The place of Computer Science in the National Curriculum for England

In April 2011 ALT responded to the DFE consultation about revisions to the National Curriculum for England[1]. In recent weeks there has been plenty of discussion in the media and in Government about the place of Computer Science in the curriculum. We've consulted within ALT and more widely and have framed some views on this question, in the form of a response to three questions:

- **To get the next generation of comp scientists do we need CS in the NC?**
- **Where do we put CS?**
- **Should CS be only for those who are interested or for all?**

We offer these points as a contribution to the discussion.

A To get the next generation of comp scientists do we need CS in the NC?

1. There is a total consensus that modern life is increasingly dependent on having a familiarity with aspects of Computer Science, and not just at a "surface" level. This is at least as important as knowing about Physics, Chemistry or Biology. It underpins the way we live and work and we are hugely reliant on it for the future success of society.

2. So CS is needed as part of the NC in England, as seems already to be the case in Scotland. There are clearly two ways in which to tackle this. One is to have a separate line of CS as a "subject in its own right". Some of those contributing to this response take this view, which is shared by the Chartered Institute for IT. Most of those who do not share it do so mainly because they are cautious that the school system in England does not have the capacity to cover CS properly as a subject in its own right. An alternative, which may be more realistic under current circumstances, is for the NC at the top level explicitly to reference the need to integrate CS in other subjects to make sure that key concepts ideas and techniques are covered. This approach had the support of the majority of those we consulted; but it is fair to say that if the recently stated intention of the Prime Minister in response Eric Schmidt's McTaggart Lecture[2] to embrace CS as a subject in the NC is sufficiently firm for the right policies, resources and processes to be put in place to make it happen, then many would support CS in the NC as a subject in its own right.

3. In either context we would strongly encourage the adoption of technology enhanced approach to the teaching and learning of that curriculum by pupils, and to the essential development of the teacher workforce.

4. Turning to the content of CS in the NC, we think that the NC at the top level should refer to the need to develop the ability to define and control computations and understand and be able to deploy and exploit communication and information systems more generally, and to understand some of the ethical and societal issues relating to computers in society that will without doubt grow in importance during the lifetime of

[1] http://repository.alt.ac.uk/2099/ - last accessed 14/12/2011
[2] http://www.bbc.co.uk/news/technology-15672607 - last accessed 14/12/2011

the new NC.

5. However, first it should be noted that those inventing a discipline did not study it at school by definition. As a subject matures it gets larger and the ability to "jump into" it at a later stage gets harder. There has been a clear shift over time from the "great and good" having started in other disciplines (in the UK usually Maths, Science or Classics), to having a more standard background in the subject itself. In addition, while the very top students may be able to make large leaps of this sort, we are talking about needing numbers where this is not possible. So it will not do simply to leave CS until universities or until KS4.

6. The case for having optional KS3 and KS4 qualifications is not what this is about. We need to facilitate an easier and more rapid shift into CS at a later stage. Ignoring CS in the NC makes this much more difficult. Essentially the "Mark Zuckerberg did not study CS as a subject at school" argument is unwise.

7. In the model (CS not treated as a separate subject in its own right), ideas from CS permeate the NC and examples and exercises used need to be up-to-date and relevant to modern society and hence contain elements of both ICT and CS. As a rule of thumb, CS is correctly aimed at "doers" in the computing area whereas ICT is aimed at "users". Both need support in the NC but CS is much more important in the long run as ICT user-skills are getting increasing easy to acquire.

8. By having a lighter and more durable NC that sticks to principles as is proposed rather than specifying coverage in the sort of detail that cannot remain current, it becomes easier for teachers and especially examining and awarding bodies to include material that is relevant and with which learners can identify. This should be the case throughout the NC but obviously some areas will have more CS related material and examples than others.

9. A CS education has many pieces, and serves many ends:
   - **Educating CS professionals and professors**. This has to be done at some point, what the NC should do is make it easier for those whose KS4 background does not include CS can make an informed and rapid change at degree level or subsequently.
   - **Providing tools that can be used in other disciplines**. We are not talking about word processing and other office tools (useful, but part of computer literacy, not computer science), but rather the ability to do an analysis of some data (which could be statistical, exploratory, exhaustive or whatever), or to use information systems to find data that already exists over networks or in the cloud and pull it together exposing links and relationships. Such data could for instance arise from a set of questionnaires. Another example is the ability to model some process as a computer simulation, rather than as a system of mathematical equations. These are tools for the mind as well as the hand; it is not just that you can get an answer faster: you will also be able to take approaches that you couldn't even consider before.
   - **Understanding CS theory/technology as a citizen**. How could/should government regulate privacy? Understanding how computer networks and encryption work will help you answer this. Likewise for decisions about

regulating banks and insider trading. Are the climate science graphs fake or real? A little CS education can go a long way here as well.

- **Understanding CS theory/technology as a curious "philosopher"**. As CP Snow put it, you'd be considered ignorant if you didn't know some of the basic works of Shakespeare. There is equal depth and beauty in the works of Turing or Knuth or Karp and perhaps in some modern forms of technology assisted communication.

10. While it may be very hard to find appropriate teachers for formal CS below KS4, there are places where elements, currently thought of as being CS, should appear as part of the NC in other disciplines. The idea is that many of the underpinning concepts and techniques of CS should already have been encountered through other subjects. Lack of appropriate teacher development is an inhibitor here that needs to be addressed.

11. Mathematics is the subject most likely to be relevant at all levels. It must contain lots of examples and approaches that occur naturally in CS: concepts of binary notation and calculation, algorithms, their definition and their complexity, logic and the solution of logic problems, discrete structures such as networks, sorting and searching, axiomatics etc. all need to be in the Mathematics NC or used as examples and the basis of assessment by examining authorities. We need to encourage computational thinking by all. There may be a tendency among some professional mathematicians to de-emphasise this in favour of more traditional material: it is important to guard against this.

12. Science needs to include examples of simulations and modelling more generally. There is not really a special case for Physics here although there remain hardware links - most CS will occur equally in Chemistry, Biology and especially in Earth Sciences.

13. It is hard to envisage doing any modern school course without covering somewhere how to ask the opinion of others and process the resulting data, making appropriate deductions and avoiding bad ones. Some of this is obviously statistics and should be placed wherever that goes eventually. Other aspects about how to avoid asking leading questions and the like and how to see relevance are not so obviously in mathematics and may need to be situated carefully - one suggestion is that subjects such as geography could cover this but there is a case for it being pervasive.

14. Aspects of CS arise within Technology, Art and Design, and Music. Again the aim should be to introduce technology into these disciplines and include some theoretical base rather than have “traditional approaches” which are far removed from modern usage. While some of this is ICT some is “genuine CS”.

15. The overall argument is that barriers to getting into CS subsequently (e.g. at degree level) are getting higher for those with no knowledge of CS at all. We therefore need to ensure that a sufficient amount of material has been covered by all those who might subsequently consider a move into CS and/or its application, so that entry is not too hard. This is a part of the case for wide exposure to material in “CS-lite”. This can only be achieved by a wide inclusion of CS ideas and concepts in a number of subjects.

16. But the main requirements of doing well in CS subsequently remain having a rational, structured, determined, and enquiring mind. This is required widely in the NC but perhaps is more focused within mathematics.

B Where do we put CS?

1. We have suggested above that a GCSE is not necessary, provided sound CS is exemplified in many other GCSE disciplines and reinforced by assessment regimes. It is not too late to do formal CS only at KS4 and some would argue even later, provided there is a firm knowledge and skills base. This also potentially makes best use of the currently scant teaching resources (but that should not be a long term argument).

2. We therefore suggest it is a strand in Maths, Science, Design, some Social Science and possibly some Humanities. This leads to a large need for professional development for teachers both CPD and initial training. Until recently this has been beyond the system but young prospective teachers now often have a lot of skills in a way that was not the case before and the changes in the job market may make this push doable now as never before, especially if any push itself takes advantage of technology enhanced learning methods.

C Should CS be only for those who are interested or for all?

1. It would be wholly wrong for something that underpins society to be "only for those interested" We suggest that there are minimum levels of knowledge of "things CS" that need to be understood by all (as appears to be the case in the Scottish curriculum[3]). This is covered by the middle two sections above. The public needs to engage with certain aspects of (ICT and) CS in order to engage with debates, get data from electronic sources, understand its legitimacy or otherwise, interpret data, process data, and understand and act on ethical issues etc. Perhaps some of this could have been put into "Citizenship" but that did not happen effectively - what matters is that the new NC takes account of the way that the products of CS pervade everyday life, and the way in which an awareness of the underlying issues is important if people are to participate successfully in discussion about the profound issues that arise as a result.

2. Understanding technology is more for ICT but is also important and does contain some aspects of CS. Engineering concepts and skills in general (such as the ability to do "rough sums" and have three dimensional insight) have always been underplayed in our curricula. Having a highly theoretically underpinned NC (good) is not the same as having a completely theoretical NC (bad).

3. There is currently a severe shortage of CS qualified graduates (single and joint honours). The school system responds very slowly to changes in demand. The financial crash in the computing industry in the early noughties triggered changes in demand for CS graduates but it then took a few years for the teachers to notice and advise KS3 choices, two more for the learners to get to KS4 and then a further 3 for

[3] see for example http://goo.gl/YWc74 last accessed 14/12/2011.

fewer graduates to emerge from universities. This latency is very long and things had changed back to higher demand before the result of the changes was through. For this reason, being able successfully to make later choices in the direction of CS because one had the basic knowledge acquired through the NC as a whole is essential to support a more flexible approach.

4. The economy also needs everyone to have a reasonable degree of computer literacy but that is very different from formal CS. However, we should be seeking to get the number of highly qualified (i.e. CS university graduates) up by a factor of about 2 to 4 on today (but still a very low proportion of the overall population). This can only happen if switching is easier because of pre-existing knowledge.

5. Concerning the question "should CS be only for those who are interested (thus getting some great classes of motivated pupils together)" there certainly would be scope to provide online learning in CS at quite an advanced level for motivated learners, though obviously this stands outside decisions about the NC itself.

6. Finally to pick up the last bullet in our list above, it would be appropriate if the English NC were to include some aspects of understanding the languages of CS and technology more generally - including the languages of phones, the Internet etc. Writing a good tweet is likely to be more important to most than some other more traditional forms. Is writing good hypertext or writing for accessibility important (we suggest yes) and if so the English curriculum needs to address this.

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