Enabling the information society

**BCS, The Chartered Institute for IT**

**in association with the Computing At School group**

**Consultation Response to:**

# Reform of the National Curriculum in England

## Dated: April 16 2013

**BCS**
The Chartered Institute for IT
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## BCS, The Chartered Institute for IT

The Institute promotes wider social and economic progress through the advancement of information technology science and practice. We bring together industry, academics, practitioners and government to share knowledge, promote new thinking, inform the design of new curricula, shape public policy and inform the public.

As the professional membership and accreditation body for IT, we serve over 70,000 members including practitioners, businesses, academics and students, in the UK and internationally. We deliver a range of professional development tools for practitioners and employees. We also accredit the computing degree courses in ninety eight universities around the UK.

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## Computing At School

Computing At School (CAS) is a membership association within BCS, The Chartered Institute for IT. The Computing at School Working Group (CAS) is a grass roots organisation focused on developing computer science as a proper, rigorous school subject.

CAS has 3,700 members, with new members currently joining at a rate of over 400/month. Our members include school teachers, university academics, parents, school governors, members of professional societies, and IT professionals. We are supported by Google, Microsoft, ARM, and a range of other IT employers in the UK.

http://www.computingatschool.org.uk/

## Table of Contents

# 1. BCS response to consultation

This section contains the BCS response to the DfE consultation document[1]. That document has been inserted verbatim annotated with our responses to the relevant questions. Additional comments that accompany our responses are detailed in Sections 2, 3 and 4.

## 1.1 DfE Consultation Response Form

Are you answering this consultation in response to particular subjects? Please tick all those that apply.

| | | | | | |
|---|---|---|---|---|---|
| | English | | mathematics | | science |
| | art & design | | citizenship | X | computing |
| | design & technology | | geography | | history |
| | languages | | music | | physical education |
| | Not applicable | | | | |

1 https://www.education.gov.uk/consultations/downloadableDocs/Reform%20of%20Nat.%20Curriculum%20Econ%20Consultation%20Document.docx

1 **Do you have any comments on the proposed aims for the National Curriculum as a whole as set out in the framework document?**

| |
|---|
| No |

2 **Do you agree that instead of detailed subject-level aims we should free teachers to shape their own curriculum aims based on the content in the programmes of study?**

| | | | | | |
|---|---|---|---|---|---|
| | Agree | x | Disagree | | Not sure |

**We strongly disagree with this proposal**. Our members have found it extremely helpful to articulate subject-level Aims for Computing, and would deeply regret their loss. The aims of the Computing programme of study embody over-arching principles whose vigour will be lost if articulated in a piecemeal way. Here they are:

*The National Curriculum for computing will ensure that all pupils:*

- *Can understand and apply fundamental principles and concepts of computer science, including abstraction, logic, algorithms, and data representation;*
- *Can analyse problems in computational terms, and have repeated practical experience of writing computer programs in order to solve them;*
- *Can critically evaluate and apply information technology, including new or unfamiliar technologies, to solve problems;*
- *Are responsible, competent, confident, and creative users of information and communication technology; and*
- *Can critically articulate the individual, social, and cultural opportunities and risks of digital technology.*

Articulating these aims explicitly gives a context for every teacher, and for all the detail that follows. See Section 2.3 below.

3 **Do you have any comments on the content set out in the draft programmes of study?**

| |
|---|
| ***Yes. Our primary contribution is inserted at the end of this document setting out specific and detailed suggestions for improvements in the draft PoS for Computing. Please see Sections 2, 3 and 4.*** |

4 **Does the content set out in the draft programmes of study represent a sufficiently ambitious level of challenge for pupils at each key stage?**

| | | | | | |
|---|---|---|---|---|---|
| X | Sufficiently ambitious | | Not sufficiently ambitious | | Not sure |

| |
|---|
| Yes, for Computing, but see our detailed proposed changes in Sections 3 and 4. |

5 **Do you have any comments on the proposed wording of the attainment targets?**

| |
|---|
| No |

6 **Do you agree that the draft programmes of study provide for effective progression between the key stages?**

| | | | | | |
|---|---|---|---|---|---|
| X | Agree | | Disagree | | Not sure |

| |
|---|
| Yes for Computing, but see our detailed proposed changes in Sections 3 and 4. |

7 **Do you agree that we should change the subject information and communication technology to computing, to reflect the content of the new programmes of study?**

| | | | | | |
|---|---|---|---|---|---|
| X | Agree | | Disagree | | Not sure |

**Strongly agree**. We warmly welcome the change in title to "Computing", for two reasons. First, it removes the explicit reference to "technology" in the title, a reference that pulls in the opposite direction to that of establishing Computing as a subject **discipline**. Second, it gives a clear signal that something has changed, and that head teachers, parents, governors, and students, should take notice.

8 **Does the new National Curriculum embody an expectation of higher standards for all children?**

| | | | | | |
|---|---|---|---|---|---|
| X | Yes | | No | | Not sure |

Presumably the question asks whether the new NC embodies an expectation of higher standards than the old NC.

Yes, in Computing it clearly does. The previous NC did not embody any clearly-articulated standard for Computer Science, whereas the new one quite explicitly does so, something that is extremely important and welcome. It is also important that the new curriculum promotes the aim that all pupils reach an appropriate standard of digital literacy by the time they leave school, which is clearly expressed in the aims of the programme.

9 **What impact - either positive or negative - will our proposals have on the 'protected characteristic' groups?**

No specific comments

10 **To what extent will the new National Curriculum make clear to parents what their children should be learning at each stage of their education?**

Whilst the Programmes of Study for Computing, by its nature must use precise and sometimes technical language, the overall Aim statements will help parents to understand what their children should be learning.

11 **What key factors will affect schools' ability to implement the new National Curriculum successfully from September 2014?**

- In Computing there is a huge issue of teacher training, both initial teacher training, and in-service training. Please see Section 2

- It is unreasonable to expect all schools to be ready to teach the new Computing PoS in September 2014. Transitional arrangements will be required, and should be made clear via Ofsted guidance. Please see Section 2

12 **Who is best placed to support schools and/or develop resources that schools will need to teach the new National Curriculum?**

In the case of Computer Science, schools have the benefit of the CAS/BCS Network of Excellence for Teaching Computer Science. This network brings together university academics, IT professionals, and classroom school teachers to help support, equip, and encourage the latter in their delivery of the new Computing programme of study.

Other organisations are working in partnership with the Network of Excellence, including Naace, the National Science Learning Centres, Code Club, the Raspberry Pi Foundation, and the NextGen Skills campaign.

13 **Do you agree that we should amend the legislation to disapply the National Curriculum programmes of study, attainment targets and statutory assessment arrangements, as set out in section 12 of the consultation document?**

| | Agree | | Disagree | X | Not sure |
|---|---|---|---|---|---|

It already is dis-applied for ICT.

14 **Do you have any other comments you would like to make about the proposals in this consultation?**

| |
|---|
| **Yes. We make a number of other important observations in Sections 2, 3, and 4.** |

Thank you for taking the time to let us have your views. We do not intend to acknowledge individual responses unless you place an 'X' in the box below.

| | |
|---|---|
| **Please acknowledge this reply** | X |
| **E-mail address for acknowledgement:** | bill.mitchell@hq.bcs.org.uk; simonpj@microsoft.com |

Here at the Department for Education we carry out our research on many different topics and consultations. As your views are valuable to us, would it be alright if we were to contact you again from time to time either for research or to send through consultation documents?

| | | | |
|---|---|---|---|
| X | Yes | | No |

# 2. Further comments on the proposed Programme of Study

This section details the further comments on the proposed Programme of Study from the Computing at School working group (CAS)

**Our main contribution to the consultation is a detailed, clause-by-clause analysis of the draft Programme of Study, and detailed, concrete suggestions for improvements, each individually justified. This list of proposals appears below in Section 3.**

The Programme of Study is necessarily highly compressed, and teachers will need clearly-signposted explanatory guidance notes to make sense of it. We have begun work on Guidance Notes for the Programme of Study in Computing, available at

https://draftin.com/documents/43564

Readers of this response may find it useful to refer these draft notes, where the thinking is discussed in more detail.

Our contributions are informed by

- Responses to an open call for contributions to all 3,700 CAS members, using the CAS Online forum.
- A working party of 11 CAS members met on 4th April 2013 to digest this input, and work through the draft PoS line by line.
- A meeting of the 30 CAS members held at Microsoft Research in Cambridge on the 8th, 9th April of 2013.

## 2.1 Computer science as a discipline

The proposed programme of study for Computing clearly establishes Computer Science as a rigorous subject that every child should have the opportunity to learn, from primary school onwards. We warmly welcome this development.

## 2.2 The title of the subject

We warmly welcome the change in title to "Computing", for two reasons. First, it removes the explicit reference to "technology" in the title, a reference that pulls in the opposite direction to that of establishing Computing as a subject discipline. Second, it gives a clear signal that something has changed, and that head teachers, parents, governors, and students, should take notice.

## 2.3 Aims

The consultation asks (Question 2) whether it would be useful to dispense with subject-level aims, leaving only the purpose and detailed content.

We strongly disagree with this proposal. We have found it extremely helpful to articulate subject-level Aims for Computing, and would deeply regret their loss. The aims of the Computing programme of study embody over-arching principles that it is hard to articulate in a piecemeal way; but which are too specific to Computing to put in the Aims of the National Curriculum itself. Here they are:

*The National Curriculum for computing will ensure that all pupils:*

- *Can understand and apply fundamental principles and concepts of computer science, including abstraction, logic, algorithms, and data representation;*
- *Can analyse problems in computational terms, and have repeated practical experience of writing computer programs in order to solve them;*
- *Can critically evaluate and apply information technology, including new or unfamiliar technologies, to solve problems;*
- *Are responsible, competent, confident, and creative users of information and communication technology; and*
- *Can critically articulate the individual, social, and cultural opportunities and risks of digital technology.*

Articulating these aims explicitly gives a context for every teacher, and for all the detail that follows.

### 2.4 Curriculum time

The Nov 30 draft programme of study for Computing, was written under instructions from ministers that it should be ambitious. That ambition has carried through to the now proposed programme of study. But there is no point in being ambitious if there is not enough curriculum time to teach it.

ICT is typically given one hour/week at KS3, and many schools have used the turbulence around ICT in the last couple of years to reduce that allocation even further, **in some cases to zero**. Some schools are even returning to the long-discredited cross-curricular model for teaching ICT, others have abolished their ICT department altogether.

If DfE wants to establish Computing as a proper, rigorous subject, schools will have to give the necessary time to Computing, as a discrete subject, comparable to other longer-established disciplines.

Lacking this, teachers may be faced with a statutory obligation to teach a programme of study that they simply cannot deliver in the time available. Although this is ultimately a decision for schools, it is a tough battle for each individual school teacher to fight.

The programme of study is not the right instrument to express that support, but we want to highlight the risk of establishing a demanding new curriculum without offering the support needed to deliver it.

| Recommendation |
| --- |
| The DfE should strongly urge schools to review the curriculum time they give to Computing as a discrete subject, in view of the changes to the Computing curriculum, with a view to treating it like other longer-established disciplines. |

### 2.5 E-safety

Many CAS members were concerned about the absence of any reference to e-safety in the draft PoS. Our understanding is that its absence is not because e-safety is considered unimportant, but rather because the PoS is not the right vehicle to ensure that children are safe online.

- E-safety is a whole-school responsibility, and should not just be treated as the job of the Computing teacher.
- E-safety is one important part of the school's safeguarding policy, and should not be divorced from it.
- The Ofsted inspection framework treats safeguarding as a major category for inspection, and it is here that e-safety should be articulated

We are content with this analysis, but it would be appropriate to review the Ofsted inspection safeguarding criteria, to ensure that they cover relevant aspects of e-safety.

| Recommendation |
| --- |
| The DfE should review Ofsted's guidance on e-safety as part of the safeguarding policy, in the light of guidance from subject experts. |

### 2.6 Technology-enhanced learning

Information and communication technology can be used to dramatically enhance teaching and learning in all subjects. We call this Technology Enhanced Learning (TEL). It is absolutely right that TEL should not form part of the Computing programme of study. It is even arguable that it should not form part of the programme of study for other subjects (say, history), because it concerns ***how*** the subject is taught and learned, not ***what*** is taught and learned.

But if not in the programmes of study, how will we guarantee that teachers have real incentives to use technology to enhance their subject? It would be a huge lost opportunity if all such incentives were lost.

| Recommendation |
| --- |
| The DfE encourage schools to use information and communication technology to enhance teaching and learning in all subjects. |

### 2.7 Impact on society

Science and technology have huge impacts on the society we live in, and it is absolutely essential that scientists, engineers, software developers, and the like, play an active role in understanding and critically evaluating such impacts. After all, only they may have the technical background to do so.

In our November 30 draft we offered this as one of the Aims of the PoS for Computing:

- All pupils can critically articulate the individual, cultural, and societal impacts of digital technology, and know how to stay safe, exploit opportunities, and manage risks.

This Aim did not appear in the version offered by DfE, something we consider to be a real loss. We received a great deal of feedback from CAS members to this effect.

A possible justification is that it is covered in some other way. Professor Tim Oates recommended that the entire National Curriculum would have some over-arching Aims, intended to "deliver things not delivered in the individual subject specifications", including one very like this. However it seems unlikely that his proposal to have new over-arching Aims will be taken up, so we urge that this Aim be put back into the programme of study for Computing (and indeed something similar for other subjects). Otherwise it will be lost altogether.

Moreover the case is particularly strong for Computing. Computing is about the principles that underlie our ability to build things that will enhance our lives; as Tim Oates expresses it "it is human intention incarnate".

We propose, therefore, to add an Aim covering the impact of Computing on the society we live in, as will be seen from our detailed proposals below.

### 2.8 Key Stage 4

We warmly welcome the inclusion of Computer Science GCSEs in the English Baccalaureate, as a clear signal that the DfE considers Computer Science to be an important and rigorous subject discipline.

Key Stage 4 is a tricky area for the Computing Programme of Study

- By the time they reach Key Stage 4 pupils should have the opportunity to specialise somewhat, as they do in Science. Our goal is that by the end of KS3 students should be **in a position to make an informed choice** about whether and how they want to specialise.
- We would like to see a range of qualifications available at KS4, ranging from academic computer science, to applied ICT, and combinations of the two (rather like Combined Science); and including more vocationally-oriented qualifications such as network management or systems administration.
- We strongly support the draft's statement that **"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."** The "must" is important here.

- We think it essential that students 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 students will choose to focus their attention elsewhere, and will choose to take no KS4 qualifications in Computing. As the DfE Consultation Document puts it (1.16) "We do not believe that further compulsion at Key Stage 4 is necessary or appropriate".

  These students should nevertheless develop the creativity, capability and knowledge they acquired in KS1-3. This requirement is stated briefly, and schools are free to deliver it in a variety of ways.

However, a real risk of the current presentation is that a reader might conclude that KS4 was not seen as very important to Computing, so that it can be downgraded or ignored, the very opposite of the desired outcome. Avoiding this risk may require some DfE guidance beyond the Programme of Study itself.

| **Recommendation** |
| --- |
| DfE should make it clear to schools that the minimal nature of the KS4 Programme of Study for Computing should be read as an indication of the flexibility that is expected at KS4 for students to follow a range of different paths within Computing, and emphatically **not** as an indication that Computing is considered unimportant at KS4. |

### 2.9 Transitional arrangements

Since Computer Science is starting from a zero base, expecting every school to deliver the full content of the new Programme of Study, from September 2014, would be ambitious to the point of demoralising the troops.

Moreover, even a fully-prepared KS3 teacher will not be able to deliver the KS3 programme of study in September 2014, because the pupils arriving from KS2 will not have experienced the KS2 Programme of Study.

In short, some transitional arrangements are going to be necessary.

| **Recommendation** |
| --- |
| DfE should publish guidance that schools will not be expected by Ofsted to implement the full content of the new Programme of Study for Computing, but would instead be expected to have a clear plan for its staged introduction |

### 2.10 Training for teachers

It is no good writing a Programme of Study for Computing if we do not equip teachers to deliver it. We need:

- **Bursaries for Computing PGCEs** set at the same level as those for Physics (£20,000 for a First, £15,000 for a 2:1, £12,000 for a 2:2).
- **Subject Knowledge Enhancement courses in Computer Science** should be continued. Some are running in the academic year 2012/3, but there has been no announcement about funding for SKE places from September 2013.
- **A national programme of CPD to equip Computing teachers**, especially for the new Computer Science elements of the curriculum.

CAS is deeply involved in the third of these, via the Network of Teaching Excellence in Computer Science, but the task is huge since it includes tens of thousands of primary teachers, as well as thousands of secondary teachers. All three elements need sustained attention by government. If the focus quickly moves elsewhere, teachers will be left with a statutory curriculum that they are not equipped to deliver, which is both unfair on them, and does not achieve the DfE's goals.

| **Recommendation** |
| --- |
| DfE must pay sustained attention to the task of training and equipping Computing teachers to deliver the new Programme of Study. |

# 3. Proposed detailed changes to the Programme of Study for Computing

This section describes the detailed changes that we propose to the draft Programme of Study.

Each change is individually justified. Changed text is highlighted in yellow. The full draft including these changes can be found in Section 4.

| Where | Old version | New version | Reasoning |
|---|---|---|---|
| Intro para 1 | It combines creativity with rigour: pupils apply underlying principles to understand real-world systems, and to create purposeful and usable artefacts. | It combines creativity with rigour: pupils apply underlying principles to create purposeful and usable artefacts. | Both the previous and the subsequent sentence refer to "the world"; it is redundant here |
| Intro para 1 | has substantial links with the teaching of mathematics, science, and design and technology. | has substantial links with the teaching of mathematics, science, digital arts and media, and design and technology. | Digital arts and media are major application areas for computing and communication, but are easily overlooked or neglected. This addition will reinforce the existing but sparse references to creativity, and to curriculum elements such as the creation and processing of images, sounds, and other aspects of digital creativity - as the document says, "to create products and solutions". It responds to the arguments made by Eric Schmidt (and others) that creativity should not only not become divorced from the more purely technical subject-oriented aspects of computing, but should indeed be encouraged through hands-on engagement with digital arts in all their many forms. |
| Intro para 2 | in which pupils are taught how digital systems work, how they are designed and programmed, and the fundamental principles of information and computation. | in which pupils are taught the principles of information and computation, and how digital systems work. | Omit superfluous "fundamental".<br>Put principles before practice. |
| Intro para 2 | Building on this core, computing equips pupils to apply information technology to create products and solutions. | Building on this knowledge and understanding, pupils are equipped to use information technology to create digital artefacts, including programs, | Adopting the Naace point here about the pedagogic progression of "knowledge and understanding". |

| | | | |
|---|---|---|---|
| | | systems, and a range of media. | Stress using technology for creative purposes.<br>We have adopted "digital artefact" consistently to mean "a digital, made thing" whether that be a document or a program. "Product" sounds too commercial. |
| Intro para 2 | A computing education also ensures that pupils become digitally literate – able to use, and express themselves through, information and communication technology | A computing education also ensures that pupils become digitally literate – able to use, critically evaluate, and express themselves through, information and communication technology | Adopting Naace's point here that digital literacy includes critical abilities, not just the ability to use.<br>The term "digitally literate" neatly finesses the hotly-contested question of whether one should say "digital literacy" or "digital literacies"! |
| Aims | can understand and apply the fundamental principles of computer science, including logic, algorithms, data representation, and communication | Can understand and apply fundamental principles and concepts of computer science, including abstraction, logic, algorithms, and data representation | Algorithms and data representation are not really "principles"; hence adding "concepts". Whereas "abstraction" is a fundamental principle, and really belongs in here. To keep the aim manageable, we omitted "communication". |
| Aims | | Add a new aim "Can critically articulate the individual, social, and cultural opportunities and risks of digital technology." | This is a big, important change. See covering notes. |
| KS1 | understand what algorithms are, how they are implemented as programs on digital devices, and that programs execute by following a sequence of instructions | understand what algorithms are; how they are implemented as programs on digital devices; and that programs execute by following precise and unambiguous instructions | A re-draft to eliminate "sequence". Even at primary school, parallel algorithms make perfect sense; eg see the videos at http://csunplugged.org/sorting-networks<br>The redraft does not suggest that parallel algorithms must be covered – far from it – but it focuses on the key point: precise and unambiguous. |
| KS1 | write and test simple programs | create and debug simple programs | Two minor changes of nuance; first, to encourage creativity; second, to avoid the implication of boring test plans (create test data, run program, compare outputs…), in favour of something more exciting and interactive. |
| KS1 | organise, store, manipulate and retrieve | Use technology purposefully to create, organise, | Several points here: |

| | | | |
|---|---|---|---|
| | data in a range of digital formats | store, manipulate, and retrieve digital content | • "Create". Pupils shouldn't just be manipulators of pre-created data they should create as well.<br>• "Purposefully". There should be a purposeful context, not a bare collection of facts to recall.<br>• "Digital content" not merely "data" again gives more purpose. |
| KS2 | Design and write programs that accomplish | Design, write, and debug programs that accomplish | Similar to KS1. Debugging is better mentioned here than in the next bullet |
| KS2 | generate appropriate inputs and predicted outputs to test programs | Omit | Covered by the previous and next bullet; and we want to avoid the paper-heavy test-plan implication. |
| KS2 | use logical reasoning to explain how a simple algorithm works | Use logical reasoning to explain how some simple algorithms work | A drafting point. We don't want to allow an interpretation that a teacher can say "my students can explain one particular algorithm X, so this is covered". |
| KS2 | the opportunities it offers for communication and collaboration | the opportunities it offers for creative communication and collaboration. | Again stressing the opportunities for creativity |
| KS2 | New bullet | Design, create, and evaluate digital artefacts for a given audience. | We received very strong feedback about the lack of emphasis on design (graphic design, human-computer interface, fitness for purpose, attention to the audience), and creativity, especially outside the realm of programming. |
| KS2 | describe how internet search engines find and store data; use search engines effectively; be discerning in evaluating digital content; respect individuals and intellectual property; use technology responsibly, securely and safely | Replace with two bullets<br>• Use search technologies effectively, and appreciate how results are selected and ranked.<br>• Be discerning in the use and evaluation of digital content; respect intellectual property; use technology responsibly, securely, and safely. | Naace rightly worries that "search engine" may become dated. And "describe how internet search engines find and store data" is too vague. Finally, the discernment and intellectual property part are a separate thought.<br>The redraft is simpler and clearer. The term "appreciate" connotes an awareness that selection and ranking is going on, and some knowledge of how it happens, but nothing like as strong as "understand" or even "know". |

| | | | |
|---|---|---|---|
| KS2 | including collecting, analysing, evaluating and presenting data and information. | including collecting, analysing, evaluating and presenting information | Simplify slightly |
| KS3 | Understand at least two key algorithms each for sorting and searching. | Understand several key algorithms that reflect computational thinking, such as ones for sorting and searching. | If we specify "sorting and searching" that is what will be taught and only that. Being less precise here allows the curriculum to be more responsive to the needs of a particular class.<br><br>Nevertheless, we strongly wanted to retain sorting and searching problems, because (a) it is particularly easy to describe the problem they solve (b) they both ubiquitous in real programs (c) they have a particularly rich spectrum of algorithms to solve them.<br><br>"Reflect computational thinking" is meant to reinforce the "thinking" aspect, and emphasise that what matters here is the ingenuity and beauty of the algorithm rather than the detail of its expression in a particular programming language. |
| KS3 | Use logical reasoning to evaluate the performance trade-offs of using alternative algorithms to solve the same problem. | Use logical reasoning to compare the utility of alternative algorithms for the same problem | Simpler and less prescriptive wording. The key points here are (a) awareness that the same problem may be solved by difference algorithms, and (b) that there are trade-offs involved.<br><br>"Utility" is better than "performance trade-off", because it can include aspects such as space usage, subtlety of the code, data set size (eg insertion sort may be better than quicksort if the data set is always small), etc. This needs unpacking in guidance notes. |
| KS3 | use two or more programming languages, one of which is textual, each used to solve a variety of computational problems; | use two or more programming languages, one of which is textual, to solve a variety of computational problems; | Drafting point: simplify wording. |
| KS3 | use data structures such as tables or | make appropriate use of data structures such as | Be less prescriptive |

| | | | |
|---|---|---|---|
| | arrays | lists, tables or arrays | |
| KS3 | use procedures to write modular programs; for each procedure, be able to explain how it works and how to test it | design and develop modular programs that use procedures or functions | Simplify. Lead with the stress on modularity, with procedures (and functions!) as the mechanism. Reduce emphasis on testing. |
| KS3 | understand simple Boolean logic (such as AND, OR and NOT) and its use in determining which parts of a program are executed; use Boolean logic and wild-cards in search or database queries; appreciate how search engine results are selected and ranked | Understand simple Boolean logic (such as AND, OR and NOT), and some of its uses in circuits and programming. | This bullet was the only place at which the potentially-huge topic of "databases" was mentioned, which seems unhelpful. Boolean logic is not much used in search queries in practice.<br>The re-draft focuses just on Boolean logic, and encourages a broad view of its usefulness, rather than focusing only on control flow in programs. |
| KS3 | understand the hardware and software components that make up networked computer systems, how they interact, and how they affect cost and performance; explain how networks such as the internet work; understand how computers can monitor and control physical systems | Understand the hardware and software components that make up computer systems, and how they communicate with one another and with other systems | This bullet seemed far too long. We do not want 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. Yet some elementary knowledge of the hardware on which everything runs, up to and including the internet itself, is important. The redraft tries to simplify down to that single notion. |
| KS3 | explain how instructions are stored and executed within a computer system<br>explain how data of various types can be represented and manipulated in the form of binary digits including numbers, text, sounds and pictures, and be able to carry out some such manipulations by hand | Understand how instructions are stored and executed within a computer system; understand how data of various types (including text, sounds, and pictures ) can be represented and manipulated digitally, in the form of binary digits; be able to convert between binary and decimal, and perform simple binary arithmetic | Combines two bullets that concern low-level representation into one.<br>Clarify what "manipulations by hand" might mean.<br>Although it is arguable that binary is just an implementation detail, we believe that it is helpful for students to gain some visceral understanding of how computers actually work, in much the same way that we teach arithmetic as part of maths. |
| KS3 | create, reuse, revise and repurpose digital information and content with attention to | Create, reuse, revise and repurpose digital artefacts for a given audience, with attention to | Broaden from "information" to "artefacts".<br>Include some element of critical appraisal of origin |

| | | | |
|---|---|---|---|
| | design, intellectual property and audience | trustworthiness, intellectual property, design, and usability. | "trustworthiness".<br>"Usability" allows consideration of the user interface and fitness for purpose of programs, which is very important but otherwise gets no mention.<br>"Design" here is intended to connote graphic design, user interface design, visual design, but NOT software engineering systems design (requirements analysis, rapid prototyping, agile development etc). |
| KS3 | | Understand and demonstrate good practice when participating in online communities. | **New item**. By this age students have started to belong to online communities, within and sometimes beyond their school. The focus here is not primarily e-safety (important though that is -- see the section on e-safety above), but rather on developing awareness of the opportunities of online communities, of their differences to in-person communication (eg lack of body language), and of guidelines for effective online collaboration (something adults are often poor at). |
| KS4 | develop their capability, creativity, and knowledge | develop their creativity, capability, and knowledge | A stylistic point; reads better. |
| KS4 | | Manage their online identity; reflect on the personal, social, economic, and ethical impacts of technology and technological change, and the implications for rights, responsibilities, and freedoms. | New item. See the accompanying notes about impact. |

## 4. Revised Draft Programme of Study for Computing

This section contains the full draft of the amended Computing PoS including the changes that were detailed in Section 3.

**Purpose of Study**

A high-quality computing education equips pupils to understand and change the world through computational thinking. It develops and requires logical thinking and precision. It combines creativity with rigour: pupils apply underlying principles to create purposeful and usable artefacts. More broadly, it provides a lens through which to understand both natural and artificial systems, and has substantial links with the teaching of mathematics, science, digital arts and media, and design and technology.

At the core of computing is the science and engineering discipline of computer science, in which pupils are taught the principles of information and computation, and how digital systems work. Building on this knowledge and understanding, pupils are equipped to use information technology to create digital artefacts, including programs, systems, and a range of media. A computing education also ensures that pupils become digitally literate – able to use, critically evaluate, and express themselves through, information and communication technology – at a level suitable for the future workplace and as active participants in a digital world.

**Aims**

The National Curriculum for computing will ensure that all pupils:

- Can understand and apply fundamental principles and concepts of computer science, including abstraction, logic, algorithms, and data representation;
- Can analyse problems in computational terms, and have repeated practical experience of writing computer programs in order to solve them;
- Can critically evaluate and apply information technology, including new or unfamiliar technologies, to solve problems;
- Are responsible, competent, confident, and creative users of information and communication technology; and
- Can critically articulate the individual, social, and cultural opportunities and risks of digital technology.

**Subject content**

**Key Stage 1**

Pupils should be taught to:

- Understand what algorithms are; how they are implemented as programs on digital devices; and that programs execute by following precise and unambiguous instructions.
- Create and debug simple programs.
- Use logical reasoning to predict the behaviour of simple programs.
- Use technology purposefully to create, organise, store, manipulate, and retrieve digital content.
- Communicate safely and respectfully online, keeping personal information private; recognise common uses of information technology beyond school.

**Key Stage 2**

Pupils should be taught to:

- Design, write, and debug programs that accomplish specific goals, including controlling or simulating physical systems; solve problems by decomposing them into smaller parts.
- Use sequence, selection, and repetition in programs; work with variables and various forms of input and output.
- Use logical reasoning to explain how some simple algorithms work, and to detect and correct errors in algorithms and programs.
- Understand computer networks including the internet; how they can provide multiple services, such as the world wide web; and the opportunities they offer for creative communication and collaboration.
- Design, create, and evaluate digital artefacts for a given audience.
- Use search technologies effectively, and appreciate how results are selected and ranked.
- Select, use and combine a variety of software (including internet services) on a range of digital devices to accomplish given goals, including collecting, analysing, evaluating and presenting information.
- Be discerning in the use and evaluation of digital content; respect intellectual property; use technology responsibly, securely, and safely.

**Key Stage 3**

Pupils should be taught to:

- Design, use, and evaluate computational abstractions that model the state and behaviour of real-world problems and physical systems.
- Understand several key algorithms that reflect computational thinking, such as ones for sorting and searching. Use logical reasoning to compare the utility of alternative algorithms for the same problem.
- Use two or more programming languages, one of which is textual, to solve a variety of computational problems; make appropriate use of data structures such as lists, tables or arrays; design and develop modular programs that use procedures or functions.
- Understand simple Boolean logic (such as AND, OR and NOT), and some of its uses in circuits and programming.
- Understand the hardware and software components that make up computer systems, and how they communicate with one another and with other systems.
- Understand how instructions are stored and executed within a computer system; understand how data of various types (including text, sounds, and pictures) can be represented and manipulated digitally, in the form of binary digits; be able to convert between binary and decimal, and perform simple binary arithmetic.
- Undertake creative projects that involve the selection, use, and combination of multiple applications, preferably across a range of devices, to achieve challenging goals, including collecting and analysing data and meeting the needs of known users;
- Create, reuse, revise and repurpose digital artefacts for a given audience, with attention to trustworthiness, intellectual property, design, and usability.
- Participate safely and responsibly in online communities.

**Key Stage 4**

All pupils must have the opportunity to study aspects of information technology and computer science, at sufficient depth to allow them to take qualifications supporting progression to higher levels of study or to a professional career.

All pupils should be taught to:

- Develop their creativity, capability, criticality, and knowledge in computer science, digital media and information technology;
- Develop and apply their analytic, problem-solving, design, and computational thinking skills; and

- Manage their online identity; reflect on the personal, social, economic, and ethical impacts of technology and technological change, and the implications for rights, responsibilities, and freedoms.