cycle and decrease during the cooling cycle.

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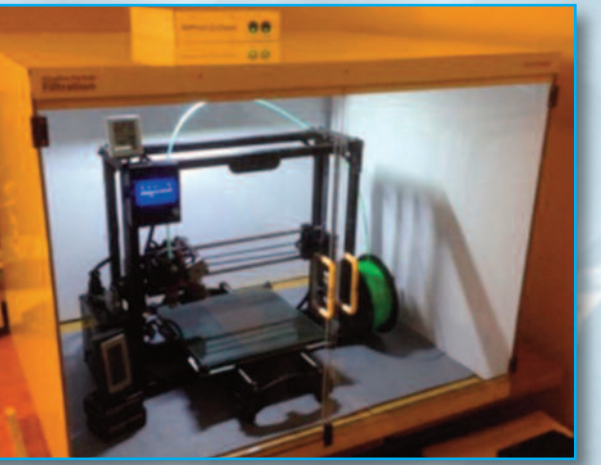
3D printing update



Conclusions from the Emission Tests:

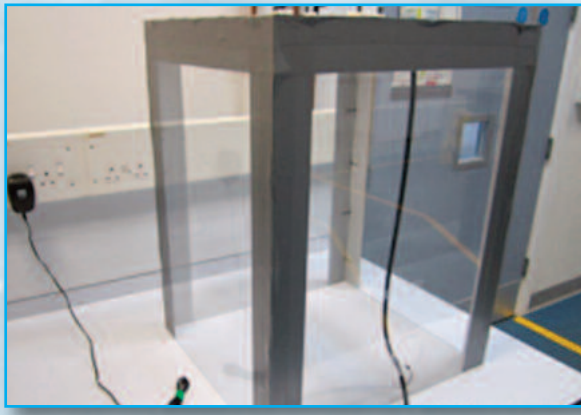
- All the printers tested, produced emissions that contained nanoparticles.
- The particle size and concentration of these is related to the heat of the printer extruder nozzle (hot end).
- An increase in the hot end temperature decreased the size of the particles.
- An increase in the hot end temperature increased the concentration of the particles.
- An increase in the hot end temperature increased the emission rate of the particles.
- Emissions from the same filament are different when used in different printers or under different conditions.
- Emission rates and average particle size depend on filament material.
- Exposure controls could reduce particle emissions by up to 99%.

Guidance to schools:

The hazards associated with 3D printing include:

1. Emissions of fumes and particles
2. Trapping hazard from moving parts
3. Burns from hot components

These hazards can become significant risks in school. Trapping and burning can be controlled by having a fully enclosed printer, however emissions may still present a risk. Ventilation, or placing the machine in an extracted unit should be sufficient to control emissions.



CLEAPSS Model Risk Assessment: 1.088 *Additive Manufacturing 3D printing*, is under review, but our current advice is to install ventilation for 3D printers, because it seems likely that HSE will recommend that systems are put in place to control the emission of potentially harmful particulates. The MRAT also gives advice regarding trapping and burns, running a machine in a controlled environment such as an enclosure will also reduce the risk of trapping and burning.
In a desire to take up these new technologies, schools are increasingly buying several 3D printers, and even developing 'maker spaces' where multiple machines run simultaneously. Some schools are installing maker spaces in public areas such as the library or school foyer. These require careful consideration prior to installation, in order to ensure appropriate hazard control, including emissions. Schools should refer to the MRAT, more information regarding the testing is available on the CLEAPSS site and if schools are concerned about their arrangements they should contact CLEAPSS via the ***Helpline***.

Integrating 3D Printing into the new Design Technology GCSE

by Sonya Horton, Ultimaker

The new GCSE specifications do not have an explicit requirement to deliver programmes including 3D printing technology (additive manufacturing). This is a disappointment to many manufacturers and other businesses, as they see this is a missed opportunity. There continues to be a widening gap between the skills of school leavers and the requirements of employers in the additive manufacturing industry.

Teachers with access to 3D printing can embed their use in the GCSE curriculum. Students can use these new technologies to model and modify their design ideas. The knowledge and practical skills they gain can help with further studies in education or employment.

The benefits of embedding 3D printing within the GCSE Design Technology courses include:

- More meaningful development of students' 3D CAD modelling skills. Students are modelling designs with a purpose as they have the ability to print them.
- Real replication of industrial practices. Students can undertake short projects such as making custom tools, jigs and templates or making moulds for casting.
- Deeper understanding of the benefits of new and emerging technology, and the hands-on experience which allows them to effectively and critically evaluate it's impact.
- Real rapid prototyping technology, allowing students to make multiple, quick iterations during the development of their product ideas simply by tweaking a CAD file and reprinting, which was not possible with traditional workshop techniques.
- The ability to design and make custom parts for final prototypes that would not be possible with traditional workshop techniques.
- The ability to manufacture high quality final prototype products and parts to specific sizes and tolerances.

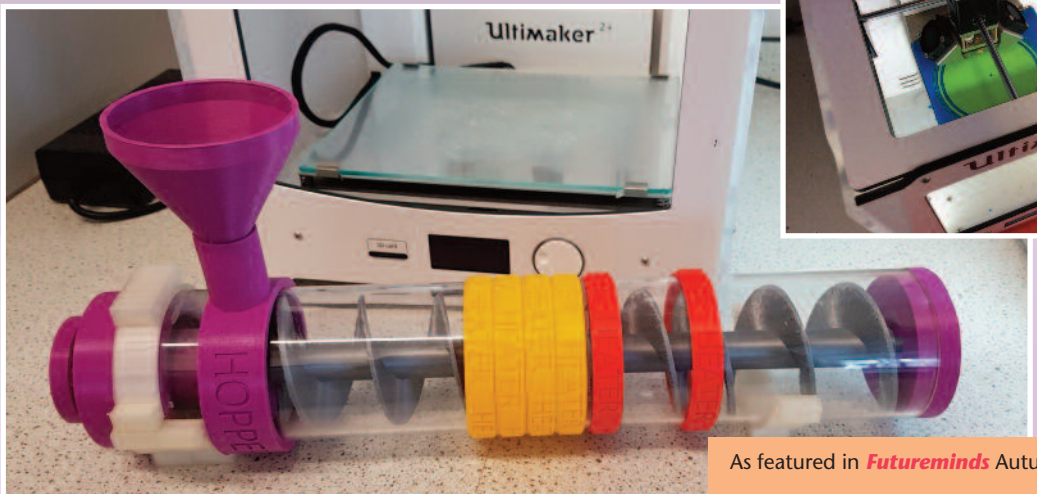
3D printing allows students to develop unique design solutions with a professional quality finish. The ability to manufacture complex geometries allows more sophisticated designs and solutions to be realised. For example, students could develop a bespoke aid for a user with a specific difficulty or disability.

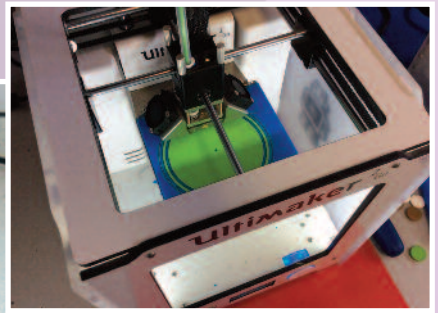
Printed models can have various percentages of internal structure and can even be hollow, this allows for lightweight models, perfect for projects that involve flight, such as prototype gliders and drone projects.

Students can also utilise 3D printing for creating custom casings for electronics, or integrating electronics and micro-controllers directly into a 3D printed product, such as a robotic device.

A novel way of utilising the 3D printer is to make instructional models. For example, students can learn about the injection moulding process, using the 3D printed model of simplified injection moulding machine produced by Lloyd Griffiths, Design & Technology teacher at Newport High School. Normally a difficult process to understand, the model aids learners understanding of both the process and the materials used.

If you are considering introducing 3D printing and don't know where to start, or you have the technology and are looking for inspiration, visit the CREATE Education Project at www.createeducation.com to download the FREE 3D Printing in the New Design Technology Guide and access lots more free projects, resources and ideas. You can also borrow a 3D printer for a month to run a project in your school to try it out with its free educational loan scheme.





3D printing has landed

now it is time for the curriculum to evolve

by Phil Cotton Learnbylayers

3D printing has made its way into classrooms up and down the country, and around the world. It's no longer a novelty for a well-equipped DT department to have a 3D printer. With the new GCSE specs all mentioning additive manufacturing it is safe to say that 3D printing is here to stay and that all students should be exposed to the technology. Over the past five years 3D printers have evolved from quite basic, not very user-friendly, machines, to reliable high-spec automated machines that almost anyone can operate. Whilst the development in the industry has been focused on hardware and software, curriculum content has often been left behind.

Created and tested by teachers

After working with National STEM learning and Dave Parry from CLEAPSS for the past three years delivering 3D printing CPD to teachers, it was clear from delegates that there is a huge demand for 3D printing in education and the curriculum. I've heard many horror stories of 3D printers sitting in boxes not being used, as teachers haven't had the time to plan lessons where the equipment can be effectively utilised. With this in mind, I wanted to create a solution and make teaching 3D printing as stress-free as possible for teachers.

Learnbylayers is a complete curriculum for teachers and their students. There are over 150 resources to help teachers deliver high quality lessons in the classroom. The curriculum is split into three categories, Beginners, Intermediate and Advanced lesson packs, and are aimed at students aged 11–16. All lesson resources are fully editable, and schools have a lifetime license to use them. There are no annoying subscriptions. The resources have also been mapped against the Design and Technology subject content for KS3 and the new GCSE subject content.

Every lesson comes with a lesson plan, teaching Powerpoint, lesson worksheets, homework tasks, stl files, design challenges, video tutorials, and assessments with answer sheets. The lessons are based around AutoDesk which is a free software system for education. The Beginners use TinkerCAD and the Intermediate and Advanced uses AutoDesk Fusion 360. As they are all cloud-based students can continue their learning at home with ease.

What can students learn with **Learnbylayers**? Lessons focus on the theory of 3D printing and how to design models. The Beginners scheme of work introduces students to the basic concepts of how a 3D printer works and what materials are used. Then students learn how to create simple models and how to slice them using basic settings in CURA (the most commonly used slicing software).

The Intermediate and Advanced lessons build on this with more in-depth theory along with more challenging design tasks. Lesson topics include, an introduction to parametric modelling, materials and 3D printing, how to slice models, 3D printers and sustainability, 3D printing and manufacturing and many more. All the schemes of work come with differentiated design challenges so that all students in the class can access the learning.

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LEARN BY LAYERS 3D

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3D printing has landed

now it is time for the curriculum to evolve

by Phil Cotton learnbylayers

Every lesson pack can be used 'straight out of the box' with little planning for the teacher. With an ever-increasing workload being demanded of schools, **Learnbylayers** can drastically reduce the time needed to introduce 3D printing to all year groups as the lessons are pre planned ready to go.

Since it's launch in late October the package has gained an international footprint. Currently it's being taught in schools in the UK, USA, Australia, New Zealand, Brazil, UAE, Kuwait, France, Netherlands, Singapore and Trinidad and Tobago with over 14,000 students attending schools where the **Learnbylayers** curriculum is taught.

As part of my ongoing work with STEM learning, teachers who attend the 'Using 3D printers creatively in KS3 and KS4 Design and Technology' will receive a free copy of the 'Intermediate lesson pack' which is an ideal follow on from the 2-day course. The course includes workshops on the theory of 3D printers and where they are used in society, how 3D printers work, Fusion 360 tutorials, dedicated health and safety sessions, and analysis of 3D printing projects at KS3 and GCSE. Teachers who attend will be able to go back to their school fully prepared to integrate 3D printers into their curriculum, and, with the free Intermediate lesson pack, have all the resources needed to start delivering lessons from day one.

Learnbylayers can be purchased alongside 3D printers as bundle packages. We have partnered with Kodak which has just released its first 3D printer onto the education market, and Technology Supplies, where it can be bought alongside selected printers. In addition, GoPrint3D is reselling the curriculum with its range of printers.

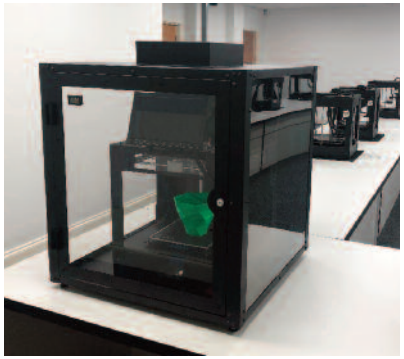
To find out more about the **Learnbylayers** curriculum visit www.learnbylayers.com and check out our social media channels @learnbylayers and www.facebook.com/learnbylayers

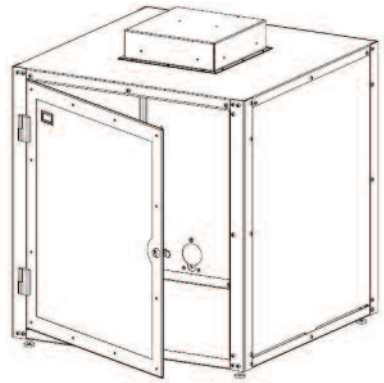
enclosing your 3D printer

by Dale Charnock, Secure Micro Solutions Ltd (SMS)

Over the past few years SMS has been involved in the testing of 3D printing machines and materials with CLEAPSS at the HSE labs in Buxton. The guidance ,which was written following these tests, is available on the CLEAPSS web site.

The results of these tests led SMS to develop a safety cabinet that encloses the printer and has filtered extraction to control harmful emissions.



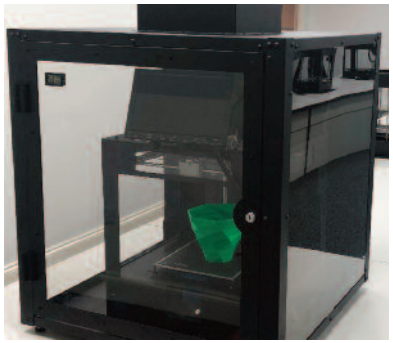


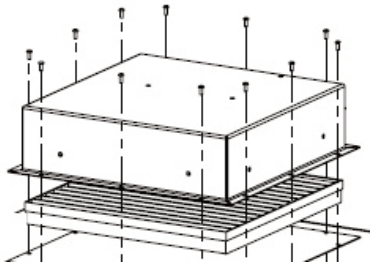
Manufactured in the UK and tested at the HSE labs, the SMS Safety Cabinet (SC) works on the principal of drawing in clean air through lower vents, and gently washing it over an operating FFF desktop 3D printer before exhausting it back out through a specially treated 'easily replaceable' high volume HEPA / Active Carbon Filter system. This removes the harmful emissions before the circulated air is returned to the room. Many different filaments were tested and found to produce ultrafine particles and volatile organic compounds (VOCs) during the desktop FFF / FDM 3D printing process. The SC filter system removed 99% of these during comprehensive ‘real time’ testing at the HSE labs.

The SC has many additional safety features. It is fully enclosed and has a lockable front access door which can prevent access to potential hazards present on most desktop FFF 3D printing machines, including:

- Trap or entanglement hazards (fingers, hair, clothing etc.) caused by mechanical parts and belts moving on an open or exposed gantry systems
- Burn hazard from the hot 'printing head' often reaching temperatures in excess of 250°C and the 'heated build plate' sometimes reaching temperatures exceeding 100°C

Additionally, the cabinet will help reduce noise from the printer and cooling fan during operation.





The lockable SC can be fixed to the desktop surface, preventing opportunist theft of the printer or the SC itself, and denies any unauthorised access to the machine.

The enclosed SC prevents gusting drafts of air caused for example by an open door or window. Such gusting drafts can seriously affect the final quality of any 3D printed model. The SC is constructed of steel and fire-resistant clear PETG sheet materials

A fully automatic fire extinguisher can be added inside the SC, triggered by extreme temperature within the enclosure.

Also an option is a heat detector unit that operates in a similar way to a domestic smoke detector, but emits a continuous piercing alarm if the heat in the SC rises significantly above expected levels (around 55 °C)

With the addition of these two options, the SC would suppress the spread of any 'open hearth' fires in the case of a catastrophic machine system failure (most relevant to non CE approved and home DIY-constructed 3D printers)

LED lighting can also be added to enhance the SC, 3D printer and the model that is being printed. This is particularly useful for videoing 3D prints , and observing the machine in poorly lit areas.

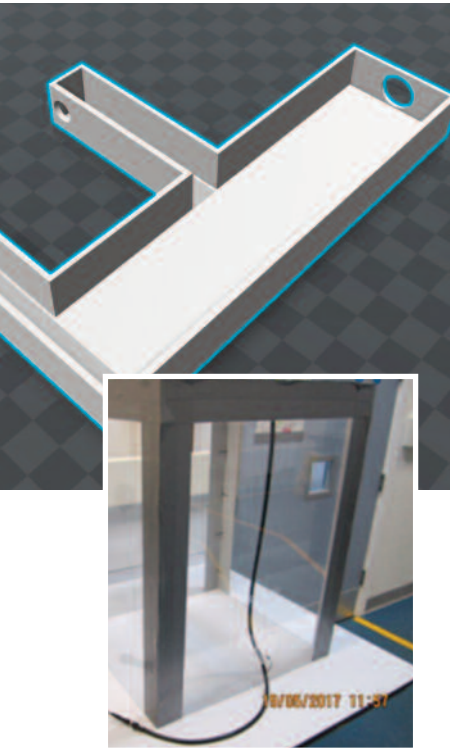
An independent heater system can also be added to establish an increased ambient printing environment temperature. This can prove beneficial for printing with some of the more exotic filament materials.

for more information click www.securemicrosolutions.com

3D printing guidance

As readers will have been aware, over the past few years we have been working with HSE to develop guidance on the safe use of 3D printers in schools and colleges.

This work has included a whole range of tests and experiments, carried out at the HSE laboratory in Buxton.

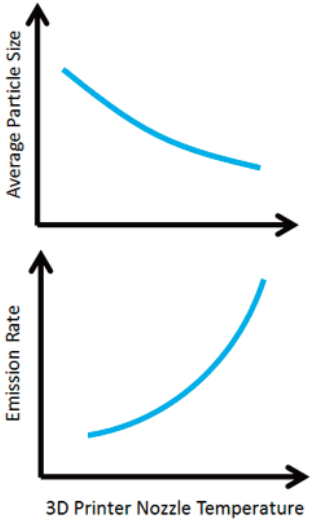


The tests covered two areas:

- Characterisation of the particulate emissions
- Volatile organic compound (VOC) emissions

Pyrolysis testing was used to find out what the filaments produced when heated. We tested a number of different filaments including:

- PolyLactic acid (PLA)
- Acrylonitrile-Butadiene Styrene (ABS
- High Impact Polystyrene (HIPS)
- Nylon
- Embedded Metals
- Wood
- Ceramic
- Carbon Nanotubes

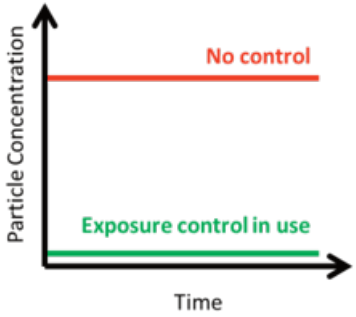


During this test a small sample of the filament was heated to the temperatures used in printing and a gas chromatograph with mass spectrometry was used to determine the chemical emissions.

The size and quantity of emitted particles was also measured and it was seen that as the temperature increased the number of particles increased, and the size of the particles reduced.

The risk to health is increased as particle size decreases, because the particles can enter further into the breathing system, and potentially transfer across the air/blood surfaces of the lungs.

It became apparent that, in use, all filaments give off chemicals and particulates. Under COSHH regulations, any harmful emissions must be risk assessed and, where necessary, controlled. There are currently no work exposure limits (WELs) for the emissions from fused filament fabrication (FFF) 3D printing so to achieve effective control of emissions we need to apply the general principles of good practice for the control of exposure to any volatile substance hazardous to health.



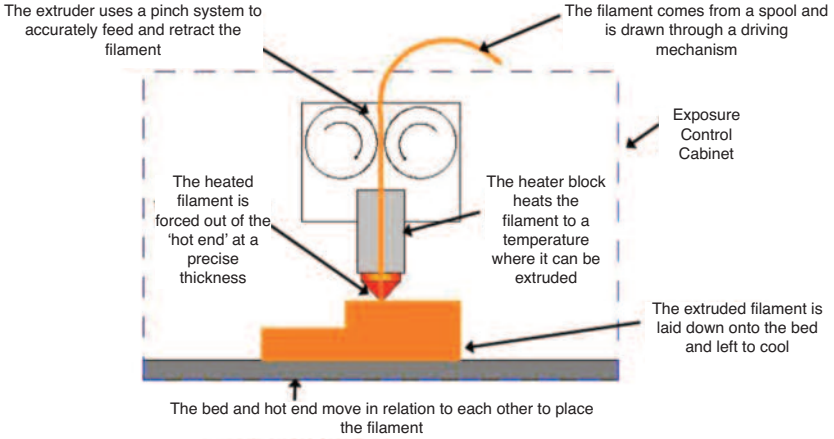


Diagram of a Fused Filament 3D printer inside an exposure control cabinet

For some individuals, brief exposure to these emissions may trigger symptoms but there may also be longer-term health risks for individuals who spend long periods using 3D printers. This is why the guidance is to have some sort of ventilation and/or extraction in place where 3D printers are used.

At CLEAPSS, we have installed our printer within an extracted enclosure, which draws the air through the cabinet and expels it via a HEPA and a carbon filter. The filters remove both harmful chemicals and trap particulates, so the air itself can be re-circulated into the room.

Placing the machine in such a cabinet also overcomes the other hazards associated with 3D printers: trapping and burns from moving hot components.

For more information see the guide on the website: ***3D Printing In Schools and Colleges: Managing the Risks***

Search for 3D on the CLEAPSS D&T site.

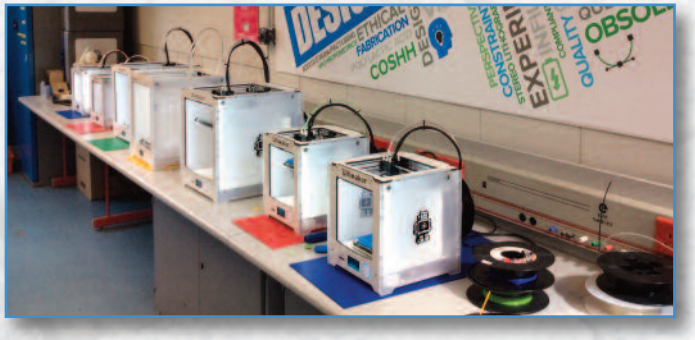
DEVELOPING KNOWLEDGE AND SKILLS FOR CAREERS IN ENGINEERING, ADDITIVE MANUFACTURING AND A RANGE OF OTHER INDUSTRIES.

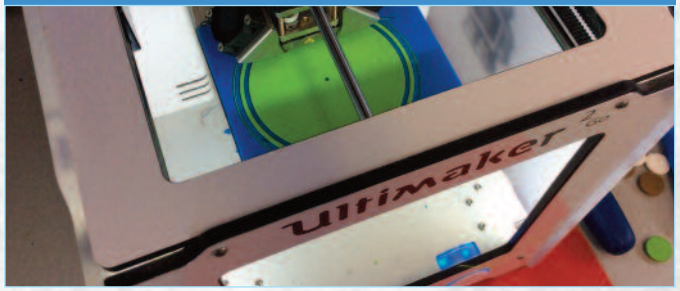
By Sonya Horton,
www.createeducation.com

There is no doubt that additive manufacturing (industrial 3D printing) is becoming more and more mainstream, with the technology permeating into a wide spectrum of industries including engineering, manufacturing, medicine, architecture, product design and even the food industry.

The rise in adoption of this technology also brings a rise in the number of career opportunities for young people, with many new job types that didn't exist just a few years ago. New job types are being created all the time as additive manufacturing develops and combines with other Industry 4.0 technologies. Consequently, many organisations are reporting increasing problems in recruiting young people with the skills that they need. In fact education and skills is cited in the top 4 issues facing the industry by the UK Additive Manufacturing National Strategy Group.

Unfortunately, there is currently no requirement for schools to develop any of the knowledge and skills required by industry to prepare them for future careers in additive manufacturing. As the curriculum, GCSE's and A-Levels have all been recently updated, it is unlikely that these requirements will be addressed anytime soon.





However it is promising that many schools are actively adopting 3D printing technology. 3D printing provides Design & Technology departments with a number of benefits, including the use of the technology as a rapid prototyping tool, allowing students to quickly produce multiple iterations of a product or part.

But most of all, access and experience in the technology provides students with the opportunity to get ahead and prepares them to take advantage of the jobs and careers available to them.

The introduction of the new statutory guidance from the DfE around offering career guidance linked to the Gatsby Benchmarks a further opportunity to forward thinking departments for linking their Design & Technology curriculum to careers in Additive Manufacturing (Gatsby Benchmark 4). They can achieve this by providing students with the opportunity to develop the knowledge and skills required by the industry, alongside their standard curriculum delivery. To help with this the CREATE Education Project has worked with industry partners to develop a 3D Printing Knowledge and Skills Progression Framework. The framework consists of the following three strands:

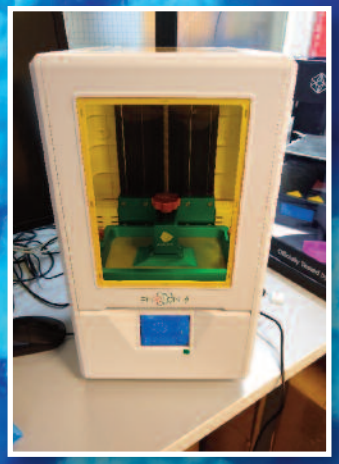
- Additive Manufacturing & 3D Printing Processes
- Designing for 3D Printing and Slicing Models
- 3D Modelling

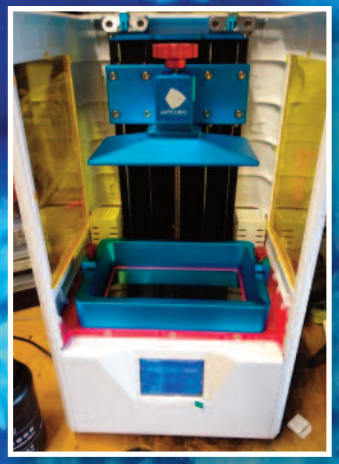
Within these three strands, the knowledge and skills have been organised into three levels (Foundation, Intermediate and Advanced) to allow for structure and progression.

For each level and strand a series of discrete knowledge and skills have been listed, these can be used to inform planning of schemes of work and discrete lessons, devising assessment opportunities and for embedding into existing or new curriculum and assessment frameworks.

You can learn more and download the knowledge and skills progression document from the CREATE Education Project at www.createeducation.com/resource/knowledge-skills-progression. You can also access lots more free resources, learn more about CPD opportunities and borrow a 3D printer for a month, for free, to run a project in your school.

3D printing





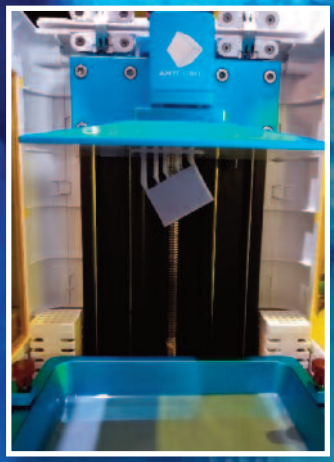
In December we took possession of a new 3D printer. It is a Digital Light Projection printer (DLP), which works on a very different principle to the FFF printers we have been using and testing over the past three years.

The DLP projects ultraviolet light into a vat of photosensitive liquid resin. The light 'sets' a small amount of the resin, which adheres to the underneath of a flat metal surface, which is the build plate. The build plate then rises a fraction of a millimetre and the process is repeated.

The shape of the light projection defines the shape of the 'set' resin. The light projects can be very fine which, therefore, can allow for incredibly sharp detail.

We plan to test this machine and produce a guide on its use for schools. The chemicals used for the resin and for cleaning the final print are particularly hazardous.

As you will have read in past editions of Futureminds, we have worked closely with HSE in developing our guidance and we are hoping to be carrying out some more testing of machines and materials in the next few months. These tests will include finding out what the emissions from the DLP process contain, as well as carrying out some emission testing with printers running in schools.



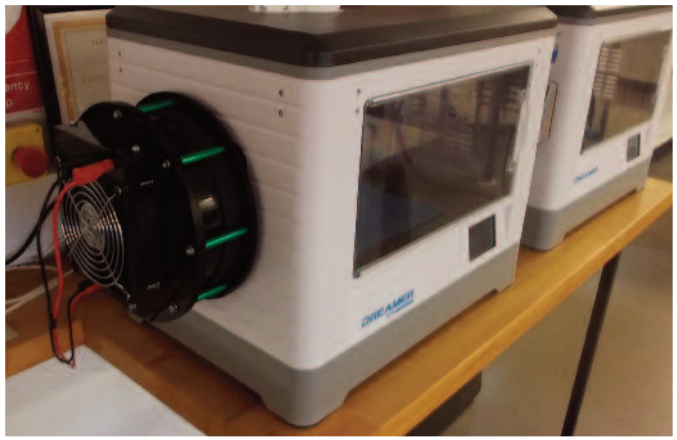
Improving the extraction on 3D printers

Nigel Harris,
D&T technician at Churston Ferrers Grammar School

In November last year, Nigel contacted CLEAPSS about the guidance on the fumes and particulates emitted by 3D printers. The school was considering the options of making a cabinet, using the CLEAPSS designs or designing their own filtered extraction units for their machines.

The printers used in the department are Flashforge Dreamers, which are fitted with fans, which seem to be used for temperature controlling the build space rather than for extraction. In discussion, we were able to identify a better type of fan and filter, which enabled the staff to design, manufacture, and fit small extraction units to their machines. The following article explains some of the design work that the school worked through to develop their solution.

We discussed fan sizes and speeds, filter combinations and the advantages of a hood over individual extraction units. Low speed, high volume fans, can be placed outside the filter, so that the air is drawn from the build space, through a filter then through the fan, and cause minimal air disturbance in the build area.



The benefit of using a cabinet, is that there are no drafts because the air around the build area is not disturbed. However, a cabinet is a large piece of equipment, whereas a small extractor may be less obtrusive. As the school decided to work with small extractors staff had to work through some constraints:

- **The filter size**
- **The aperture**
- **The fan size**

The filter has to be capable of controlling fumes and particulates, so we chose to use a Levoit filter (LV-H132-RF), because it was large enough to cover the rectangular hole on the side of the printer, where the side grill pops out. It cost £16 and is cheaper than the larger rectangular one used in the CLEAPSS hood. The filter size also matched the computer cooling fan from the IT department (a Delta Electronics AFB1212HHE 12V 0.7A & will run between 6 & 12 Volts, liberated from an old server).

These fans are still available, costing around £24, with postage. There are cheaper fans on Amazon and other retailers, but they are not powerful enough. Nigel tried one at 0.07A and found that the decimal place makes a big difference!
Using *Fusion*, Nigel drew up a 3D housing which was split into 2 so that the filter could be loaded and that the print shape would fit the printer bed. This design required 48 hrs to print, so was scratched in favour of laser cutting a number of connecting discs & rectangles. The 2D design drawing is available if you contact CLEAPSS. For the spacers we used an old broken DofE tent pole that was cut and faced off on the metal lathe (these are the green anodised tubes, which looks nice on the black). Inside these is some M4 stud cut to length, which clamp the fan & fan discs together, and help locate the unit onto the printer.

Power is provided from a 30W max2A universal adapter that can be set at various increments from 3-12v. At 12 V the fan will shift some air (probably too much) so it's generally running at 7.5V. The extraction has been in use since Christmas and it seems to work well. The school use PLA, and staff have not tried the units with ABS or anything else.

As the filters are relatively cheap, the staff will probably aim to change them annually, but they will need to be checked regularly to make sure they are not clogged or damaged.