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| **Design and print a model town** |
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| Designing and 3D printing a model town using CAD software |
| **Subject(s):** Design and Technology, Engineering**Approx time:** 60-100 minutes |  | **Key words / Topics:** * architecture
* computer aided design
* filament
* specification
* template
* Onshape
* extrude
* slicing
* 3D printing
* PLA polymer
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| **Stay safe** Whether you are a scientist researching a new medicine or an engineer solving climate change, safety always comes first. An adult must always be around and supervising when doing this activity. You are responsible for: • ensuring that any equipment used for this activity is in good working condition• behaving sensibly and following any safety instructions so as not to hurt or injure yourself or others  Please note that in the absence of any negligence or other breach of duty by us, this activity is carried out at your own risk. It is important to take extra care at the stages marked with this symbol: ⚠ |
| **Suggested Learning Outcomes**  |  |  |
| * To be able to communicate a design
* To develop design skills using the Onshape CAD software
* To be able to 3D print a design idea successfully
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| **Introduction** |  |  |
| This is one of a set of resources designed to allow learners to use practical methods to support the delivery of key topics within Design & Technology and Engineering. This activity is based on CAD and 3D printing and provides a straightforward, practical way to introduce these technologies into the curriculum.This activity involves generating creative design ideas for a building, drawing the final design idea using CAD software, and 3D printing a model of the building. The software used for the CAD activity is the free and widely used Onshape; however, this could easily be substituted for any other 3D CAD software already available in school. The models of the building have a small footprint to facilitate relatively short printing time. Copies could be printed for both the learner and for display purposes. A miniature ‘town’ created from the different models can be an effective way of displaying learner creativity, differentiation, and the effective application of new technologies within the curriculum. |
| **Purpose of this activity**In this activity learners will create a visual answer to a design situation using both sketching and CAD drawing software, followed by 3D printing a physical model.This activity could be used as a main lesson activity to reinforce CAD drawing skills or to introduce 3D printing. It could also be used as part of a scheme of work learning about the design process. |
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| **Activity** |  | **Teacher notes** |
| **Introduction (5-10 minutes)**Teacher to introduce the activity, designing and making a model of a building, using slides 3-8 in the presentation. **Design (20-30 minutes)**Learners decide the purpose of their building and review its requirements. Using the activity sheet, learners sketch three draft ideas for their building. They then select the best features of their ideas and draw a final design idea.Once learners have created different concept sketches, they could share their work with their peers, explaining the choices that they made in their designs and seeking feedback. **CAD (40-60 minutes)**Learners use Onshape to produce a CAD model of their design. Slides 11-14 can be used to introduce or support this activity.**3D printing (10-20 minutes, plus printing time)**Teacher to demonstrate the set up and operation of the 3D printing process.**Plenary (5-10 minutes)**In future years it is possible that 3D printers could become standard tools in every home – what do learners they think they could be used to make? |  | It should be noted that step by step instructions on the use of Onshape are not provided – any 3D modelling software can be used for this lesson, depending on what facilities and capabilities are available in the school.**Introduction**This includes a brief overview of the 3D printing process, as this creates constraints for the design (in terms of size limits and the capability of having overhanging features.**Design**Differentiation could be introduced at this stage by specifying the building functions to learners – for example, some could create domestic homes; others could be tasked to produce libraries, sports centers, schools, shops, art galleries etc.This section could be extended to allow for research on building styles and architecture. Alternatively, a prior homework activity could be set to identify a set number of different styles of building or architecture.**CAD**If learners have never used Onshape before, it is recommended that the teacher identifies the location of the various CAD tools on the screen. Once learners have finished their 3D designs, they should be checked by the teacher, to reduce the risk of wasted material and time when 3D printing. The teacher should look for anything that does not meet the requirements or anything that could potentially cause printing issues/errors. **3D Printing**It is anticipated that most of the learners’ models would be produced outside of the lesson time.Depending upon the printer available, it may be possible to print directly from the CAD software. However, with some printers it may be necessary to save the image as a .stl file, then use the software supplied with the printer to slice the image, producing a .gx file or similar. This can then be sent to the printer (by a direct connection or by using a USB memory stick, as appropriate for the printer available).The 3D printer should have a bed of at least 50 mm square. The material used should be PLA polymer of a diameter appropriate to the machine. The examples in the presentation used 1.75 mm diameter PLA. A single 250g reel was sufficient to produce over 30 models of buildings (with internal honeycomb filling of 15%).Please note that PLA is hygroscopic - it will naturally absorb moisture if exposed to open air environments, which can result in degradation and brittleness. If the 3D printer is not used regularly, it is recommended that the PLA is removed from the machine between uses and stored in an airtight container.The time required for printing will depend upon the building designs and the type and model of printer available. The examples in the presentation took between 20 and 80 minutes using the default settings on a Flashforge printer. |
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| **Differentiation** |  |  |
| **Basic** |  | **Extension** |
| * Learners could modify or adapt a provided simple design
 |  | * Learners could produce more complicated buildings with specified functions.
* Learners could try to draw a famous building, such as Sydney Opera House, Golden Gate Bridge – this then could be added to the town model
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| **Resources** |  | **Required files** icon-docicon-pdficon-ppt |
| * Pencils
* Computer access with 3D drawing package (Onshape, Tinkercad, Fusion 360, Solidworks etc)
* 3D Printer and filament
 |  | icon-ppt Design and print a model town presentationicon-doc Design and print a model town activity sheet |
| **Additional websites** |  |  |
| * **Onshape** website: <https://www.onshape.com/en/>
* **Thingiverse:** – an online repository of (mostly) free to download products that can be made on 3D printers: https://www.thingiverse.com/
* **What is 3D printing:** <https://ultimaker.com/learn/what-is-3d-printing/>
* **National Geographic video showing how 3D printers work:** <https://www.youtube.com/watch?v=HlvK6DLwCz4>
* **Magazine article explaining 3D printing (for teacher information):** https://kidscodecs.com/what-is-3d-printing/
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| **Related activities (to build a full lesson)** |  |  |
| **Starters** (Options) * Watch the National Geographic video on how 3D printers work: <https://www.youtube.com/watch?v=HlvK6DLwCz4>
 | **Plenary*** Learners to share their designs with their peers. What do they like about them? What could be improved?
* In future years it is possible that 3D printers could become standard tools in every home – class discussion on what learners think they could be used to make.
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| **The Engineering Context**  |
| CAD is a versatile tool used by engineers across various disciplines to conceptualize, design, analyse, and document complex systems and structures. For example, engineers use CAD to design cars and buildings and to carry out virtual testing of aircraft wings.3D printing in engineering facilitates rapid prototyping, customisation, and the production of complex geometries while reducing material waste and enabling on-demand production. |

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| **Curriculum links** |
| **England: National Curriculum**D&T KS3* understand developments in design and technology, its impact on individuals, society and the environment, and the responsibilities of designers, engineers and technologists
 | **Northern Ireland Curriculum**KS3 Technology and Design* Persist in the face of difficulty and setback. Be able to carry on. Develop own value judgements about the merits of their work.
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| **Scotland: Curriculum for Excellence**Technologies* I can apply my knowledge and understanding of engineering disciplines and can develop/build solutions to given tasks.
* TCH 3-12a
 | **Wales: National Curriculum** D&T KS3* identify and use appropriate sources of information to help generate and develop their ideas for products
* be creative and innovative in their thinking when generating ideas for their products
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| **Assessment opportunities** |
| * Formative assessment of the CAD model by the teacher.
* Summative assessment of the 3d printed model by the teacher.
* Peer assessment and feedback on the design ideas.
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