

## Teachers Notes

**The aim of this guide is to provide an overview of the purpose, structure and use of the Siemens Designing The Future resources and interactive.**

### Purpose of this resource

Manufacturing in the UK and across the world is changing rapidly. We are now in the fourth industrial revolution, where Smart Factories use digitally connected systems, virtual simulations and artificial intelligence to manufacture every day, engineered products.

This resource aims to contextualise computer-aided design (CAD) within current engineering practice and digital technologies, following the development of a familiar engineered product. Along the way, students will learn about Smart Factories, Product Lifecycle Management (PLM) systems, important job-roles in product engineering and use Siemens NX software to craft their own product. In short, students will find out how digital technologies are changing the way that products are manufactured and use some of those technologies themselves.

### About Siemens NX

Siemens NX is Siemens own CAD/CAM/CAE solution, available to schools and education institutions as NX Student Edition. Siemens NX is an industry standard in aerospace, automotive and manufacturing industries, with powerful tools such as generative design, and fully integration with Siemens Product Lifecycle Management software for collaborative working and increased workflow.

### How this resource works

This resource is split into three episodes of learning. Each episode includes a research component, exploring a digital interactive, and a hands-on computer-aided design component, where students learn to use Siemens NX. The research component builds students' knowledge about where products come from, whilst the CAD component builds students towards 3D printing and taking home their own 3D robot figure. Each episode comes with its own teacher presentation. Students will simultaneously take a deeper journey into product engineering whilst increasing their own engineering skills.

**A breakdown of each episode is detailed below:**

Episode Name	Key Questions	Key Skills
1 Where do products come from?	<ul style="list-style-type: none"> <li>How are products made?</li> <li>Who makes engineered products?</li> <li>What is Product Lifecycle Management?</li> </ul>	<ul style="list-style-type: none"> <li>Understanding the function and workforce of a Smart Factory</li> <li>Basic CAD Skills</li> </ul>
2 Digital Modelling	<ul style="list-style-type: none"> <li>What are the features of a CAD model?</li> </ul>	<ul style="list-style-type: none"> <li>Advanced CAD Skills</li> </ul>
3 To Manufacturing and beyond	<ul style="list-style-type: none"> <li>How are products made using digital manufacture?</li> <li>What are the benefits of digital manufacture?</li> </ul>	<ul style="list-style-type: none"> <li>Use of 3D printing to create a practical model</li> </ul>



### Using this resource

This resource aims bring a detailed view of up-to-date product engineering to your classroom, in a concise and flexible format. There will be lots of new words and concepts for your students, and we have not shied away from using industry standard terminology.

At the back of this guide, there is a glossary for teachers and students, and you may wish to differentiate and customise the resource materials and delivery depending on student ability or your own curriculum aims.

You may also wish to adjust delivery depending on your availability of equipment and lesson timings. For students to fully participate in each learning episode, you will require computers for each student and optionally one or more 3D printers.

You will also require web access and a Siemens NX Student Edition installation for each computer. Each learning episode could be spread over several lessons, depending of your own timings.

If you do not have access to 3D printing, you may wish to skip some aspects of Episode 3.

Further information on how to download Siemens NX Student Edition can be found at <https://trials.sw.siemens.com/nx-student-edition/>

### Curriculum links

Each episode is applicable to and incorporates aspects of the following areas of the Design & Technology 2013 programme of study:

#### Evaluate

- Analyse the work of past and present professionals and others to develop and broaden their understanding
- Investigate new and emerging technologies
- Understand developments in design and technology, its impact on individuals, society and the environment, and the responsibilities of designers, engineers and technologists

#### Make

- Select from and use specialist tools, techniques, processes, equipment and machinery precisely, including computer-aided manufacture

### Extensions

Each learning episode has an extension activity included to expand the learning. You could set these extensions as homework or plan extra class time for their completion.



### Episode 1: Where Do Products Come From?

#### Lesson Plan

##### Introduction

In this episode students will tour a Smart Factory and learn how Product Life Management (PLM) systems are used to manage the engineering of a hairdryer. Students will also complete a simple computer-aided design (CAD) model using Siemens NX.

##### Episode Aims

The aim of this lesson is for students to become familiar with the language and production processes of the product lifecycle – in this case of a hairdryer. Students will experience a virtual tour of a Smart Factory and can interrogate each room in the factory to help them answer the worksheet questions. Students will then take on the role of a product designer, with an introduction to Siemens NX CAD software. Students will learn more CAD skills each week, culminating in them having design and manufactured their own robot figurine.

A specific focus of this scheme of work is the relationship between manufacturing processes and digital technologies, which should be emphasised throughout delivery.

##### Learning Objectives

This episode is designed for students to understand:

- The product lifecycle of an everyday product
- The people involved in a product's lifecycle
- How digital technologies such as Siemens NX and Product Lifecycle Management are beneficial to product development

##### What you will need

- Siemens NX ready installed and internet access on suitable devices
- Designing The Future Episode 1 presentation
- Designing The Future Episode 1 worksheets
- 3D printed robot figurine
- 3D printed badge
- Scissors
- Glue
- Blank Paper



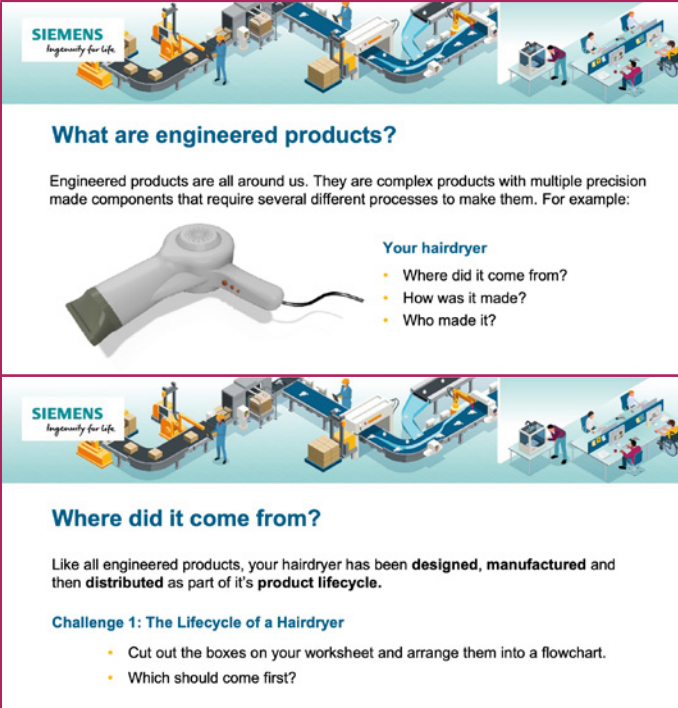

##### Preparation

Review the interactive, presentation, worksheets and teachers guide. Decide on which content you will include in your teaching and adjust the timings below to suit the length of teaching time. It is also advisable to familiarise yourself with the functions of Siemens NX.

The example session below details how you might spread this episode over a double lesson of two hours, with a mixed ability group of year 8 students. You may wish to split the learning over two separate, shorter sessions. You could also use the CAD component of the session as a homework activity, if students have access to NX at home. In this instance you should give an introduction to NX during class time.



## Sequence

Time (120 mins)	Slide	Notes
5 mins	 <p><b>Siemens NX: Designing The Future</b> Episode 1: Where do Products Come from?</p>	<p>Briefly introduce the scheme of work. Explain that this topic aims to show how digital technologies are changing the way that products are made, and that they will learn to use the technologies themselves. Show students the 3D printed robot figurine and badge as the overall outcome.</p> <p>You may wish to pause briefly to use the lesson title as the starter question.</p>
5 mins	 <p><b>Objectives</b></p> <p>This episode is designed to get you to understand:</p> <ul style="list-style-type: none"> <li>• The product lifecycle of an everyday product</li> <li>• The people involved in a product's lifecycle</li> <li>• How digital technologies such as Siemens NX and Product Lifecycle Management are beneficial to product development</li> </ul>	<p>Introduce the learning objectives. This lesson examines Product Lifecycle Management in the context of the design, manufacture and distribution of a hairdryer. They will then design a 3D badge.</p>
20 mins	 <p><b>What are engineered products?</b></p> <p>Engineered products are all around us. They are complex products with multiple precision made components that require several different processes to make them. For example:</p>  <p><b>Your hairdryer</b></p> <ul style="list-style-type: none"> <li>• Where did it come from?</li> <li>• How was it made?</li> <li>• Who made it?</li> </ul> <p><b>Where did it come from?</b></p> <p>Like all engineered products, your hairdryer has been <b>designed, manufactured</b> and then <b>distributed</b> as part of its <b>product lifecycle</b>.</p> <p><b>Challenge 1: The Lifecycle of a Hairdryer</b></p> <ul style="list-style-type: none"> <li>• Cut out the boxes on your worksheet and arrange them into a flowchart.</li> <li>• Which should come first?</li> </ul>	<p>Start students thinking about where products come from and introduce the key questions for the lesson. Introduce Challenge 1, Students should try to work out the best order for the boxes from Challenge 1 in pairs or individually.</p>



20 mins



## Designing the Future Interactive

Use the **Designing the Future Interactive** to check your answers.

- Were you correct?
- Were there any surprises?
- What are the limitations of creating a flowchart to show the product lifecycle?

Students should now check their answers against the Designing the Future Interactive. Question students on how the interactive effected their decisions and use the answer sheet feedback the correct order. For higher level students, question the limitations of a flowchart for Product Lifecycle. Ask students to assess whether product lifecycle is a linear process – they should be considering the iterative nature of the design, make and evaluate process. You could link this to their project work, or to everyday tasks where the aim is constant improvement in many cycles.

20 mins



## Product Lifecycle Management

Coordinating all of the **processes** and **people** involved in developing a product is a complex task. It requires a **Product Lifecycle Management Strategy** and specialist **software** and **systems** to implement it.

### Challenge 2: Product Lifecycle Management

Using the Designing the Future Interactive and the worksheet information, answer the worksheet questions.

- Who uses PLM software?
- How does a PLM strategy improve sustainability?

Students should now explore Product Lifecycle Management more deeply using the Designing the Future Interactive and answer the questions. Use the questions to initiate discussion about how PLM software allows for greater collaboration between professionals, with emphasis on how Teamcentre could enable collaboration between teams across different companies internationally. Also discuss each aspect of sustainability; economic, environmental and social. Feedback worksheet answers.

2 mins



## PLM and Industry 4.0

**Digitally integrated systems** such as **PLM software** are changing the way that industry operates. Our factories are becoming Smart Factories, where PLM systems interact with **Internet of Things** enabled machinery and where manufacturing processes use **artificial intelligence**.

- Who benefits from these developments?



Introduce the concept of Industry 4.0. Industry 4.0 refers to the Fourth Industrial Revolution. This is the age where industry is highly digitized and connected, and uses IoT and AI enabled machinery, as epitomised in the Smart Factory. Discuss the benefits in terms of professionals (safety and workflow), companies (efficiency and profitability), the product user (quality of product at a lower price), and all people due to the increased sustainability more broadly.

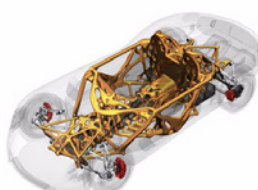
3 mins



## Siemens NX Software

Many engineered products that you will have encountered will have been modelled and engineered using **Siemens NX** – including cars, toy building blocks, construction machines, sports equipment and medical equipment.





As well as fully integrating with PLM and manufacturing, Siemens NX has powerful features such as generative design.



Use the slide to introduce Siemens NX. Students will have seen this software used in the interactive Smart Factory.

Explain the features of Siemens NX and it's application in industry. Siemens NX can integrate fully with PLM and is used across many industries including automotive and aerospace. The image shows an example of generative modeling, where advanced geometric models are generated digitally using constraint and material data, such as the chassis of the car shown above.



<p>40 mins</p>	 <h3>Siemens NX Challenge</h3> <p>Many engineered products that you will have encountered will have been designed and engineered using Siemens NX – just like the hairdryer in <b>Challenge 1</b> and <b>Challenge 2</b>.</p> <p>You can use NX to design and engineer your own projects. Follow the Step by Step in <b>Challenge 3</b> to design your own emotion badge.</p> 	<p>Introduce Challenge 3. This activity introduces students to the basics of CAD modeling, including sketches, extrusions and fillets. You will need Siemens NX education installed on your institution machines. If you have a 3D printer, you could get students to print their badges. If you 3D print in ABS, badge pins could easily be attached to the back surface using a cyanoacrylate adhesive, following all safety measures detailed on the adhesive instructions.</p>
<p>5 mins</p>	 <h3>Siemens NX Reflection</h3> <ul style="list-style-type: none"> <li>• How did you find using the Siemens NX software?</li> <li>• What are the advantages of using CAD packages such as Siemens NX?</li> <li>• What were the challenges?</li> <li>• Who benefits from the use of CAD?</li> </ul>	<p>Use these questions to reflect on skills gained when using Siemens NX. This will be revisited next session as students' NX skills increase.</p>
	 <h3>Questions to think about</h3> <ul style="list-style-type: none"> <li>• How are engineered products made?</li> <li>• Who is involved in making them?</li> <li>• How do digital technologies such as PLM and NX software help this process?</li> </ul>	<p>Use these plenary questions to recap on the learning. Break each question into sub questions as you go, such as 'Who does the designing? Or 'Who plans the manufacturing'. Consider the benefits of PLM and NX for all stakeholders – the user, the designer, the manufacturer, the distributor and the impact on sustainability.</p>

## Extension

Students who finish early should customise the expression on their 3D badge. Students who have already been introduced to 3D printing could 3D print their badge and help other students to do the same.

## Differentiation

**Easier:** Omit Challenge 2. You could also give more time to challenge 3, modelling the badge step by step from the board.

**Harder:** Students to work individually on challenge 1. Students should design a badge with a different shape from the one shown.



### Episode 1: Where do Products come from?

#### Answers

1. Research & Problem Definition, Product Design, Simulation & Prototyping, Product Verification, Production Planning, Product Manufacture & Assembly, Quality Control, Finishing & Distribution, Using the Product
- 2a Any of the following, or any other suitable answer:
  - Design, production and sales data is instantly shared
  - Team members can communicate easily using team centre
  - Everyone works from the same database
  - Teams can easily work collaboratively
- 2b Any of the following, or any other suitable answer:
  - Digital models are easy to update or modify
  - Digital models can be tested easily
  - Digital models can be prototyped using 3D printing
  - Digital models can be shared with others easily
  - More than one designer can work collaboratively on the same model
- 2c Any of the following, or any other suitable answer:
  - PLM saves time/is more efficient
  - PLM can reduce production costs
  - PLM allows greater collaboration between teams
  - PLM can increase product quality
  - PLM can increase product sustainability
- 2d Any of the following, or any other suitable answer:
  - PLM can increase product sustainability
  - PLM can reduce the cost of the product for the end user
  - PLM can increase product quality
- 2e PLM can increase the sustainability of production processes, reducing environmental costs.  
Any other suitable answer.
- 3 Students to complete their 3D badge model.
- 4 Students should customise their badge. Product ideas should be marked based upon:
  - Originality
  - CAD Skill, such as the use of more advanced tools
  - Aesthetic qualities



### Episode 2: Digital Modelling

#### Lesson Plan

##### Introduction

In this session students will learn how to use Siemens NX at a more advanced level and find out how it is used by product designers and engineers to design products.

##### Episode Aims

The aim of this lesson is for students to become familiar with the language and production processes used in computer-aided design (CAD). Students will contextualise the use of CAD in a Smart Factory setting, learn useful vocabulary for CAD modelling and work on a more advanced CAD model – a figurine of Roblet, a cute robot.

##### Learning Objectives

This episode is designed for students to:

- Describe the common features of a CAD model
- Model a complex part using Siemens NX Software

##### What you will need

- Siemens NX ready installed and internet access on suitable devices
- Designing The Future Episode 2 presentation
- Designing The Future Episode 2 worksheets
- 3D printed robot figurine


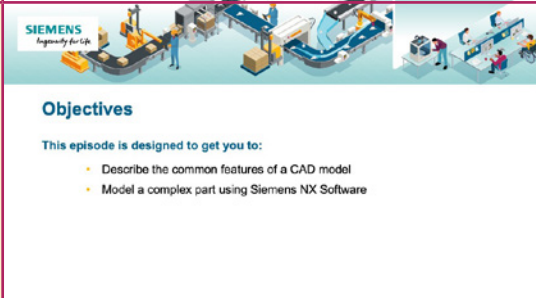
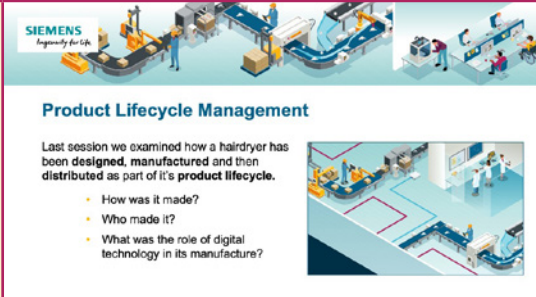

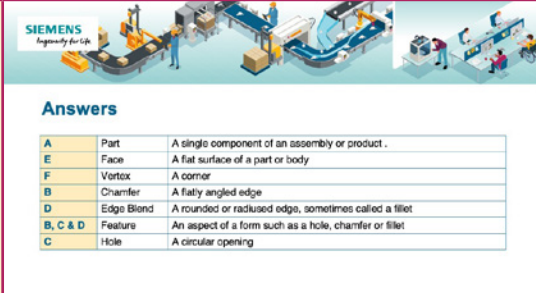
##### Preparation

Review the interactive, presentation, worksheets and teachers guide. Decide on which content you will include in your teaching and adjust the timings below to suit the length of teaching time. It is also advisable to familiarise yourself with the functions of Siemens NX.






The example session below details how you might spread this episode over a double lesson of two hours, with a mixed ability group of year 8 students. You may wish to split the learning over two separate, shorter sessions. You could also use part of the CAD component of the session as a homework activity, if students have access to NX at home. In this instance you should give an introduction to NX during class time.



## Sequence

Time (120 mins)	Slide	Notes																					
5 mins	 <p><b>Siemens NX: Designing The Future</b> Episode 2: Digital Modelling</p>	Introduce the lesson title. You could use this as a starter question – What is a CAD model? This will form part of your recap from last sessions learning.																					
5 mins	 <p><b>Objectives</b></p> <p>This episode is designed to get you to:</p> <ul style="list-style-type: none"> <li>Describe the common features of a CAD model</li> <li>Model a complex part using Siemens NX Software</li> </ul>	Introduce the learning objectives for the lesson. This lesson introduces students to CAD terminology and more advanced modelling using Siemens NX.																					
5 mins	 <p><b>Product Lifecycle Management</b></p> <p>Last session we examined how a hairdryer has been designed, manufactured and then distributed as part of it's product lifecycle.</p> <ul style="list-style-type: none"> <li>How was it made?</li> <li>Who made it?</li> <li>What was the role of digital technology in its manufacture?</li> </ul>	Remind students about last week's learning, where they followed the product lifecycle of a hairdryer. Try to get them to differentiate between the roles of different people in the factory e.g. The product designer, manufacturing engineers etc. Use this to contextualise CAD.																					
20 mins	 <p><b>Describing digital models</b></p> <p>This session you will be learning some more advanced CAD skills. Before we start, it is important to have an understanding of the terminology used by CAD designers.</p> <p><b>Challenge 1: Describing Models</b></p> <p>Match each letter to the word that describes it, then the definition for each word. You can use the Siemens NX: Designing The Future Interactive to find the answers.</p>	Introduce Challenge 2 and direct students to the online interactive. The answers are found in the design studio, on one of the product designers PCs.																					
10 mins	 <p><b>Answers</b></p> <table border="1"> <tbody> <tr> <td>A</td> <td>Part</td> <td>A single component of an assembly or product.</td> </tr> <tr> <td>E</td> <td>Face</td> <td>A flat surface of a part or body</td> </tr> <tr> <td>F</td> <td>Vertex</td> <td>A corner</td> </tr> <tr> <td>B</td> <td>Chamfer</td> <td>A flatly angled edge</td> </tr> <tr> <td>D</td> <td>Edge Blend</td> <td>A rounded or radiused edge, sometimes called a fillet</td> </tr> <tr> <td>B, C &amp; D</td> <td>Feature</td> <td>An aspect of a form such as a hole, chamfer or fillet</td> </tr> <tr> <td>C</td> <td>Hole</td> <td>A circular opening</td> </tr> </tbody> </table>	A	Part	A single component of an assembly or product.	E	Face	A flat surface of a part or body	F	Vertex	A corner	B	Chamfer	A flatly angled edge	D	Edge Blend	A rounded or radiused edge, sometimes called a fillet	B, C & D	Feature	An aspect of a form such as a hole, chamfer or fillet	C	Hole	A circular opening	Feedback answers to Challenge 2.
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5 mins	 <p><b>Advanced Digital Modelling</b></p> <p>Digital modelling is an important part of the design process. Digital models help designers to visualise and test their products before manufacture. Models also help to plan production.</p> <p>Last session you modelled an emotion badge. This session you will use more advanced tools to model Roblet, the Siemens Robot.</p> 	<p>Explain how CAD models can help designers to visualise their ideas. CAD models are quicker and more cost efficient than practical models and be tested safely and under conditions not easily replicable, simulating wear and tear over time or otherworldly conditions such as the vacuum of outer space. Introduce their challenge, using a 3D printed Roblet figurine if you have one.</p>
60 mins	 <p><b>Advanced Digital Modelling</b></p> <p><b>Challenge 2: NX Challenge - Roblet the NX Robot</b></p> <p>Follow the steps to model this cute NX robot, Roblet. In the next session you will learn how to 3D print your own Roblet figurine!</p> <p><b>Top Tips:</b></p> <ul style="list-style-type: none"> <li>• Use the search bar if you cannot locate a tool</li> <li>• Don't forget to name your sketches. This will help you to stay organised.</li> <li>• Right click to adjust your view, or select the 'View' menu.</li> </ul>	<p>Introduce Challenge 2. This activity introduces students to more advanced CAD modelling. You will need Siemens NX education installed on your institution machines. Next session features the 3D printing of their models. You could start students off on the first steps to creating their model. Be sure to point out the search bar in NX, where students can easily search for tools.</p>
5 mins	 <p><b>Siemens NX Reflection</b></p> <ul style="list-style-type: none"> <li>• How did you find modelling Roblet?</li> <li>• What was different this week?</li> <li>• How have your skills improved?</li> <li>• What else could you use NX to model?</li> </ul>	<p>Challenge students to reflect on their learning. The Roblet model is a significant step up from last session, so be heavy with the praise!</p>
5 mins	 <p><b>Questions to think about</b></p> <ul style="list-style-type: none"> <li>• Which tool would you use to turn a sketch from 2D to 3D?</li> <li>• Which tool would you use to round an edge?</li> <li>• What tool would you use to create an angled surface?</li> <li>• What sort of line do you create as guides in your sketch?</li> </ul>	<p>Plenary Questions: Use these questions to challenge students learning for the episode. Break each question into sub questions as you go. The aim of this exercise is to get students to verbalise their CAD skills.</p>

## Extension

Students who finish early should customise their badge. Consider adding antenna, more controls or change the expression.

## Differentiation

**Easier:** Omit Challenge 1. You could also give more time to challenge 2, modelling the badge step by step from the board.

**Harder:** Students should be challenged to create their own 3D product using NX.



## Episode 2: Digital Modelling

### Answers

1

A	Part	A single component of an assembly or product
E	Face	The flat surface of a part or body
F	Vertex	A corner
B	Chamfer	A flatly angled edge
D	Edge Blend	A rounded or radiused edge, sometimes called a fillet
B C D	Feature	An aspect of a form such as a hole, chamfer or fillet
C	Hole	A circular opening

2 Students should complete their Roblet model.

3 Students should customise their Roblet. Product ideas should be marked based upon:

- Originality
- CAD Skill, such as the use of more advanced tools
- Aesthetic qualities



### Episode 3: To Manufacturing & Beyond

#### Lesson Plan

##### Introduction

In this session students will learn how digital manufacture is used in industry and to use Siemens NX and a 3D printer to digitally prototype a Roblet figurine.

##### Episode Aims

The aim of this lesson is for students to become familiar with the types of digital manufacturing tools available in schools and how they are used in industry. Students will modify their NX model of Roblet and 3D print their figurine.

##### Learning Objectives

This episode is designed for students to:

- Describe range of digital manufacturing tools
- Explain the benefits of digital manufacture
- Use 3D printing to prototype a product

##### What you will need

- Siemens NX ready installed and internet access on suitable devices
- Designing The Future Episode 3 presentation
- Designing The Future Episode 3 worksheets
- Access to 3D printing
- 3D printed robot figurine
- a finished Roblet .stl file.






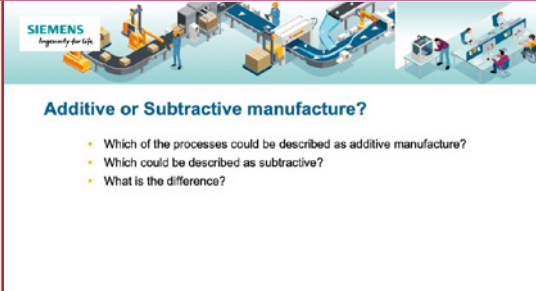
##### Preparation

Review the interactive, presentation, worksheets and teachers guide. Decide on which content you will include in your teaching and adjust the timings below to suit the length of teaching time. It is also advisable to familiarise yourself with the functions of Siemens NX and the software for your 3D printer.






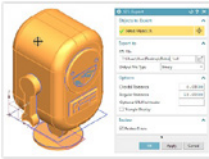

The example session below details how you might spread this episode over a double lesson of two hours, with a mixed ability group of year 8 students. You may wish to split the learning over two separate, shorter sessions. For students who were not present for the previous lessons, they could model the 3D badge from lesson 1. You could also supply them with a finished Roblet .stl file.



## Sequence

Time (120 mins)	Slide	Notes
5 mins	 <p><b>Siemens NX: Designing The Future</b> Episode 3: To Manufacturing and Beyond</p>	Introduce the lesson title.
5 mins	 <p><b>Objectives</b></p> <p>This episode is designed to get you to:</p> <ul style="list-style-type: none"> <li>Describe range of digital manufacturing tools</li> <li>Explain the benefits of digital manufacture</li> <li>Use 3D printing to prototype a product</li> </ul>	Introduce the learning objectives. This lesson introduces digital manufacturing, culminating in students 3D printing a figurine.
5 mins	 <p><b>What is Digital Manufacture?</b></p> <p>Digital manufacture is the use of <b>digitally connected machines</b> to manufacture products or product components.</p> <p>These machines are digitally controlled and require little tooling or set-up. They also produce real-time production data that can be transmitted to PLM databases.</p>	Introduce the concept of digital manufacture. Digital manufacturing machines are manufacturing machines that are digitally connected, enabling digital simulation of processes and full integration into PLM and Smart Factory systems. Many digital manufacturing machines use IoT technology and require less set up and tooling for individual jobs.
15 mins	 <p><b>Digital Manufacturing in your Classroom</b></p> <p>From CNC Milling to 3D printers, digital manufacture is now commonplace in classrooms and maker spaces. But how do you choose the right machine for your project?</p> <p><b>Challenge 1: Digital Manufacturing In Your Classroom</b></p> <p>Using the table on your worksheet, decide which digital manufacturing tool would be most suitable for each product. Write the suitable tool below each image.</p> 	Introduce Challenge 1, Introduce each type of manufacturing. You may have examples of digital manufacturing machines such as CNC lathes or laser engravers to show students in your classroom.
5 mins	 <p><b>Additive or Subtractive manufacture?</b></p> <ul style="list-style-type: none"> <li>Which of the processes could be described as additive manufacture?</li> <li>Which could be described as subtractive?</li> <li>What is the difference?</li> </ul>	Ask students to decide which processes could be described as additive and which ones as subtractive manufacture. All of the processes listed apart from 3D printing are subtractive, as they cut or remove material whilst 3D printing is additive as it builds a shape from layers of material.



15 mins	 <p><b>Digital Manufacturing &amp; Product Design</b></p> <p>Digital manufacturing is also changing the way that products are designed. Fast and cost effective, processes such as 3D printing enable the rapid prototyping and testing of ideas.</p> <p><b>Challenge 2: Digital Manufacture and Product Design</b></p> <p>Read the worksheet and explore the Siemens Designing The Future Interactive to find out how digital manufacturing is used by product designers.</p> 	<p>Introduce Challenge 2. Digital manufacturing has many advantages for product designers. The main advantages are speed, cost effectiveness, the ability to create complex shapes in plastic without moulds, products require little finishing and can be made in a range of colours, a 3D printer can be small enough to sit on a desk. The advantage over traditional plastic manufacturing is that no tooling is required which can be costly and labour intensive. If you have a 3D printer, show students it working, and some complex printed objects.</p>
5 mins	 <p><b>Additive or Subtractive manufacture?</b></p> <ul style="list-style-type: none"> <li>Which of the processes could be described as additive manufacture?</li> <li>Which could be described as subtractive?</li> <li>What is the difference?</li> </ul>	<p>Ask students to decide which processes could be described as additive and which ones as subtractive manufacture. All of the listed processes are subtractive, as they cut or remove material, whilst 3D printing is additive as it builds a shape from layers of material.</p>
5 mins	 <p><b>Digital Manufacturing &amp; Product Design</b></p> <ul style="list-style-type: none"> <li>What are the advantages of 3D printing?</li> <li>What are the advantages of 3D printing over other methods of making 3D plastic shapes?</li> </ul>	<p>Use this slide to discuss the answers.</p>
55 mins	 <p><b>NX Challenge: Roblet Figurine</b></p> <p>It's time to try 3D printing for yourself. Add a stand to your Roblet model, and send it for printing as a .stl file.</p> <p><b>Challenge 3: NX Challenge: Roblet Figurine</b></p> <p>Follow the step-by-step to 3D print your very own Roblet Figurine.</p> 	<p>In this part of the session, students will prepare and 3D print their Roblet model, by adding a base and exporting their model as an .stl file (stereolithography file). It will take some time to complete 3D printing, so show students one file being printed, and allow them to come back to print in their own time. Students should be encouraged to customise their Roblet.</p>
5 mins	 <p><b>Questions to think about</b></p> <ul style="list-style-type: none"> <li>What types of digital manufacture are available?</li> <li>What are the advantages of digital manufacture?</li> <li>What are the qualities of a 3D printed product?</li> </ul>	<p>Use these questions for the plenary. Challenge students to name all types of digital manufacture discussed and encourage students to define them as additive or subtractive. Students should consider the advantages at different scales, from the designer to the product user. Students should evaluate the qualities of their 3D printed Roblet. How long did it take? Would this manufacturing method be useful for mass production?</p>



## Extension

Students who finish early should customise their base design or add their initials to the back of their Roblet.

## Differentiation

**Easier:** Omit Challenge 2.

**Harder:** Students are to find industrial examples of digital manufacture for Challenge 1. These could include laser sintering or concrete printing.

## Episode 3: To Manufacturing and Beyond

### Answers

- 1     Small plastic ghost: 3D printer  
      Plywood puzzle piece: Laser engraver  
      Steel Gears: CNC Mill  
      Acrylic Plastic Stencils: Laser engraver  
      Electric Guitar Body: CNC mill  
      Metal cupboard knob: CNC lathe  
      ABS prosthetics: 3D printer  
      Acrylic jewellery: Laser engraver  
      Plywood furniture: Laser engraver, CNC mill
- 2a    Any four of the following, or any other suitable answer:
  - Digital models can be quickly turned into practical models
  - Digital manufacture is more cost effective than traditional plastics forming processes
  - Digital manufacture is less time consuming than traditional plastics forming processes
  - Designers can 3D print prototypes in their office
  - 3D printing can produce accurate products
  - 3D printed products require little finishing
- 2b    Any of the following, or any other suitable answer
  - 3D printing is less time consuming and more cost effective than traditional plastic forming processes.
  - It can also be done on a desk, rather than in a plastics workshop.
- 3     Students should complete the stand on their Roblet model and export their design as a .stl file.
  - Students should design their own 3D printed product.
  - Product ideas should be marked based upon:
    - Complexity of model
    - Suitability for the material and manufacturing process
    - Originality
    - Functional application
    - Aesthetic qualities



## Glossary

<b>3D Printer</b>	A digital manufacturing machine that forms 3D shapes in layers using melted plastic, squirted from a nozzle.
<b>Artificial Intelligence (AI)</b>	Computer systems that can undertake complex thinking tasks.
<b>Assembly</b>	The joining of product components.
<b>Assembly Line</b>	A series of machines that join components together.
<b>Autonomous Mobile Robot</b>	A robot who moves products around a warehouse and loads vehicles.
<b>Axis</b>	One of three points in Euclidian geometry, labelled as the x, y and z axes.
<b>CAD</b>	Computer-Aided Design. The design of a product using models drawn using digital software.
<b>Chamfer</b>	A edge that has been sloped at an angle.
<b>Component</b>	Part of a product.
<b>Datum Point</b>	The starting point on a digital model, from which all other points are measured.
<b>Design</b>	The refining of product ideas into sketches, drawing or models towards a finished version.
<b>Dialog Box</b>	A window within a software screen.
<b>Diameter</b>	The width of a circle.
<b>Digital Manufacture</b>	Manufacture using computer systems to simulate production and control robotic machinery.
<b>Distribution</b>	The transport of the product to the user.
<b>Edge Blend</b>	See <i>Fillet</i> .
<b>Engineered Product</b>	A complex product manufactured using multiple processes.
<b>Export</b>	In CAD, to output a file of a different type.
<b>Extrusion</b>	In CAD, The expansion of a 2D sketch (or part of a 2D sketch) into a 3D shape.
<b>Fillet</b>	A rounded or smoothed edge.
<b>Final design</b>	The design idea that has been verified for manufacture.
<b>First Industrial Revolution</b>	The mechanical age, where machines were operated using water and steam power.
<b>Fourth Industrial Revolution</b>	The age of digitally connected machines, digital manufacture, artificial intelligence and Smart Factories.
<b>Industry 4.0</b>	See <i>Fourth Industrial Revolution</i> .



<b>Logistics Manager</b>	Someone who oversees and plans the distribution of a product.
<b>Manufacture</b>	The making of a product using machinery.
<b>Manufacturing technician</b>	Someone who oversees the manufacture of products on the production line.
<b>Material</b>	The substance that a product component is made from.
<b>Model</b>	A real-life or digital 3D construction of an idea, used for testing.
<b>Plane</b>	A flat surface in space.
<b>Product Designer</b>	Someone who designs products.
<b>Product Life Management (PLM)</b>	A digital system for managing the design, manufacture, distribution, maintenance and disposal of a product.
<b>Product Manager</b>	Someone who oversees and manages the entire production of the product.
<b>Product Requirements</b>	The list of qualities or features that the product must have to be a success.
<b>Product Researcher</b>	Someone who finds out and records data to aid in the design of a successful product, including user data and data from previous products.
<b>Production Engineer</b>	Someone who designs how a product will be manufactured and plans the production line.
<b>Production Line</b>	A series of machines that carry out manufacturing processes.
<b>Prosthetic</b>	An artificial body part e.g. a prosthetic hand or leg.
<b>Prototype</b>	A model of an idea or part of an idea, for testing.
<b>Quality control</b>	The process of testing a finished product to make sure that it is of the correct quality and to refine manufacturing processes.
<b>Second Industrial Revolution</b>	The age of electricity and mass production.
<b>Siemens NX</b>	Siemens NX digital modelling package.
<b>Sketch</b>	In CAD, a 2D drawing created using lines and shapes, drawn on a plane or surface.
<b>Smart Factory</b>	A manufacturing plant that employs digitally connected systems and machines to manufacture engineered products.
<b>.stl file</b>	The standard file type for 3D printing. A sterolithography file.
<b>Supply chain</b>	The network of sources that supply materials or components for a product.
<b>Third Industrial Revolution</b>	The electronic age, of automated machines and computer control.
<b>User</b>	The person who will use the finished product.
<b>Verification</b>	The ensuring that a design meets the product requirements.