Key stage 2

Design, write and debug programs that accomplish specific goals, including controlling or simulating physical systems; solve problems by decomposing them into smaller parts

The focus on algorithms at key stage 1 leads pupils into the design stage of programming at key stage 2. Algorithms are the necessary start of the process of creating working code, and identifying the steps needed to solve any problem is essential.

Splitting problems into smaller parts is part of computational thinking. For example, designing a game in Scratch will involve thinking about algorithms, programming, drawing sprites and backgrounds, making animations, and even composing music or recording sound effects.

We think of computers as boxes with keyboards, mice and displays, but built-in computers (or 'embedded control systems') are an increasingly significant application of information technology. Pupils can gain valuable insights into how computers are used to monitor and control real-world systems by using sensors, switches, motors and lights. Computers also make it possible to explore real-world situations that would be too difficult, too expensive or too dangerous to create in real life.

Use sequence, selection, and repetition in programs; work with variables and various forms of input and output

Sequence in this context is the step-by-step nature of computer programs, mirroring the sequence of steps the algorithm would list.

Selection refers to instructions such as *if ... then ... otherwise* decisions in which the operation (what the program does) depends on whether or not certain conditions are met. For example, a quiz provides different feedback if the player answers the question correctly or incorrectly. It is helpful to refer pupils to selections (choices) they make in everyday life; for example, *if* it rains in the morning, *then* I will wear my anorak to school, *otherwise* I won't.

Repetition is a programming structure such as a *repeat ... until* loop in which the computer runs part of the program a certain number of times or until a particular condition is met.

In the case of the quiz, we might want to ask ten questions, or keep going until the player has scored five correct answers. Again, it is useful to refer pupils to loops or repetition in daily routines. For example, the traffic lights on a pelican crossing will stay green *until* someone presses the button to cross the road; an oven heats up *until* it reaches the right temperature. There are many loops in the wider world, such as the days of the week or the moon travelling around the Earth.

Variables are used to keep track of the things that can change while a program is running. They are a bit like *x* or *y* in algebra, in that the values may not initially be known. Variables are not just used for numbers. They can also hold text, including whole sentences ('strings'), or the logical values 'true' or 'false'. For our quiz we would use variables to keep track of the player's score and the number of questions they attempt. Variables are like boxes, in that the computer can use them to store information that can be changed by the user, the program or by another variable.

We may think of **input** as keyboard and mouse (or touch screen), and **output** as the computer display, but pupils' experiences should be widened beyond this. Working with sound is straightforward, as laptops have built-in microphones and speakers. The latest version of Scratch provides support for using webcams. Digital cameras allow interesting work using image files.

The reference in the programme of study to 'controlling physical systems' implies the use of sensors, motors and perhaps robotics. Midi instruments like an electronic keyboard, and devices such as MaKey MaKey[6] and Microsoft Kinect provide yet further experience of working with various forms of input.

Use logical reasoning to explain how some simple algorithms work and to detect and correct errors in algorithms and programs

Key stage 2 pupils should be able to explain the thinking behind their algorithms, talking through the steps and explaining why they've solved a problem the way they have. They also need to be able to look at a simple programming project and explain what's going on. This is made easier with languages like Scratch, Kodu and Logo, which feature an on-screen sprite or turtle. The immediate feedback helps pupils to understand and debug their programs. Pupils might also be expected to look at someone else's algorithm and explain how it does what it does.

Thinking through programs and algorithms helps develop pupils' abilities to think logically and algorithmically, which leads to planned debugging of code rather than just a trial-and-error approach.

Understand computer networks, including the internet; how they can provide multiple services, such as the World Wide Web, and the opportunities they offer for communication and collaboration

This is a challenge because most of us have not thought about how these ever-present technologies do what they do.

Computer networks, including the internet, are made up of computers connected together. The computers include fast, dedicated machines that pass on data that's not intended for them (called 'routers', 'gateways', 'hubs' or 'switches', depending on particular roles), and 'servers' (always-on machines looking after emails, web pages and files that other computers might ask for from time to time). The connections between the computers in a network may consist of radio or satellite signals, copper wires or fibre-optic cables.

Information stored on computers and information travelling over networks must be digitised (i.e. represented as numerical data). The computer network in your school and the internet use the same method or 'protocol' to send and receive this data. The data is broken up into small 'packets', each with identifying information, which includes the IP (internet protocol) address of the sender and recipient.

These packets of information make their way across the internet from source to recipient. At the far end, the packets get stitched back together in the right order and the email is delivered, the website is accessed, or the Skype call gets connected. Many of these packets, travelling at near light-speed, are generated by web servers returning web pages to the browser requesting them.

By connecting people around the world and passing on packets of data from sender to recipient, the internet has created many opportunities. These range from communication (such as email, video conferencing, blogs, forums, social networks) and collaboration, such as wikis (including Wikipedia), to real-time collaborative editing, Creative Commons media (permission to share and use creative work with conditions stated by the creator) and open-source software, which is available for us to use and change.

[6] See www.makeymakey.com

Use search technologies effectively, appreciate how results are selected and ranked, and be discerning in evaluating digital content

Using search technologies involves aspects of computer science, information technology and digital literacy. Effective use of search engines gets the results you want. It relies on specifying the right keyword, skimming and scanning the results to see which seems most relevant, and distinguishing between the main results and adverts presented as sponsored results. It may also involve using other features[7] of the search engine, including searching for phrases rather than keywords, or limiting searches to a particular time frame, language, reading level or website.

In order to return results, search engines use 'web crawler' programs. These programs visit the pages of the web, follow the links they find and can make a copy of each page visited. The pages are indexed, keeping track of keywords on each page. When you enter a search query, the search engine returns pages from its index on which your keyword(s) or phrase appears.

Search engines take many factors into account. At the heart of Google's algorithms[8] is 'PageRank', which determines the quality and rank of a page based on the quality of the pages that link to it. Their quality is, in turn, determined by the quality of the pages that link to them, and so on.

Just because a page has a high rank in Google or another search engine for a particular query, it doesn't mean that the content is true, age-appropriate or relevant to a particular project. Pupils need to develop skills in evaluating digital content, including how trustworthy the information is (perhaps by verifying it with another independent source), whether it's something that the audience for a project would be able to grasp, and why the content was posted in the first place (e.g. to give a balanced overview, or simply to advance one side of an argument).

[7] See, for example, www.google.com/advanced_search

[8] There's an overview of some of Google's algorithms at www.google.co.uk/intl/en/insidesearch/howsearchworks/algorithms.html

Select, use and combine a variety of software (including internet services) on a range of digital devices to design and create a range of programs, systems and content that accomplish given goals, including collecting, analysing, evaluating and presenting data and information

This is something of a catch-all requirement, bringing together various aspects of the computing curriculum. Pupils might typically be expected to demonstrate progression by:

- using software under the control of the teacher
- then, using software with increasing independence
- then, combining software (e.g. importing an edited image or video into a presentation or web page)
- then, selecting software themselves (perhaps from the full range of applications installed on computers, smartphones and tablets at home or at school, or available to them via the web).

Internet services might include, for example, learning platforms, school, class or individual blogs, and cloud-based tools such as Google Drive, Office 365 or image-editing sites.

The reference to 'a range of digital devices' encompasses using both fixed and mobile technologies. It also includes running software (such as that described in the previous paragraph) on web servers via the internet.

There is also recognition that design and creativity in computing encompass many forms, from the content familiar to many from the old ICT programme of study, the programming as required by earlier statements in the new programme of study, to more complex, system-level ideas, combining software and hardware to achieve a well-defined goal with a particular audience in mind.

There is an important distinction between data and information at GCSE and A level, where information is defined as structured data that has been processed and has meaning attached to it. At key stage 2 it might be more helpful to think of data as numbers and information as richer media such as text, images, audio, and video or 3D representations. However, it is worth remembering that both data and information are digitised by computers (i.e. stored in the form of numbers).

Collecting, analysing, evaluating and presenting data is an important application of computers. Pupils should gain experience of working with data they have generated or collected for themselves, as well as big, public datasets.[9]

Pupils have an opportunity to develop a more critical media literacy as they work with tools that, until relatively recently, were the domain of professionals. Tools for recording audio and video, and for creating animation, web pages, digital photos, digital music and 3D models, are all available to primary schools for low (often zero) cost. Providing a potentially global audience for the pupils' work is tremendously motivating.

Use technology safely, respectfully and responsibly; recognise acceptable/ unacceptable behaviour; identify a range of ways to report concerns about content and contact

Safe and responsible use of technology at key stage 2 builds on skills learned in key stage 1. As well as requiring pupils to keep themselves safe and to treat others with respect, the programme of study at key stage 2 introduces an emphasis on *responsible* use of technology.

Pupils need to consider how their online actions impact other people. They need to be aware of their legal and ethical responsibilities, such as showing respect for intellectual property rights (e.g. musical, literary and artistic works), keeping passwords and personal data secure, and observing the terms and conditions for web services they use (such as the 13+ age restriction on most US websites, including Facebook, resulting from COPPA[10] legislation).

Pupils should also develop some awareness of their digital footprint: the data automatically generated when they use the internet and other communication services, and how this is, or could be, used.

Pupils should be aware of, and abide by, the school's acceptable use policy, as well as the requirements of any other services they use. Encourage pupils to think twice, and to check terms and conditions, before signing up for internet-based services.

As in key stage 1, pupils should report any concerns to a parent or teacher. They should also be aware that they can talk directly to the police, report their concern to CEOP, or talk in confidence to counsellors at Childline. Your designated child protection lead might, depending on the nature of the concern, raise the matter with local social services, the police or CEOP.

[9]See http://data.gov.uk/ and www.theguardian.com/news/datablog/interactive/2013/jan/14/all-our-datasets-index

[10]The Children's Online Privacy Protection Act, which prohibits companies in the United States from storing any information on under 13s: see www.coppa.org/coppa.htm