Building Services Teacher Guide

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Introduction

This set of resources provides schools with information and activities to help pupils understand the roles and impact of the building services industry.

It includes five video-based case studies of civil engineers working in the sector to allow pupils to understand their roles and the work they do, and to consider their options when thinking about career choices.

Each of the engineers is also presented as a cartoon-style character introducing a number of activities that teachers can adapt to suit their classes, whether at late Key Stage 2 or Key Stage 3. The challenges in the activities can be adapted and developed into research, design-only, or design and make projects to suit your school and pupils.

Presentation tips

Using video

General tips: Run through videos with a timer and note the points at which you might like to pause to make a point or ask questions. You may also want to add your own commentary. You may need to point out that some of the views expressed by interviewees or the originator will be their own opinions and may need to be considered.

Using PowerPoint presentations

The PowerPoint presentations contain instructions and activities for students and may contain links to videos. Ensure you have YouTube enabled in school to allow these to load correctly.

Challenges

The materials with each of the activities are in PowerPoint format and can be adapted to suit your teaching requirements.

Online links

To get the best from online resources ensure your web browser is updated and that you have YouTube enabled to allow videos to load correctly. Online CAD systems may have minimum systems requirements.

What are building services?

Building services turn buildings into places that meet the needs of their users. Places in which we live and work have to be safe and have the appropriate heating, lighting, levels of humidity and access to services such as water, drainage, electricity and online access.

Much of what building services engineers do may be invisible in a finished building, and often taken for granted until things go wrong, but without them we would not be able to go about our daily lives safely and work efficiently.

Encourage your pupils to imagine life without some of the services that surround them. What if there was no heating; no lighting; no security… How would this affect a hospital, school or office, or in the home?

New technologies such as solar power and the ability to store electricity are changing the buildings we inhabit. The development of these technologies and the ability to miniaturise systems means that they can be incorporated into a building design in new ways. As we move towards a low carbon future, systems have to change to ensure targets are met and efficiencies maximised.

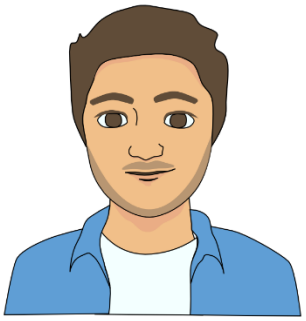
Pupils' designs for their projects should reflect this and consider efficient use of energy and minimum loss of heat etc. This might mean having lighting systems that turn off when no-one is in the room, or making use of appropriately aligned roof surfaces for solar panels.

Salaries

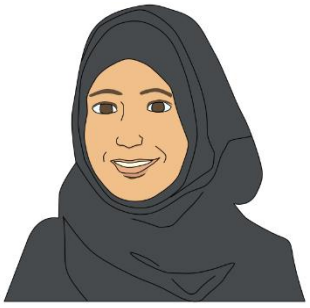
The average graduate starting salary for civil engineers is £24.5k. Average salaries for senior managers is in excess of £45k.

Case studies

Included are profiles and interviews with engineers working in a civil and structural engineering consultancy that handles a wide range of projects, from schools to health care and industrial and commercial projects; and from consultancies working with renewable energy, and developing shop, office and domestic installations and alarm systems.

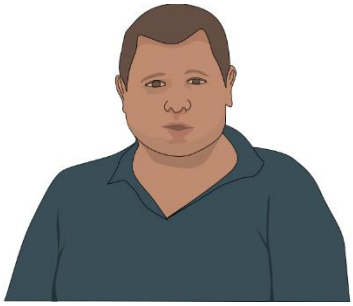


Louis Adam is a Project Engineer. He works as part of a team alongside architects, building services, mechanical and electrical engineers, builders and contractors. Part of his work includes site meetings to oversee projects taking shape. Louis sees the industry as having plenty of opportunities with new projects being developed across the country and finds it rewarding to see the effect of his work on communities. He tells of his career path from work experience and GCSEs to college and an apprenticeship as a trainee civil engineer which took him to university and then his present job.



Alaa Ahmed is a Design Engineer mainly working on design concepts and overseeing the development of projects and their management. In her role she needs to have a good knowledge of all the services that might be installed in a building to make it habitable and efficient. Her job requires her to have good problem-solving and communication skills and be able to make clear decisions and a good technical knowledge to know how installations might work in different locations. She is largely office based but visits sites where the work is taking place, working alongside architects, contractors and building services engineers.

Poppy Smith is a CAD Technician specialising in designing renewable energy systems. She works alongside specialists in electrical and renewable energy, as well as other building services and structural engineers to develop affordable and viable designs. She is largely office based, using AutoCAD and Building Information Modelling (BIM) to draw up proposed designs but also works with surveyors and different people in building services roles on sites and at different locations.



Mark Davenport specialises in electronic article surveillance (anti-theft devices in shops) but also installs and services CCTV cameras, access control and alarm systems. His job means he travels a great deal, getting details of the projects he need to work on through his iPad, and may work in schools, prisons, shops and offices. He became an alarm systems engineer through an apprentice scheme.

Harry Smith works as a Building Services Consultant, with mechanical, electrical, plumbing and drainage systems and installations. He works closely with the client to develop designs that meet their needs and with contractors and site engineers to make sure they are installed to the right standard to keep the client happy.

Activities

In each activity the character introduces the challenge and provides tips to help guide pupils when they research and design solutions to meet the needs of users. The challenges are all based around real-life situations, drawn from the engineers' experiences and other examples, linked to activities that typically take place in delivering school projects and to National Curriculum content. There is a strong STEM component in the challenges. Each activity challenge can be adapted to suit the level of your pupils' skills, knowledge and prior learning.

The activities can be used with individuals or as group-based tasks and include opportunities for research, discussion and written work looking at the impact of building services engineering on society and the environment, and the way these feed back into the industry. Through the challenges offered there are opportunities for pupils to investigate and explore careers, operations and technologies in building services.

Depending upon your school's priorities and available teaching time these can be developed into practical hands-on challenges around:

- designing only projects
- making only projects
- designing and making projects

Creative solutions to the challenges will need to consider:

- What is the challenge?
- Who is it for? What are their needs?
- Who should be consulted in the planning?
- The selection of materials and the construction of structures
- Whether it is best to work in a team or alone
- The roles in a team
- Developing presentations to clients to justify decisions and solutions
- Evaluation opportunities and who will be best placed to contribute to this.

D&T across the curriculum

These activities provide ample opportunity for including cross curricular work, particularly in engineering, maths, science, computing and English. Check with colleagues in other departments to ensure that the correct levels are being addressed.

The maths component of the GCSE is now 15% and pupils should be encouraged to get into the habit on incorporating number, measurement, ratio and proportion, algebra, geometry and statistics, including showing working out, in their design planning.

Materials, light, electrical systems, forces and of course physics are all relevant areas of science that are used in building services applications.

CAD, CAM and software for e-portfolios are aspects of computing that apply.

Opportunities for developing speaking and listening through discussions, negotiations and presentations are plentiful as well as written work.

The challenges

Challenge 1 Upper KS2 / KS3

Playing field shelter challenge

A playing field shelter keeps out the rain but what else can it do for those using it? How might any electrical solutions be powered?

Pupils are asked to research the users of a playing field shelter to see what their needs are. Issues might include being there after dark, keeping out of the rain and wind in a space that is comfortable, needing to charge phones and other devices, and perhaps wi-fi access.

Prompts on the challenge sheet invite them to think about using solar and wind power to power their circuits, and proximity sensors or switches to turn on the circuit only when the shelter is occupied. Solutions can range from simple circuits with hand-made toggle or rotary switches to programmable systems that respond to levels of daylight and proximity using a microcontroller.

This also introduces photovoltaic (PV) systems and briefly outlines how they are used in modern building design to provide services.

Depending upon the time available this can be a design-only activity in which pupils draw and annotate their design and the circuits, or they could make a model of the shelter using card or construction kit materials and incorporating the circuit, solar or wind power and a Crumble or similar microcontroller.

The ‘inspirations’ sheets contain images of possible users, examples of existing shelters and images of solar and wind-powered energy sources and circuits.

Depending upon the solutions chosen, it is a good idea to make exemplar circuits ranging from simple to complex to ensure you can answer any queries that arise.

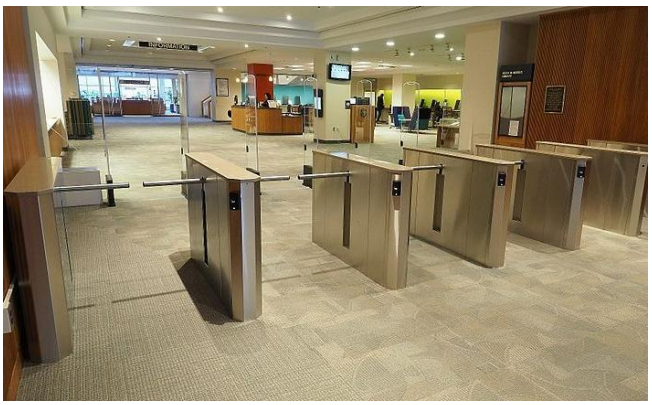
Resources from the Design and Technology Association

- KS2: Projects on a Page planners: Frame Structures, Monitoring and Control and Electrical systems: More complex switches
- KS3: Learning about structures and mechanisms at KS3
- KS3: Sustainable power supply
- KS3: STEM Careers resources Light Up the World

Challenge 2 KS3

Library access challenge

A library needs to improve its access to ensure everyone can use the facilities. Which building services will need to be considered?



This challenge focuses on the access needs of library users. Pupils might think about blind or partially sighted users, wheelchair access or other users with limited mobility who have special requirements for access.

Pupils are asked to consider who might use the library and to put themselves in the place of a user with visual impairment or mobility issues. What accessibility solutions can they come up with? Prompts include suggesting changing the lighting, clear signage or painting lines on surfaces to improve access.

Solutions might include:

- Consideration of doorways, floor levels, access to other floors
- Lighting levels and audible guidance
- An iPad/smart phone app that includes a searchable map and uses GPS to guide users to an area of the library
- Signage that uses clarity, colour and graphics that can guide users to areas of the library they might be seeking
- A scale model of the library, for display in the entrance
- A system of coloured paths, tapes or arrows on the floor, colour coded to lead users to different areas
- Accessible parking and easy access to the entrance

If an alternative appropriate venue is available you might choose to use this and different users instead, for example a school entrance for new pupils or accessing transport.

Resources from the Design and Technology Association

- KS3: Research methods: Design Innovation
- KS3: Design challenges: Get Designing - Generating real design idea
- KS3: Inclusive design: Designing Everyone In
- KS3: Virtual Client Interview - Library

Challenge 3 KS3

Alarm systems challenge

A small business is worried about the risk of break-ins and having their documents stolen? Their building has been secured with locks and bars, but they are looking at installing two alarm systems to make them feel safer. One will detect intruders and one will be triggered when the safe is moved or there's an attempt to break into it.

The emphasis here is on meeting the client's needs when providing solutions to a particular problem.

The client's requirements can be clearly defined, so there may be limited room for creative decisions and solutions. Pupils should still come up with ideas that include alternative solutions to meet the client's requirements. Presentations to the 'client' and consideration of their feedback helps inform the iterative design process in developing ideas. You might get another staff member or parent to act as the client and feed back to the pupils.

This may be delivered as a design-only task focused on generating ideas for solutions, or as a series of design and make activities in which a prototype is developed. Solutions can be designed using circuit simulation software such as Circuit Wizard or Yenka or with circuits, input and output devices and microprocessors.

A range of input devices: switches and sensors, can be employed and alarms can be triggered by floor pads, proximity and tilt switches, light and heat sensors and light beams.

Outputs can include sound, light and perhaps taking photos of the intruder.

Other alarm considerations might include warning of water ingress or fire. Security systems for screening people on the site can be through inputting codes into electronic locks, or fingerprint, facial and iris recognition.

The importance of collaborating and team working is emphasised to ensure that safety and security standards are complied with.

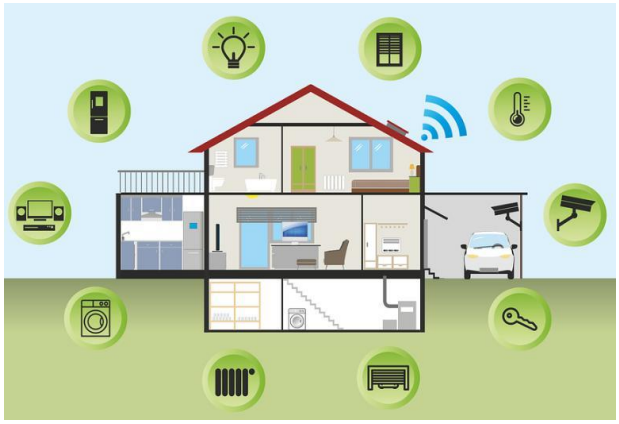
Resources from the Design and Technology Association

- KS3: Putting the Communications in Electronics and Communications Technology
- KS3: Programmable Components - Multi-Light and Coin-operated Charity Box
- KS3: Systems and Control – Dusk Lights On
- KS3: Crumble Controller Class Pack

Challenge 4 KS3

A home for the elderly

The local authority has asked for an assessment of plans for a home for the elderly. They need to be sure that all stakeholders are catered for and that it provides a safe and secure environment for the residents.



This will include researching the choice of potential materials, the environmental impact, costs of materials and construction, incorporation of and anticipation of new technologies. Pupils will need to consider:

- who is it for and the needs of the staff and residents
- access for all, including those with mobility issues or disabilities, visiting relatives and medical professionals and the emergency services
- building regulations and planning approval, including consideration of the ongoing impact of the building
- the internal environment, including kitchens and eating areas, heat, light, humidity, noise levels, access to bathing facilities and shared areas
- the external environment and impact upon wildlife, neighbours and visitors; vehicular access and outdoor facilities for residents
- security for staff and residents

The focus in this challenge is on research and generating design ideas and an awareness of all the elements that go into providing buildings to meet users' requirements, but there may be opportunities to model designs and plans using a range of materials and (free) CAD software such as Google SketchUp and Ikea Home Planner. Proprietary CAD software may be appropriate for more sophisticated designs.

The slides include an introduction to Building Information Modelling (BIM) which building service engineers use to plan and test all the proposed services before a building is built and the services installed.

Resources

- Ikea Home Planner
- Google SketchUp

Challenge 5 KS3

Conversion challenge

An old church is being converted into a community centre and needs a scheme for heating and lighting the building.
It is down a rough track and currently has no services except an outside tap and some very old electrical lighting. The client wishes the services to be concealed as far as possible.

The main focus here is on site management and installation of concealed services. When designing a scheme for heating and lighting an existing building that is being converted there are many things to consider, including: the client's requirements, regulations, access for contractors and services, security and safety, and meeting the needs of the community centre's users.

The site currently has no services except an outside tap and some very old electrical lighting, and access to the building is along a rough track, so contractors may need to consider this. The client's wish for services to be concealed as far as possible may cause servicing and maintenance problems but may also allow for creative solutions when incorporating them into existing features of the building.

How planning drawings and Building Information Modelling (BIM) are used to allow building services to be installed alongside one another and in concealed spaces is covered in the slides.

Resources from the Design and Technology Association
KS3: Sketching and rendering 2-point perspective
KS3: Skills for Industry – Severn Trent water supply challenge

Applying the National Curriculum at Key Stage 2

The Primary National Curriculum for Key Stage 2 states:

Through a variety of creative and practical activities, pupils should be taught the knowledge, understanding and skills needed to engage in an iterative process of designing and making. They should work in a range of relevant contexts [for example, the home, school, leisure, culture, enterprise, industry and the wider environment].

When designing and making, pupils should be taught to:

Design

- *use research and develop design criteria to inform the design of innovative, functional, appealing products that are fit for purpose, aimed at particular individuals or groups*
- *generate, develop, model and communicate their ideas through discussion, annotated sketches, cross-sectional and exploded diagrams, prototypes, pattern pieces and computer-aided design*

Make

- *select from and use a wider range of tools and equipment to perform practical tasks [for example, cutting, shaping, joining and finishing], accurately*
- *select from and use a wider range of materials and components, including construction materials, textiles and ingredients, according to their functional properties and aesthetic qualities*

Evaluate

- *investigate and analyse a range of existing products*
- *evaluate their ideas and products against their own design criteria and consider the views of others to improve their work*
- *understand how key events and individuals in design and technology have helped shape the world*

Technical knowledge

- *apply their understanding of how to strengthen, stiffen and reinforce more complex structures*
- *understand and use mechanical systems in their products [for example, gears, pulleys, cams, levers and linkages]*
- *understand and use electrical systems in their products [for example, series circuits incorporating switches, bulbs, buzzers and motors]*
- *apply their understanding of computing to program, monitor and control their products.*

Its **aims** say that pupils should:

- *develop the creative, technical and practical expertise needed to perform everyday tasks confidently and to participate successfully in an increasingly technological world*
- *build and apply a repertoire of knowledge, understanding and skills in order to design and make high-quality prototypes and products for a wide range of users*
- *critique, evaluate and test their ideas and products and the work of others*

The emphasis here is on designing and making ‘Something for Someone for Some purpose’, identifying a need for an identified individual or group and providing practical, realistic solutions. In the context of the challenges outlined here, a user and purpose are clearly identified, and pupils should use appropriate skills and knowledge to develop design solutions from the skills and knowledge they have acquired.

The Design and Technology Association’s scheme of work ‘**Projects on a Page**’ includes planners and helpsheet advice on Structures (Frame and Shell), Mechanisms (Levers and Linkages, Pulleys and Gears, Cams), Electrical systems (Switches and Circuits) and Programming (Monitoring and

Control), all of which may be applied to developing ideas and solutions to be able to prototype models.

Pupils should cover:

- **Investigative and Evaluative Activities** to explore possible solutions and learn from a range of existing products to find out about Design and Technology in the wider world
- **Focused Tasks** in which pupils develop specific technical knowledge, designing skills and making skills
- **Design, Make and Evaluate Assignment** where children create functional products with users and purposes in mind

Applying the National Curriculum at Key Stage 3

The National Curriculum for Key Stage 3 states:

Through a variety of creative and practical activities, pupils should be taught the knowledge, understanding and skills needed to engage in an iterative process of designing and making. They should work in a range of domestic and local contexts, such as the home, health, leisure and culture, and industrial contexts, such as engineering, manufacturing, construction, food, energy, agriculture (including horticulture) and fashion.

When designing and making, pupils should be taught to:

Design

- *use research and exploration, such as the study of different cultures, to identify and understand user needs*
- *identify and solve their own design problems and understand how to reformulate problems given to them*
- *develop specifications to inform the design of innovative, functional, appealing products that respond to needs in a variety of situations*
- *use a variety of approaches, such as biomimicry and user-centred design, to generate creative ideas and avoid stereotypical responses*
- *develop and communicate design ideas using annotated sketches, detailed plans, 3-D and mathematical modelling, oral and digital presentations and computer-based tools*

Make

- *select from and use specialist tools, techniques, processes, equipment and machinery precisely, including computer-aided manufacture*
- *select from and use a wider, more complex range of materials, components and ingredients, taking into account their properties*

Evaluate

- *analyse the work of past and present professionals and others to develop and broaden their understanding*
- *investigate new and emerging technologies*
- *test, evaluate and refine their ideas and products against a specification, taking into account the views of intended users and other interested groups*
- *understand developments in design and technology, its impact on individuals, society and the environment, and the responsibilities of designers, engineers and technologists*

Technical knowledge

- *understand and use the properties of materials and the performance of structural elements to achieve functioning solutions*
- *understand how more advanced mechanical systems used in their products enable changes in movement and force*
- *understand how more advanced electrical and electronic systems can be powered and used in their products [for example, circuits with heat, light, sound and movement as inputs and outputs]*
- *apply computing and use electronics to embed intelligence in products that respond to inputs [for example, sensors], and control outputs [for example, actuators], using programmable components [for example, microcontrollers].*

Progression from Key Stage 2 to Key Stage 3

The age-related expectations for pupils are laid out in the Design and Technology Association's Progression Framework which lays out ways in which progress should be cumulative, developing on earlier learning in the areas of designing, making, evaluating and technical knowledge. Pupils who have learned about frame and shell structures and simple electrical circuits at KS2 can apply this knowledge to projects and prototypes at KS3 by, for example, developing programmable

electrical circuits in more sophisticated structures that response to the environment by e.g. lighting a walkway in a model structure.
The Progression Framework is freely available from the Association's website.

Links to maths and science
With the GCSE now having 15% of its marks for maths, preparatory work at Key Stage 3 using realistic scenarios is a valuable way of getting students used to its inclusion. Estimating material quantities and developing plans for buildings have maths included in any case and this is often an easier way for some pupils to absorb the concepts of number, place value, fractions, geometry and ratios.

Science links include understanding the principles of forces and properties of matter and materials. (NC)

Useful Links

Links to resources are included in each of the challenge outlines. The following will be of help for general Design and Technology guidance and information on building services.

Design and Technology Key Resources is a bank of 45 units aimed at Key Stage 3 pupils across different aspects of D&T. It includes a free Learning Planner and Assessing Without Levels Teacher Guide to help teachers plan effective learning at KS3.

The Design and Technology Progression Framework is a free resource covering progression from Key Stages 1 to 3.

CIBSE (Chartered Institution of Building Service Engineers) has information on college course, building services, building information modelling (BIM) and case studies of the people shaping the world in which we live.
www.cibse.org

Born to Engineer offers classroom toolkits and outlines the range of things engineers do in their daily work.
www.borntoengineer.com

Building Services Engineer job profile at the National Careers Service.

Building Services Engineer at Wikipedia.

The D&T Association's Skills for Industry programme includes free teaching resources that teachers may find useful.