Naace and CAS Joint Guidance
2014 National Curriculum for Computing

A wiki approach to developing joint guidance to support the Computing Curriculum

Naace and CAS have been working together to provide some joint guidance about what each part of the English National Curriculum for Computing means. This joint guidance provides detailed interpretation of those parts of the DfE document which need clarification for those who will be teaching the subject. The joint guidance will be helpful for those who are developing schemes of work for the subject and was developed in a wiki, with comments and suggestions from our enabling its development.

Examples of learning activities have also been added to the wiki and can be found here: http://naacecasjointguidance.wikispaces.com/. We look forward to being able to add more of your suggestions - please send all examples to jan.harrison@naace.co.uk.

Contents

AIMS OF THE JOINT GUIDANCE

- To develop clear agreed definitions for the terminology used in the National Curriculum draft programme of study (in some cases this might include showing how a definition develops from early years through to KS4)
- To develop guidance for the use of technology enhanced learning across the curriculum that takes into account the development of skills, knowledge and understanding within the computing curriculum
- To develop guidance about what each bullet point in the programme of study means, including expanding information about the range of activities/learning that might be included in digital literacy, safe and responsible use, IT aspects of the curriculum
- To provide iillustrations of what learning activities might look like

Purpose of Study and Aims

Purpose of Study

The "purpose of study" section says: **"The core of computing is computer science, in which pupils are taught the principles of information and computation, how digital systems work and how to put this knowledge to use through programming. Building on this knowledge and understanding, pupils are equipped to use information technology to create programs, systems and a range of content. Computing also ensures that pupils become digitally literate -- able to use, and express themselves and develop their ideas through, information and communication technology – at a level suitable for the future workplace and as active participants in a digital world."**

These three underlined aspects correlate to the three areas of Computer Science (CS), Information technology (IT) and Digital Literacy (DL) and how they are connected. The three aspects of the subject Computing are referred to throughout the document. Within each aspect, the inter-related nature of each aspect is noted and although the description (or statement) is simplistic, it could be considered that "creating programs" relates to CS, "systems" relates to IT and "range of media" is DL. Although these are not to be treated as discrete parts of the subject, finding references to the aspects (as indicated by the colour coded example above) indicates the balance between them.

The clear balance between these different aspects of Computing within the Purpose of Study and within the Aims should be visibly present at every stage in a pupil's Computing education. The implication of the distinct but inter-related aspects is that one lesson will not be on computer science, whilst another is on digital literacy. They are conceived as a whole. For example, consider the Key Stage 2 content: "use search technologies effectively, appreciate how results are selected and ranked, and be discerning in evaluating digital content". It makes little sense to split the elements up but rather to deal with this problem as a whole. There will be a ranking algorithm that will take the words being searched for and return relevant pages. This is a complex problem that can be broken down (decomposition) but allied to this will be the search terms being used and evaluating the validity of an information source, ethics regarding paid for search results etc.. This is not a CS, IT or DL problem. It is all three at the same time!

Aims

The Aims begin to introduce more detail.

- "**All pupils can understand and apply the fundamental principles and concepts of computer science, including abstraction, logic, algorithms and data representation**". The biggest single change in the Computing curriculum is the introduction of computer science as a foundational subject discipline that, like maths and science, every pupil should study. Like other disciplines, computer science is about ideas rather than technology; has a body of knowledge and techniques; and dates relatively slowly.
- The programme of study uses the technical vocabulary of computer science, such as "abstraction", "algorithms", and "data representation". Although precise, each is applicable in a variety of every-day contexts; for example, the Tube Map is an an abstraction of the London underground; and a recipe is an algorithm for making a meal. These terms are further elaborated in the rest of this guidance, and in additional supporting materials available from CAS and Naace.
- "**All pupils can analyse problems in computational terms, and have repeated practical experience of writing computer programs in order to solve such problems**". This point introduces the computational thinking (CT) that is a feature of the programme of study.

Computational thinking has been the subject of much discussion over recent years and aspects that can be clearly seen within the programme of study include problem decomposition, data representation and modelling. It involves a set of skills and techniques that are used by people to solve problems and create digital solutions to those problems. In truth it is not just important for computing but applicable across subject areas and goes beyond critical/mathematical thinking because of the unique combination of thinking skills, use of digital tools and automation.

- The relationship between programming and computer science is similar to the relationship between practical labwork and physics. Labwork is fundamental to physics, and no one would dream of teaching physics without practical experimentation; but physics is much more than labwork! Similarly, programming brings computer science alive; but computer science is much more than coding.

- "**All pupils can evaluate and apply information technology, including new or unfamiliar technologies, analytically to solve problems**" provides a clear indication that it is important for pupils to continually re-evaluate the tools that they are using as new technologies become available. Given that the technologies pupils learn to use now in school may be defunct by the time they enter their future *workplace or become active participants in a digital world*, it is important that flexibility, resilience and adaptability are developed. As such, it is important to ensure pupils learn to use a range of software and hardware tools. However, this needs to go beyond a superficial development of skills and pupils need to be encouraged to increasingly use the full potential of the tools that are available - which links closely with the next aim; it is an important part of the development of higher thinking skills that are so desirable in the workplace.

For example, this might include looking at several different presentation tools to find the most appropriate tool for the ideas that are being conveyed, with comparisons being made about techniques for e.g. editing text or using techniques that make the presentation interactive, with a focus on making justified choices about the tools and techniques in order to efficiently and effectively solve the problem that has been set. It might also include the design of an appropriate system with a combination of hardware and software to solve a problem. This process of evaluation, application and analysis may be likened to a design cycle, with evaluation of an existing solution, adaptation as part of a design process to answer a question or solve a problem, then being able to skillfully create a product, which is then evaluated, refined and improved as part of the analytical approach to solving problems. This cycle of evaluation - design - creation - evaluation - improvement can be applied in a range of contexts, in a similar way to the computational terms being applied in a range of contexts. A level of discernment and choice is an important part of applying technology and such decisions need to be based on an understanding of the full potential of the options that are available.

- "**All pupils are responsible, competent, confident and creative users of information and communication technology**" is a clear indication that pupils are not simply to be consumers of the experiences technology may provide. Becoming creative users of information and communication technology using a range of tools, in a range of contexts to solve a range of problems links very closely to previous aims, where pupils "*evaluate, apply, analyse information technology*" and "*write computer programs to solve problems*" and again emphasises that different aspects of the subject are very closely linked. Responsible use refers to the safe and appropriate use of technology, as well as expecting pupils to understand the implications of ownership, with ethical and legal considerations that need to be included. Responsible use may be both online, with e-safety considerations for privacy and identity, and offline, such as using digital photography or recording equipment appropriately and with permission of those who are being photographed or recorded. Becoming competent and confident is a clear indication of a high level of skill being developed in order that pupils are able to realise their creative ideas. Confidence also suggests that the skills developed using one particular technology need to be transferrable to using another technology. For example, developing competence in presentations (to continue an example used above) might include using techniques that make a presentation interactive in a range of different software.

Readers may also find the following sites useful:

Naace supporting materials for the curriculum and Naace curriculum framework: www.naace.co.uk/curriculum

CAS resources: http://community.computingatschool.org.uk/resources

Learning activities from joint guidance: http://naacecasjointguidance.wikispaces.com/

CAS Curriculum for computer science: http://www.computingatschool.org.uk/index.php?id=cacfs

DfE subject expert group: https://sites.google.com/site/primaryictitt/

CS Unplugged: http://csunplugged.org

Thinking Myself: http://games.thinkingmyself.com/

Programme of Study: Key stage 1

- **Algorithm**. An algorithm is a precise method for solving a given problem. At KS1 an understanding of algorithms might be that a problem can be solved through a number of clear steps (e.g. open bread bin; take 2 slices; put bread in toaster; wait until toast pops up; take toast out; eat it). Including steps such as "counting" and "waiting until" adds an element of decision making and flexibility (e.g. take 4 slices) and encourages pupils to understand why algorithms are so useful for solving a wide range of problems and that they are using algorithms every day!
- *Pupils should make algorithms in a range of ways, with a range of tools.*
    - **Example**: Make a toy robot, floor turtle or screen turtle move around a square with sides of length 4.
    - **Algorithm**: go forward 4, turn right, and do that repeatedly until you get back to where you started.
- *Pupils should learn that there may be many algorithms that solve the same problem.* Describing the route home may have different answers and provides a context for learning that reinforces understanding that algorithms exist in a variety of forms. The toy robot may be given different instructions to travel around a square with sides of length 4.
    - **Algorithm 1:** go forward 4, turn right, and do that repeatedly until you get back to where you started.
    - **Algorithm 2:** repeat four times: go forward 4, turn right
- The algorithm above could also be used to draw a square with a screen turtle, then draw a tilted square with sides the same length.
- *Pupils should explore and devise "real world" algorithms and appreciate that a good algorithm will enable things to be achieved better, faster or more easily.*
    - **Example**: from a pile of 64 coins, all of equal weight except one that is lighter, find the light coin, with only a weighing balance.

   - **Algorithm 1**: weigh the first two coins. If one is lighter, that's the light coin. If not, discard both. Repeat until you find the light coin.
   - **Algorithm 2:** divide the pile in half, and weigh the two halves. Pick the lighter half, and repeat.

- *An algorithm might be executed on a computer – but it might not.* Algorithms can be physically "acted out" by pupils in an analogue way, such as a precise set of instructions for leaving the classroom during a fire drill without losing any children. The coin sorting is done manually - both of these are algorithms even though they are not executed using any technology.

- *An algorithm may be expressed informally, unlike a program; but should be precise enough that a reasonable person would not be in doubt about how it works*. There is no irrelevant detail, even though it might appear to be informal.

- **Programs execute:** The computer carries out the instructions contained in the programme.

- **Simple programs.** These may be sequences of instructions for controlling outputs such as the movement of a robot (eg Bee Bot or ProBot) or an on screen turtle or sprite. Simple programs might be responsive to input e.g. mouse, touch, keyboard, sensor. Other examples of programs may be the algorithm that navigates a person around an obstacle course (move left, right, jump etc); or an algorithm that plays noughts and crosses on paper; or an algorithm to dance the "Gay Gordon" or similar dance. These can be created, and 'debugged'.

- **Logical reasoning** is not used here as a technical term. It just means that students should be able to explain cause and effect, rather than randomly guess without reasoning. It includes predicting what will happen as a result of applying a program.e.g. "If the robot turns right four times (through a right angle), it will be facing the same way as it started".

- **Creating and manipulating digital content** should include the use of text, images, video, sound. Pupils should learn to use different input methods effectively and efficiently - e.g. touch, mouse, keyboard, voice recognition, gestures, etc. Manipulating the digital content refers to editing and refining their text, images, video and sounds. The key idea here is that they can control their own final product and there is more than one way to do it.

- **Organising, storing and retrieving digital content** includes the efficient and effective use of the computer file system or equivalent cloud-based storage (which is simply an alternative file system). This should be closely linked with pupils' own work.
- **Use technology safely and respectfully** may be through a whole range of digital content types. Using appropriate online etiquette for online interactions can be included here, as well as developing skills in using different tools. Knowing what 'stranger' means and associated online risks is an important part of safe use. It also includes knowing how to report inappropriate content to a responsible adult. It may be taught and reinforced within the context of creating digital content.
- **Keeping personal information private**. At KS1 the context for this learning may include passwords that are used to access the school network, learning platform, website or other online/offline tools or content. Using a "garden-walled" non-public online environment may provide the opportunity for pupils to explore the use of digital communication and which personal information they would not wish to share widely - and why it is not a good idea to share it widely. Personal information includes the obvious identifying information such as full name and address. It also includes less obvious information that enables inferences to be drawn, such as photographs with school uniform, membership of a club that meets at a particular time.
- **Recognising common uses** of information technology beyond school is about raising awareness of the vast number of devices, tools and everyday activities that make use of technology.
- **Knowing where to go for help and support** is an important aspect of safe and responsible use. In the first instance, this might mean identifying an appropriate adult to speak to. Consideration may include who this might be in school, at any out of school club setting or at home. It is also important for pupils to know that such information may be passed onto appropriate people who can help, whether that is through a measured response by teachers, parents, carers or the head teacher; online support; or through others involved when responses to serious incidents need to be escalated.

Programme of Study: Key stage 2

- **Design, write, and debug programs.** This should take place in a range of contexts from the use of programmable toys and devices to creating textual programs that can be run and tested. Programming should also include the use of software that provides a visual or graphical environment to support the design, writing and debugging of programs and to simulate physical and real world systems. Debugging is simply find out why a programme may not be working properly and correcting it; for example a floor robot may be intended to move in a square, but may move in a triangle if the angle is incorrect

- **Controlling or simulating physical systems.** These systems might include programmable toys and devices which are able to sense and respond to their environment using inputs such as switches and sensors and outputs such as lights, buzzers and motors. Pupils should form an awareness of common devices that use control/monitoring, such as the sensors that are part of a burglar alarm or the temperature control system in a freezer or central heating system

- **Sequence, selection and repetition** describe the basic structures of computer programs. These principles can be illustrated through flow diagrams or using software that visually or graphically represents programs.

- **Sequence**: programs consist of logically sequenced instructions or actions that are executed in order one after another. Pupils should create sequences of instructions to control events, and understand the need to be precise when framing and sequencing instructions.

- **Selection:** in a selection structure, a question is asked, and depending on the answer, the program chooses between two or more possible courses of action. At KS2, selection should include "if..then..else" type actions or statements. (E.g. in a game program, if the sprite is touching a wall then bounce back, else move forward). (Sprite - A 2D graphic image that can move within a larger graphic)

- **Repetition:** means repeating a sequence of instructions a certain number of times, or until some condition is met or result is achieved. In programming terms this means loops of all kinds, such as repeat, for, while, until etc. (e.g. move dog 1 step forward; repeat until dog is in kennel then stop).

- **Work with variables:** numbers and text can be stored and referred to in programs by using variables (e.g. name = "John"; print name; move dog (*variable is the number*) steps forward). The value a variable takes might come from user input by typing or selecting a value, or by setting a program so that a random variable is selected, or might be set and used by programmed instructions (e.g. for counter = 1 to 10; print counter; next counter). Pupils should explore the effects of changing the variables in computing based models, programs or simulations.

- **Various forms of input and output:** Methods of input may include keyboard, mouse, touch, microphone, camera, motion sensors, environment sensors and output may include screen, printers, speakers, switches and simulated or physical control devices. An output could be the action that a sprite performs as a result of being programmed or it could be a light coming on in response to movement in a room. Pupils should understand how computing devices with sensors can be used to monitor and measure external events.

- **Use logical reasoning to explain how some simple algorithms work** is a progression from "predict the behaviour of simple programs". Here we might hope for some explanation about why the algorithm will work regardless of the input or starting situation.

- **Understand computer networks** means, at this stage, knowing that a network consists of one or more computing devices connected together, using shared protocols, so they can share data and resources. Networks will include those that pupils may be familiar with, such as school or home networks. Protocols are the signals, messages and "passwords" that different computers use when "talking" to each other. A classroom is analogous to a network with lots of 'communicating devices' i.e. the pupils and teacher. Protocols in this case might include the various routes used to pass messages form one person to another, and/or using a protocol such as hand up to speak to the teacher.

- **The internet and provision of multiple services:** The internet is an example of a global computer network. The **world wide web** of hyperlinked webpages and websites is just one of the services that the internet provides. Examples of other services include email, voice calls, video conferencing and streaming media such as television and films.

- **Opportunities for communication and collaboration** is one of the most powerful impacts of the internet on pupils' lives. Students should personally experience opportunities to exchange information and ideas both internally within the school and, where possible, externally. That experience should in turn inform, and be informed by, reflective discussion about issues such as respectful communication in a context where body language is absent; cultural differences; privacy; ownership of shared information, music, images, text; and safety.

- **Search technologies** include, but are not limited to, internet search engines. Pupils should be familiar with a number of search technologies, including those for searching for files and emails, and develop an appreciation of how to select the most effective search terms and criteria to get the best search results.

- **Appreciate how results are selected and ranked:** Pupils should understand that different search engines have algorithms that work in different ways (e.g. some ignore high frequency words and some consider word order). They should learn to critically evaluate search results and be aware that results and ranking are influenced by factors such as popularity, number of links to a page, availability, commercial interests, advertising and filtering.

- **Be discerning in evaluating digital content:** It is important that pupils have opportunities to validate information that they have found when using search engines. This could include exploring the reliability of content by checking against other sources or considering whether an author may have a biased viewpoint. The critical skills that pupils have started to develop when considering online digital content should also be applied to other sources of digital content.

- **Know a range of ways to report concerns and inappropriate behaviour:** This builds on pupils' prior learning, where the major emphasis will have been on reporting to an appropriate adult and the steps they may then follow on behalf of a pupil. Reporting concerns and inappropriate behaviour usually has a clear pathway for incidents in school and it is important that pupils are able to handle such concerns and behaviour when using digital content and tools when they are not in school, too. Pupils will need to know how to report concerns online and understand that different organisations are able to support people who have concerns; they will also understand that different organisations may be specialists in different areas, such as bullying. This learning will continue to be consolidated across the contexts provided by the whole Computing curriculum.

- **Variety of software on a range of devices:** This should include developing appropriate and effective use of online and offline productivity tools, creative tools, collaboration tools and software that enhances learning. In order to**select and use**, pupils need to have developed skills and understanding of the tools and devices from which they can choose. Creative tools will enable pupils to have experience of developing a full range of images, graphics, videos, digitally prepared text, sound, multimedia, animations, databases, websites, presentations, e-books and programs. Such creative tools allow pupils to develop and edit the digital artefacts they create in order to refine and improve them to achieve high quality solutions. For example, "selecting and using" might involve making an appropriate decision about the best text creation tool for the task, or pupils might need to decide whether it is better to present their ideas through an interactive presentation or an animation.

- **Analysing and evaluating information** to interpret information, check it is current, relevant and reasonable and to think about what might happen if there were any errors or omissions. Pupils should consider the source, quality, validity and any possible bias they might introduce to information. Pupils use spreadsheets, databases, models and simulations to analyse and evaluate patterns and relationships in data. (The acronym GIGO - garbage in, garbage out - related to the £million electricity bill can emphasise the point of evaluation in amusing fashion)

- **Collecting information** may be from both online and offline sources. Pupils select the information they need for different purposes, check its accuracy and organise it in a form suitable for processing. Information can be checked to find if it is replicated in other places and if it is consistent with other sources.

- **Presenting information and data** should be done with consideration to accuracy and quality. A range of different digital artefacts can be used such as images, graphics, videos, digitally prepared text, sound, multimedia, animations, databases, websites, presentations, e-books and programs. When presenting information pupils should show awareness of, differentiate for and respect, intended audiences including teachers, peers, parents, friends, families and the public. Opportunities should be provided to exchange and present information interactively and through joint projects mediated via the Internet.
- **Use technology safely, respectfully and responsibly:** This builds on experiences in Key Stage 1, with increasing thoughtfulness about responsible use. This may include ethical and legal considerations. For example, when using digital content from online sources, it is important that pupils consider ownership issues, copyright and attribution. They might be encouraged to seek out different Creative Commons licensed images for use in their own work rather than a picture from a commercial copyright source. Using technology safely should include the choices and decisions that are made when using digital content and tools, such as opening pop-ups, links within communication from unknown sources, the explicit information that pupils share about themselves and the clues they provide which allow inferences to be drawn about e.g. their school, location. Introducing pupils to the behaviour that might be appropriate in an online community might be through a school learning platform or other collaborative/communication tools and it will also refer to the types of social media that they are familiar with, which might include "child-oriented" social media or gaming, such as Club Penguin. This learning will continue to be consolidated across the contexts provided by the whole Computing curriculum.

Programme of Study: Key stage 3

- **Design, use, and evaluate computational abstractions that model the state and behaviour of real-world problems**. This is a highly-compressed sentence!

- ***What is a "computational abstraction"?*** Suppose you are trying to predict the population of rabbits and wolves on an island. We might model the **state** at any moment by two numbers: the number or rabbits and the number of wolves. We might model the **behaviour** of the rabbits by saying: every six months the rabbit population increases by a factor of 1.3 due to breeding, and decreases in proportion to the wolf population by the wolves eating them. And so on. This model is an **abstraction** because it ignores masses of detail (fur, blood, etc), including some that might be relevant (food supplies for the rabbits). But the model is **computational** in the sense that we can write a program, or a spreadsheet, that explores how the two populations evolve under various assumptions of breeding and predation rate.

- ***Simulation and modelling*** of real-world situations offers a rich source of motivating examples of computational thinking, and helps to make concrete the idea of computation as a source of "insights into both natural and artificial systems" (see “Purpose” section of the POS). The subject of real-world problems can be taken from any area and pupils should be encouraged to explore and consider all the key factors that will influence what is being modelled. Examples of real-world problems that are particularly suitable are those that include feedback or user interaction such as population growth, climate change, traffic flow, supply and demand, production and stock control, event planning, chemical reaction rates and physical environments including virtual realities and games environments.

- ***Simulations*** can be used at every key stage, not only KS3, and may involve spreadsheets, games, or full programming languages. Models sometimes require a student to "imagine" what is going on inside the model when they cannot see it. Whilst not making a game, students might come to understand that you can "play" with a model and that many video games are in fact models - leading them to see the value of what they are learning.

- **Understand several algorithms that reflect computational thinking.** Sorting and searching are provided as examples, that can be used as starting points or applied to a wide range of contexts. They form a good and interesting source of discussion about the nature of many algorithms and the data they might be applied to but there are others that could also be used just as well.

- **Compare the utility of alternative algorithms for the same problem**. The key idea is that there usually is more than one algorithm for a given problem; and that it takes judgement to compare different algorithms. "Utility" includes a variety of aspects such as; being more accurate at solving a problem; more efficient or faster in finding a solution; more concise or shorter in the way it is expressed; or more general and flexible in it's application. Pupils might for example describe and compare algorithms for drawing shapes and patterns that use more sophisticated selection and repetition rather than simple sequencing. Pupils could test out such algorithms by writing code in languages such as logo to create programs of increasing flexibility and complexity.

- **Use two or more programming languages, one of which is textual**. Programming can be done in a wide variety of ways and different languages support different styles; knowledge of two or three different languages makes it is easier to learn new languages and programming environments as they develop. Learning multiple languages allows pupils to generalise and learn lessons that are not tied to the particular syntax or semantics of any one language. Meaningful, purposeful contexts for learning programming languages may be used to provide increasingly sophisticated challenges. Programs that are constructed using visual or graphical interfaces reduce the need for pupils to remember specific function calls and syntax. It is therefore important that pupils have experience of using a textual language which requires pupils to understand the importance of accurate syntax and structure.

- **Programming languages** used depend on the resources available to a school. Visual languages may include for example the use of Flowol, Kodu or Scratch. Languages such as Logo have been developed as simple textual languages and can be used to both introduce textual languages and develop higher level programming skills with possible links to Maths. The formula language of spreadsheets is a textual language but has limited scope for programming, although use of Visual Basic behind most spreadsheets opens up many more possibilities. Markup languages such HTML and XML can be used to introduce ideas of syntax, finding and correcting errors and can help prepare pupils for using programming languages used by web browsers, such as JavaScript. Pupils should have opportunities to use more fully-fledged languages that support procedures, data structures, and types, and that have rich eco-systems of libraries and programming environments. Appropriate textual languages include Greenfoot (Java), Small Basic, Visual Basic and Python.

- **Make appropriate use of data structures such as lists, tables or arrays:** These are techniques that pupils will learn as part of their programming. Lists are groupings of items such as names; pupils should be aware that these may be a string or an integer list. Tables may form part of a database and pupils should understand the difference between a flat file and a relational database. Arrays which are systematic arrangement of objects, usually in rows and columns and form an ordered map of data.
- **Design and develop modular programs that use procedures or functions:** These may be done within the context of Logo, Scratch/BYOB, Flowol or other similar programming tools. NB the latest online version of Scratch allows procedures to be developed but earlier versions do not have that functionality.

- **Understand simple Boolean logic (such as AND, OR and NOT) and some of its uses in circuits and programming.** Boolean logic might be introduced through the use of using more advanced search terms. Pupils come across Venn diagrams in Maths and consequently this can easily link in to simple Boolean logic to explore NOT, OR, AND. For example; a search for 'pupils AND red hair' would produce a list only of pupils having red hair,'pupils OR red hair' = all pupils plus everyone with red hair and 'pupils NOT red hair' = any pupils without red hair

- **Understand the hardware and software components that make up computer systems, and how they communicate with one another and with other systems**. Elaborate rote learning, in which students simply learn to recite the names of CPU, memory bus, network switch, TCP/IP, Ethernet etc, and draw diagrams of them, is inappropriate, although some elementary knowledge of the hardware on which everything runs, up to and including the internet itself, is important. Consider using a real microchip and a video on how it is made from silicon with thousand of layers of microcircuits - this leads easily into 'on-off' switching, binary, coding and finally why we program. The software components may include the use of binary within systems. Consideration should be given to cost/performance trade-offs, such as a CPU may take hundreds of cycles while the RAM performs a single memory fetch. For example, pupils could compare the power constraints that determine the CPU of a phone against the CPU in a PC. Changes in performance over time (i.e. Moore's law) are also relevant here because they have historically been so large.

- **How instructions are stored and executed**. A basic understanding of the Von Neumann fetch-execute model is intended here, although anything like "little man computer" (LMC) would be more than adequate to cover this concept at this level. A CPU fetches one instruction at a time and executes it; instructions are held in memory, just like any other data; the program counter gives the address of the next instruction to execute. Simple analogies may be useful here; for example, a knitting pattern is a "program" and a knitting machine is the "computer" that executes it; the knitting machine carries out the knitting instructions in a totally simple-minded way. Despite this simplicity, the resulting garment is a work of art whose creativity is all in the knitting pattern. Again a knowledge of how a computer system stores all data, including program instructions, as binary data is important.

- **Explain how data of many sorts can be represented and manipulated digitally, in the form of binary digits**. Pupils used to learn the base-2 numbers system in Mathematics in Year 6 but this is not in the new Mathsprogramme of study and pupils will only have come across this if it has been part of any additional content. Pupils should be able to count and do simple arithmetic (add up) in binary, but they should also explore the specifics of some particular data representations, which can include numbers, text, images, sound, such as learning how these . these binary representations are different.

- **Understand and use binary digits:** Key Stage 3 pupils need to be able to convert between decimal and binary and vice versa. Pupils need to understand that all computers work in binary and how large numbers can be represented by small sequences of 1's and 0's. Pupils should learn how to add in binary. Examples of kinaesthetic activities to support this learning can be found on video clips at: http://csunplugged.org/binary-numbers

- **Undertake creative projects that combine multiple applications**. As confident and independent users of technology, pupils should make reasoned choices from a range of applications, combining these effectively to achieve complex goals, including solving problems and creating digital content, to take into account the needs and expectations of their intended users or audience. The inter-connected nature of the different aspects of computing may be exploited through the use of extended project-based learning, with explicit opportunities within the project to extend knowledge and skills that have previously been developed at Key Stage 2, when pupils will have experienced a full range of creative tools, including those that enable them to prepare and edit images, graphics, videos, digitally prepared text, sound, multimedia, animations, databases, websites, presentations, e-books and programs.
  Example 1: Pupils might start by capturing audio, video and image content using a smart phone, edit images and audio and combine these with video using editing software on a desktop PC, before uploading the edited video to a web service and embedding the streamed video within a website of their own design.
  Example 2: Machinima, which is the use of online collaborative gaming environments to create a scripted story that is captured and edited onto video. A well-known example from the game Halo is the 'Red vs. Blue' series. Multiple applications are used by a group to write, story-board and then act out a script in an online collaborative game, stream their efforts in real-time onto a PC, edit the video and add sound/music/VFX, convert to a standard video format and finally upload onto a public repository such as YouTube.

Example 3: Programming languages such as Python can be used to create small scripts/macros that can add new items/behaviours to a computer video game. e.g. creating Python 'mods' for Minecraft.

- **Collecting and analysing data.** It is important that pupils explore and compare different tools, including online and offline options, in order that they can choose and use the most appropriate tool in response to different problems. Pupils should be developing an increasingly critical and analytic approach to the data they collect and/or analyse, considering whether it makes sense, is reliable and repeatable.

- **Create, reuse, revise and repurpose digital artefacts** The range of media may include open source, creative commons and public domain content, as well as that created by others within the class or school. Pupils should learn how to work creatively, using others' digital work as a starting point whilst respecting copyright. They should also learn how content can be selected, edited and combined with other content, perhaps in other media to produce work fulfilling a different purpose or meeting the needs of a different audience than that on which it is based. A digital artefact is made by a human being with skill or art. Although digital content is produced using technology tools and applications, it is "made with skill" and may result from preparative or investigative procedures. Learners need to be taught both the knowledge and skills required to create high quality "artefacts" that can compete against the best in the world. Digital artefacts include information prepared or shared in digital forms e.g. photos, videos, digitally prepared text, multimedia, databases, websites, presentations, music, e-books, programs, coding, etc.

- **Create digital artefacts** This includes creating clear digital communications, with evidence of skills being developed and extended from the work pupils have done at KS2. There should be a focus on efficient and effective use of a full range of features of digital communication tools to achieve different effects and the range of digital artefacts should include text, images, sound. Pupils should create digital artefacts with a range of purposes, including those with some interactive opportunities for the audience. Image editing may include vector graphics, bitmap or object editing; documents may include macros; sound may include equalization and removal of noise.

- **Trustworthiness, design and usability.** Pupils should learn to make discerning use of digital artefacts, checking the source is reliable and that it is legal or responsible to use the artefact. Good practice will include exploring the ethics and current legislation surrounding online interactions, ownership and copyright issues.

- **Understand a range of ways to use technology safely, respectfully, responsibly and securely including protecting their online identity and privacy:** At an stage in their development when pupils will be exploring a range of different tools in school and beyond formal learning contexts, it is important that they have a clear structure on which to base the decisions they make about their digital interactions, whether those are for learning or social purposes. Learning at Key Stage 3 should reflect the new possibilities that are available as e.g. social media is ever evolving, as is the way in which pupils are using tools for learning and social purposes. Pupils should learn to protect their online identity through careful consideration of what they share about themselves, including how to ensure they have a digital footprint that will be appropriate for their lives beyond school, when, for example, a potential employer might check how appropriate their digital presence is. Protecting online identity also includes making appropriate choices for their own protection from online predators. An awareness of inappropriate online activity will build on the key messages from Key Stage 2 about appropriate contact. It will begin to address concerns including online shopping, file exchange/sharing, banking and how such activities may be done safely and securely. Pupils should also develop an understanding of how the Data Protection Act and related legislation can be helpful.

- **Recognise inappropriate content, contact and conduct and know how to report concerns**: By Key Stage 3 pupils' experiences are broadening and they are becoming increasingly aware of the nature of different content and interactions. Practical strategies for reporting concerns will include those that are appropriate in both learning and social contexts; they will also begin to include recognising and reporting concerns about security issues in online transactions. Learning about what constitutes appropriate content, contact and conduct will be an important part of communication and collaboration opportunities and provide ongoing contexts for consolidating pupils' understanding.

Programme of Study: Key stage 4

There are particular challenges in drafting a programme of study for Key Stage 4.

- By the time they reach KS4 pupils should have the opportunity to specialise somewhat, as they do in Science. By the end of KS3 students should be in a position to make an informed choice about whether and how they want to specialise.
- A range of qualifications may be made available at KS4, ranging from academic computer science, to applied ICT, and combinations of the two, such as Information Systems and Design, which includes a combination of Computer Science and applied ICT; qualifications may include more vocationally-oriented qualifications such as network management or systems/database administration; real project contexts and business/employer requirements will inform the real project contexts within learning takes place.
- It is important that pupils taking such KS4 qualifications (e.g. in Computer Science, or in Digital Media) be considered to be fulfilling the statutory KS4 Computing programme of study, even though it may not cover the whole range of Computing.
- Other pupils will choose to focus their attention elsewhere, and will choose to take no KS4 qualifications in Computing. These pupils should nevertheless develop the creativity, capability and knowledge they acquired in KS1-3. This requirement is stated briefly, and schools are free to deliver is in a variety of ways.

However, there is a real risk that the limited number of points within the KS4 programme of study might convey a message that KS4 is not seen as very important to Computing, so that it can be downgraded or ignored. That is the very opposite of the desired outcome and the programme of study includes a necessity for all pupils at KS4 to access rigorous teaching and learning in computing, whichever route is chosen for specialisation and whether or not it leads to a formal qualification: "**All** pupils **must** have the opportunity to study **aspects** of information technology and computer science **at sufficient depth** to allow them to progress to **higher levels of study** or to a **professional career**."

- **Opportunity** means that pupils must be able to take KS4 qualifications in computing subjects, but should not be obliged to do so. "Option blocks" at KS4 are already very constrained and highly cherished. Whilst not every pupil in KS4 will take a qualification in computing subjects, continuing to engage with learning in this subject area should prepare them for ongoing and future studies or employment. If pupils have not done a formal qualification at KS4, this should not preclude them from taking the subject at A level, though such qualifications are desirable.
- **Aspects of information technology and computer science**. Good schools offer a range of KS4 qualifications in ICT subjects, including both CS and IT variants; but not every school will be able do so from September 2014 as they will be phasing their implementation as appropriate qualifications become available. If a school is unable to offer a range of qualifications, then they must provide the opportunity to study a qualification covering topics from IT, CS and DL that would allow a student to progress to IT, Computer Science or Digital Media in their post 16 studies. This parallels the Science curriculum where students taking joint or single Sciences have the pre-requisite knowledge to study full Physics, Chemistry and Biology at a higher level (e.g. A level).
- **Progression to higher levels of study or a professional career**. In line with the recommendations of the Wolf report, it is essential that any qualification offered by a school must be valued by employers and higher education institutes, and must support progression into A levels, further education, or a professional career. As such, building understanding of international and industry standards can support the effective design, creation and evaluation of digital artefacts. Awareness of the impact of technology on different industries, online commerce and creative industries will prepare pupils for the choices they make about further study or careers.
- **Develop capability, creativity and knowledge.** Developing capability will depend on the specialised route that a pupil follows, should build on skills and knowledge from KS3 and reflect the preparation required for further study or careers that depend on that area of study.
- **Develop and apply analytic, problem-solving, design and computational thinking skills:** Pupils should become increasingly analytical in their approaches to digital artefacts. Evaluating

effectiveness, quality should encourage pupils to justify the judgments they make about the artefacts and tools they create or use.

- **Understand how changes in technology affect safety:** Ongoing safe and responsible use teaching and learning should include encouraging pupils to review their online presence in the light of changing uses and available technologies. They should learn how these changing uses impact on their own safety and the safety of others.
- **Protect their online privacy and identity, and how to report concerns:** Pupils will need to build on learning from KS3 and learn about both the positive and negative implications of their digital presence on their future life, such as relationships and employment. Consideration should be given to the protection of personal information, such as when banking or shopping online, as well as protection from malicious programs and activities. Pupils should now be developing a "bigger picture" view of how technology fits within every aspect of our lives and the implications that this has for their education, employment and social lives.

Safe and Responsible Use

E-safety is an important part of the Programme of Study. But the Programme of Study for Computing is not the only context for reinforcing messages about safe and responsible use. A school which has a positive ethos about safe and responsible use will be considering:

- E-safety as a whole-school responsibility, with every member of staff, governors and parents involved in training and in reinforcing appropriate messages about safe and responsible use, in every subject area.
- E-safety as an integral part of other policies and procedures, including safeguarding, behaviour and bullying policies.
- It should be noted that the Ofsted inspection framework treats safeguarding as a major category for inspection (no school can get "Outstanding" if it falls down on safeguarding) and well-defined approaches to safe and responsible use are an essential part of school safeguarding practices.

The Programme of Study provides opportunities for clear, well-defined educational opportunities, which should be used to develop school schemes of work that address issues taking into account pupils' maturity, the ever-evolving range of technologies available and pupils' increasingly adventurous and independent exploration of technologies, both in a learning context and in social contexts.

Developing an understanding of Computing must include those aspects of responsible use that address the legal and moral framework within which we use these tools. Issues to address within school might include:

- plagiarism, copyright, other legal issues
- seeking permission when taking video, images, sound recordings
- hacking
- legislation
- data protection
- health and safety

- environmental issues

Useful activities/resources to support this may include those from well-established sources, such as UK Safer Internet Centre, SWGFL, CEOP. The following list is by no means comprehensive but will provide a starting point for schools and teachers:

The SWGFL Scheme of Work Common Sense Media

Early Years Digiducks

EY/KS1

Smartie The Penquin
The Adventures of Lee and Kim (Register with Thinkuknow to access lesson plans for teachers)
Hector's World (Register with Thinkuknow to access lesson plans for teachers)

KS2

Dongle the Rabbit Safe Surfing
The Adventures of Kara and Winston Smart Crew
Cyber Café (Register with Thinkuknow to access lesson plans for teachers)
Jigsaw (Register with Thinkuknow to access lesson plans for teachers)
Only a game (Drama Play Script)
Out of Your Hands KS2 (Mobile Phone Use)
Caught In The Web- Newsround
Beaker You Choose Cyberbullying
Horrible Histories Guy Fawkes and similar short videos from the same site for KS3

KS3

Out of Your Hands KS3 (Mobile Phone Use)

KS4

Out of Your Hands KS4 (Mobile Phone Use)

There is also a wealth of resources (videos, worksheets, handouts) for teachers of all Key Stages to use on CEOP's Think U Know website. Teachers need tto register and to access some of the resources attendance is required at a half-day training course run by CEOP. This is something the safeguarding officer in the school should be aware of as , as stated above, it is a whole-school issue

Technology Enhanced Learning

At all Key Stages, information and communication technology should be used to enhance teaching and learning right across the curriculum: this is often called Technology Enhanced Learning (TEL). When there is a clear focus on learning rather than technology, systems such as the Web, interactive whiteboards, virtual learning environments, video conferencing, blogs, wikis, podcasts, video, and mobile devices can have a transformative impact on both learning and teaching. Pupils' use of such technology both draws on and enhances their digital skills. The purpose of using technology in this way should be to improve learning in that subject, and not a back-door way to teach Computing. The technology serves learning; it is not the object of learning. It follows that:

- The Programme of Study for Computing focuses only on Computing as a discipline in its own right, and not on TEL.
- The use of technology to support learning in other subjects (English, say, or Geography) should be assessed by Ofsted as part of the school’s teaching and learning in that subject, not as part of its delivery of Computing. The DfE have not recognised the role of TEL in the statutory requirements for these subjects within the National Curriculum, as it is considered to be a "pedagogical" decision for a teacher to make and they are reluctant to specify "HOW" any subject is taught. It would nevertheless be extraordinary for any subject to make no use of technology.
- The extent and nature of the use of technology in other subjects should be driven exclusively by the needs of those subjects, and not by the needs of the Computing curriculum; except, of course, if a school consciously chooses to teach some aspect of the Computing programme of study through those subjects.

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Gathering together contributions for this joint guidance seemed to be most sensibly done on a wiki. In order to assist the reader, we have tried to ensure some flow by leaving acknowledgments for contributions to a separate page.

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About Naace

Naace is a community of educators, technologists and policy makers who share a vision for the role of technology in advancing education. Our members include teachers, school leaders, advisors and consultants working within and across all phases of UK education and all aspects of technology in schools – the Computing curriculum, technology enhanced learning and infrastructure. As a professional association, we represent the voice of the UK education technology community in the schools sector at a national and international level, as well as supporting one another across the sector through conferences, courses and the dissemination of resources, research and reflection. We play a key role in both members' professional development, through the challenge and support of a community of practice, and the development of the profession as a whole, through the sharing of innovation and expertise. Naace offers a range of powerful tools and awards designed to support excellence in schools and academies through self-evaluation and quality assurance, recognising achievement and identifying steps for further improvement.

About CAS

CAS is a grass roots organisation, whose energy, creativity, and leadership comes from its members. We are a collaborative partner with the BCS through the BCS Academy of Computing, and has formal support from other industry partners. Membership is open to everyone, and is very broad, including teachers, parents, governors, exam boards, industry, professional societies, and universities. We speak for the discipline of computing at school level, inc. FE, and not for any particular interest group.