

# 21<sup>st</sup> Century Technical Textiles

## Teacher guide

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## Introduction – smart and technical textiles

Technical textiles span a huge array of end uses which require a wide range of specific properties engineered to meet these requirements.

<b>Electrical engineering</b> Insulating fabrics Metallic braids	<b>Civil engineering</b> Drainage Retaining walls Road stabilisation	<b>Water</b> Hoses Vat linings Desalination membranes	<b>Construction</b> Reinforced composites Tarpaulins Coated fabrics	<b>Architecture</b> Awnings Tents Sling
<b>Aerospace</b> Parachutes Glider fabric	<b>Chemical</b> Filter fabrics	<b>Manufacturing</b> Sound insulation	<b>Automotive</b> Drive belts Tyre cords Seat belts Interior trim	<b>Paper making</b> Conveyors Felts
<b>Horticulture</b> Capillary matting Hail protection Wind shields Shade cloth Twine	<b>Agriculture</b> Animal coats and collars Flexible silos Sacks	<b>Mining</b> Temporary doors Soil separation Conveyor belts	<b>Shipping</b> Sails Cables Inflatables Hovercraft skirts	<b>Defence</b> Composites Brushes Camouflage Flash protection
<b>Medical</b> Bandages Sutures Absorbent cloths Cleaning cloths Swabs	<b>Apparel</b> Hats Shoes Sewing threads Protective wear Fashion Interlining	<b>Sports</b> Clothing Playing surfaces Equipment Waterproof fabrics	<b>Food</b> Wrapping Bags Ropes	<b>Furniture</b> Upholstery Bedding Floor and wall coverings Drapes

There are various terms used to define **Smart** and **Technical** textiles, but all are collectively known as **Technical Textiles** by the textile industry. For this resource the categories have been divided into **TECHNICAL**, **FUNCTIONAL** and **SMART** textiles for better understanding of their structure, function and performance; there is a section on **SUSTAINABLE** textiles and a final section looking at **FUTURE** textile developments.

Technical textiles may be defined as materials and products developed and manufactured primarily for their technical performance and functional properties, rather than their aesthetics.

‘Functional’ and ‘Smart’ textiles can be defined as those fibres, yarns or fabrics which not only fit the purpose of the end use, but also have added attributes that respond to their immediate environment and which will help to protect or aid our bodies and/or our environment.

Smart textiles are also referred to as interactive or intelligent textiles and there is some discrepancy over the true definition. Generally, it means that they will respond automatically to their changing environment without the need for any human intervention.

Functional and smart textiles:

- can incorporate electronics or protein fibres
- can be encapsulated with smells, moisturisers or chemicals
- have completely new fabric constructions
- have been developed for specific end uses, though some will eventually be adopted into general use.

In all the categories we are seeing new innovations, which have been developed through dynamic and diverse design, research and development teams that include textile and fashion designers, technologists and scientists and specialists from other disciplines.



# The resource

This interactive resource covers the range of applications and characteristics of technical textiles across different industries. It includes key facts, case studies and links to commercial and technical websites with further information on different fabrics, materials and industrial developments.

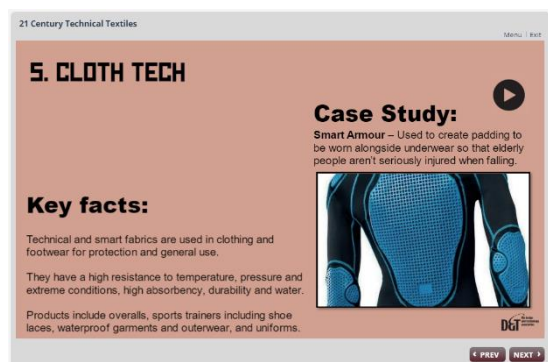
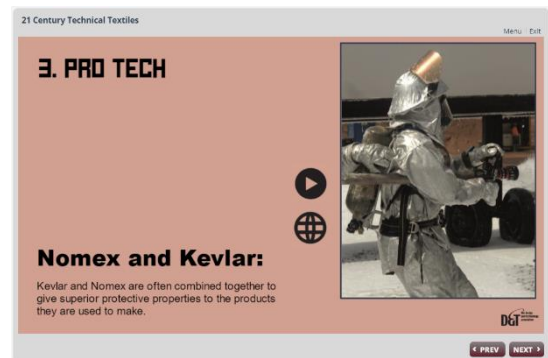
## Sections

### 1. Technical Textiles

Technical textiles are textile materials and products which have been manufactured chiefly for their technical performance and functional properties rather than their aesthetic or decorative characteristics. Modern technical fibres can be flame retardant, heat resistant, weight supporting, antibacterial and have many other attributes. Technical textiles is a large and fast-growing segment, supporting many industries, amongst them aerospace, medical, marine, military, safety, agriculture, transport and construction.

There are 12 commonly used categorisations for technical textiles, all covered in this resource:

- Build-tech – textiles used in the civil engineering and building industry.
- Geo-tech – synthetic fabrics which are extensively used with soil, rock and earth.
- Pro-tech – protective textiles used to protect people and property from hazards.
- Agro-tech – textiles with properties to support growing, harvesting, protecting and storing of crops and animals.
- Cloth-tech – technical and smart fabrics are used in clothing and footwear for protection and general use.
- Mobil-tech – providing insulation, safety, comfort and style in cars, trains, marine vehicles and aircraft.
- Home-tech – for use in the home, including furnishing fabrics, upholstery, floor coverings, and fillings and wadding in bedding, cushions, sleeping bags and furniture.
- Indu-tech – used for diverse industrial applications such as air purification, filtration and cleaning technology.
- Medi-tech – used externally – e.g. for wound dressings, and within the body – e.g. for grafting tissues or stitching during operations.
- Eco-tech – using organic and recyclable fibres to lessen the effects on the wider environment.
- Sports-tech – specialist fibres that can enhance and support athletes' performance.
- Pack-tech – includes packing material for industrial, agricultural and other products and goods.



## 2. Functional Textiles

Functional textiles are textiles with integrated functions of control or adjustment according to their end use. They include:

- temperature control breathable fabrics
- phase change materials that absorb, store and release heat
- safety and fire-retardant fibres
- protective clothing for extreme sports, military and police use
- absorbent fabrics
- anti-bacterial protective and hygienically clean fabrics
- sport performance clothing
- reflective and florescent fabrics for high visibility.

## 3. Smart Textiles

Materials that react to an external stimulus such as changes in heat, light, sound, acidity, electronic current and moisture. These textiles can display changes that may be thermal, visual or electronic.

A range of definitions are used across the textiles industry:

- Passive Smart Textiles – can only sense a stimulus.
- Active Smart Textiles – can sense and react (actuate) to a stimulus.
- Ultra-Smart textiles – can sense and react to stimuli and adapt themselves to meet the conditions, implementing reasoning.

E-Textiles are not always 'smart' as they may contain in-built technology e.g. music players or displays.

Included are:

- Microencapsulation – encapsulated substances in tiny thin-walled bubbles which release the active agents in a controlled manner.
- Breathable fabrics and performance textiles that regulate body temperature.
- Memory textiles that can return to their original shape when impacted.
- Thermochromic textiles which use temperature to initiate colour change.
- Colour changing liquid crystals.
- Leuco dyes which disappear under the influence of heat leaving only the background colour visible.
- Photochromic fabrics that change colour when exposed to sunlight or UV light.
- Electrochromic fabrics which change colour when an electric current is passed through it.

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### BREATHABLE FABRICS

**Case Study:**  
Gore-Tex® is a waterproof, breathable fabric membrane. Able to repel liquid water while allowing water vapour to pass through. Designed to be a lightweight, waterproof fabric for all-weather use.

The Gore-Tex membrane is sewn between layers of other fabrics. It contains a lot of tiny holes called pores – there are around 150 million pores per square centimetre. Each pore is 20,000 times smaller than a water droplet, so rain cannot pass through, but moisture vapour from sweat can. The wearer will always stay warm and dry.

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### PROTECTION

**Case Study:**  
Kevlar® – a fibre developed by DuPont™. High tensile strength, high heat resistance and is extremely hard wearing: five times the strength of steel.

**USES:** bullet-proof and stab proof fabric, used in protective clothing for military and police services; abrasion resistant clothing in extreme sports, such as motorbiking and skiing and also for industrial workers ropes and rigging; often combined with Nomex to create high performance protective wear for workers in potentially explosive areas.

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### PERFORMANCE TEXTILES // STOMATEX

**Case Study:**  
Stomatex® can be described as 'breathable neoprene'. It copies the transpiration system in plants. There are thousands of tiny chambers and pores within the fabric. These open up to efficiently evacuate sweat from the body when the user gets hot. They close when the user's temperature falls. Create a unique microclimate for the individual keeping them comfortable during their sporting performance, or for general healthcare. Stomatex is also a good example of biomimicry.

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### PERFORMANCE TEXTILES // NITINOL

**Key facts:**  
Nitinol is a shape memory alloy that responds to temperature. Experiments have been done to weave it into fabric that culminates in a textile product that shrinks upon heating.

One example is the Oricasco shirt designed by Corpo Nova and Grado Zero Espace. Nitinol fibres were combined with nylon and the woven fabric allows the sleeves of the shirt to shorten when the room temperature or the body temperature of the wearer increases.

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## 4. Future Textiles

New technology in modern textiles is narrowing the gap between the worlds of art, design, engineering and science, resulting in ever more sophisticated textile products and clothing with technologies and concepts continuously being researched and developed within the different sectors. To increase the desirability of clothing and to 'keep fashion fashionable', textile manufacturers must redefine 'functionality' and move beyond the historical focus on protection and appearance.

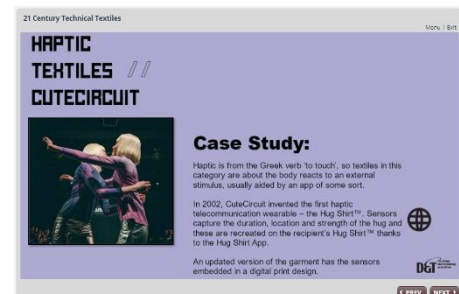
Future conceptual and visionary developments use the interaction between fashionable wearables and new arising 'netfrastructures', creating intelligent fashion interfaces rather than isolated artefacts. Tomorrow's textile products and clothing will take these new developments into another era, merging protective, interactive and communicative functions with experimental technologies currently under research in fields other than fashion.

There are many companies bringing out products which are pushing boundaries and showing what potential the future holds.

The textile industry has recognised that technical textiles is a fast growing and important sector to the future of the industry, particularly in medical, engineering and fashion, and recent international exhibitions and conferences have focused on future developments in this area. UK Universities are world leaders in the research in to the future of textiles.

Developing areas include:

- 3D printing which challenges traditional manufacturing methods.
- Fabrics and garments that incorporate lightweight heating systems.
- Haptic textiles that respond to touch by changing colours depending upon the duration, location and strength of the contact and which can be linked to sensations in virtual and augmented reality.
- Ultra-smart fabrics containing bacterial cells which expand or contract in response to atmospheric changes.
- The use of graphene in fabrics that can conduct heat and energy.



## 5. Sustainable Textiles

The future of textiles is dependent upon finding ways to produce using sustainable materials and processes. Bamboo, pineapple and nettle fibres are increasingly being used but there are many other exciting developments taking place using plant-based and bio-fabricated fabrics, such as:

- Kelp fibres – spinning seaweed fibres for knitting.
- Cotton and corn – including trainers based entirely on plant-based materials.
- Mycelium – using the raw material of mushrooms to develop products ranging from architecture to fashion.
- Bio-engineered protein fibres that mimic spider silk.
- Microbial fabrics grown in tanks using bacteria, nutrients and yeast.

There are two slides with case studies of wearable technologies looking at embedded batteries and conductive yarns.

Online quizzes are included at the end of the Technical, Functional and Smart sections to enable students to test their knowledge and teachers to see where additional support may be required.


## Glossary

A list of the major terms used in this resource and their meanings is included.

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### PLANT BASED DEVELOPMENTS // MYCELIUM

**Case Study:**  
Mycelium design is a concept that uses the raw material of mushrooms to develop products ranging from architecture to fashion.  
It is strong, flexible, light, durable and can be stitched and dyed easily. It is being developed as an alternative to leather and has been seen in catwalk collections by Stella McCartney.  
Anelia Holcik is a designer who has created MycoTEX. The full environmental impact of changing from cotton to mushrooms can be seen here.




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### BIOFABRICATION

**Case Study:**  
Suzanne Lee is the Creative Director of Modern Meadow and came to prominence when she developed her microbial fabric back in 2003.  
The ZQA™ prototype t-shirt is the first generation of microfabricated leather. Formed completely by liquid assembly, there is no stitching required.



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### PROJECT JACQUARD

**Case Study:**  
A collaboration between Levi's and Google, based on using a conductive yarn that combines thin metal alloys with other fibres, such as cotton or polyester. This allows touch and gesture sensitive areas which allows for the use of LEDs and haptic feedback.  
The Commuter Jacket is the first garment to be produced as part of Project Jacquard and features a detachable smart tag on the cuff which connects to your smart phone. It can be detached and plugged into a USB port to recharge.





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Glossary

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## Accessing and downloading the resource and quizzes

The resource is available online [https://www.data.org.uk/external/story\\_html5.html](https://www.data.org.uk/external/story_html5.html) and can also be downloaded and viewed on tablets such as iPad.

To do so you will need to first download this player for Mac OS:

<https://itunes.apple.com/gb/app/articulate-mobile-player/id505546381?mt=8>

And for Android:

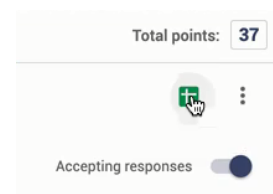
[https://play.google.com/store/apps/details?id=air.com.articulate.articulatemobileplayer&hl=en\\_GB](https://play.google.com/store/apps/details?id=air.com.articulate.articulatemobileplayer&hl=en_GB)

Once downloaded, you need to open with the address of the course and it will give the option of downloading the resource on your device.

The three online quizzes that test students' knowledge and understanding of technical textiles are available [here](#) and Word versions are free to download to adapt for your own use.

The quizzes cover Technical textiles, Smart textiles and Functional textiles and have single and multiple-choice answers. The quizzes have been developed using Google Forms and the scores on the multiple-choice questions only give a maximum score if all correct answers are selected. If one correct answer is missed the score will be zero for that question.

Teachers can adjust scores by selecting 'Responses' and 'Individual' answers from where they can look at students' scores and make changes as appropriate. Selecting the spreadsheet icon launches a linked spreadsheet of students' score which will update accordingly.



The content of the quizzes is available for teachers to adapt to suit their own requirements.



## Curriculum links

Links to online resources are included throughout and a list of key books and links is included at the end of the resource. Images used are also linked should students wish to discover more about these.

## GCSE specifications

The Design and Technology National Curriculum specifications covering Technical Knowledge say that students must:

- understand and use the properties of materials and the performance of structural elements to achieve functioning solutions.

Awarding bodies' specifications for the GCSE include understanding of the following:

- **New and emerging technologies** – understanding the impacts on industry, culture and society, sustainability and the environment, enterprise, people, and production techniques and systems, as well as how critical evaluation informs design decisions. (AQA specification 3.1.1 New and emerging technologies; Eduqas 2.1 Technical principles). Developments in modern and smart materials, composite materials and technical textiles and how the critical evaluation of new and emerging technologies informs design decisions; considering contemporary and potential future scenarios from different perspectives, such as ethics and the environment. (Edexcel specifications 1.2 The impact of new and emerging technologies; 1.4 Developments in modern and smart materials).
- **Developments in new materials** – modern and smart materials including graphene; and for technical textiles, 'How fibres can be spun to make enhanced fabrics e.g. conductive fabrics, fire resistant fabrics, Kevlar and microfibres incorporating micro encapsulation' (AQA specification 3.1.3 Developments in new materials).
- **Materials** – an overview of natural and synthetic materials used in textiles.
- **Specialist technical principles** – include an in-depth knowledge and understanding of a range of factors through at least one material category including textiles-based materials. This includes selection of materials appropriate to the product design through understanding a range of factors. (AQA 3.2 Specialist technical principles).
- **Impact of new and emerging technologies** – on influencing and informing design decisions, considering both contemporary and potential future scenarios from the perspectives, such as: ethics, the environment and product enhancement. (OCR 2.2 How do developments in Design and Technology influence design decisions and practice?).
- **Informing design decisions** – including consideration of the impact upon sustainability and environmental issues, fir trade policies and carbon footprint. (Eduqas 2.1 Technical principles)

All include core and specialist knowledge where students select a material area for in-depth study and understanding which will help them with their product and materials choices in the non-examined assessment task.

## A Level specifications

At A Level, students must draw upon knowledge learned and develop this further when applying it to product design and other specialist areas. The DfE's subject content for A Level says that design and technology (fashion and textiles) specifications require students to have knowledge and understanding of:

- the applications of smart materials, e-textiles, and technical textiles, and
- how materials, other than fibres and fabrics, can be used in textiles and fashion design and development.

The AQA specification for A Level includes that ‘Students should know and understand the term smart material’; and ‘students should be able to explain the suitability of smart materials for given applications making reference to how the material responds to external stimuli’. Similarly: ‘Students should know and understand the term modern material’ and ‘students should be able to explain the suitability of modern materials for given applications’. (AQA A Level specifications 3.1.2 Performance characteristics of materials).

Links to science and maths are evident across all areas in the impact and developments surrounding new and emerging technologies. Technical textiles provide a good illustration of this through materials – for example, Graphene and Kevlar, mycelium and microbial growth, and through the incorporation of breathable and haptic materials.



## Careers in technical textiles

These links are to descriptions of career opportunities in the textiles sector.

[Analytical textile technologist](#) – solve technical issues relating to manufacturing, check material quality, analyse faults and test fitness for purpose and check fabric contents are listed correctly.

[Textiles production manager](#) – responsibilities include overseeing the production process and liaising with suppliers about quality, price, delivery times and ethical standards. The production manager will also deal with planning, monitoring and altering the production schedules, solve production faults and issues liaising with in-house design, sales, buying and quality control teams.

[Technical textiles designer](#) – diverse position based around developing products to meet performance specifications, developing prototypes, using CAD, testing new fibres and fabrics, researching new processes, techniques and technologies, writing reports and costings.

[Textile designer](#) – create fabric designs and patterns for printed, woven and knitted materials.

[Footwear designer](#) – create designs and patterns for men's, women's and children's footwear.

[Fashion designer](#) – design clothing and fashion ranges across a wide range of areas.

[Textile machinery technician](#) – maintains, services and repairs the machinery used in textiles manufacturing.

### Other textiles careers links

[www.indeed.co.uk](http://www.indeed.co.uk) has current jobs in textiles design with specifications and salaries. They range from junior/assistant designer (first graduate job) to senior designer (proven track record).

[Top ten careers in the fashion industry](#)

[What can I do with my fashion design degree?](#)

[What can I do with my textile design degree?](#)

**Our thanks to All Saints Educational Trust for their support in developing this resource.**

