Digital Literacy, ICT Creativity and Computational Thinking

The Importance of changing the teachers.

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The Emperor and his new clothes

A vain Emperor hires two dishonest tailors who promise him the finest clothes made from a fabric invisible to anyone who is unfit for their position or "hopelessly stupid". The Emperor's ministers cannot see the clothing themselves, but pretend that they can for fear of appearing unfit for their positions and the Emperor does the same. The Emperor dons his new clothes and marches in procession before his subjects. The townsfolk play along with the pretense not wanting to appear stupid. Then a child in the crowd, too young to understand the charade, cries out that the Emperor is naked. The cry is taken up by others. The Emperor cringes, suspecting the assertion is true, but procession continues.

The Emperor's New Clothes is one of the best known stories of Hans Christian Andersen(1). It has several relevances to today's education politics.

Are academic computer scientist tailors promising "New Clothes" or something radically different that will produce the step change in learning that has eluded (2) us for at least the last thirty years? There is no shortage of high powered terminology. Take the word abstraction. It is a pivotal term for the Computer Scientists and appears in the KS3 programme of study [3] in

"design, use and evaluate computational abstractions that model the state and behaviour of real-world problems and physical systems"

What is a computational abstraction? An abstraction is a simplified generalisation of something eg using a circle to represent a wheel, a cube for a box or a series of triangles to represent a Christmas tree (4). It could be representing a person by their name, telephone number and post code. Abstraction is well used in many parts of the existing curriculum it's just not called abstraction. Physics is all about explaining the natural world in terms of abstractions but for 11-14 year old children the emphasis is mostly on empirical knowledge related directly to concrete experiment. The particle model for materials, the structure of the atom, Newtonian mechanics used to create abstractions of the solar system. There is nothing new or unusual about abstraction as a concept in itself in schools and little argument about its key role in learning.

We have learnt a lot about the way children cope with abstract concepts in the critical 11-14 age range. Critical because of its significance in transition to formal operational thinking. The CASE

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project (Cognitive Acceleration through Science Education) [5] showed scientifically quantified improvement in ALL subjects for children pushed to move from the concrete to formal operational thinking at this age. The subjects improved 1 GCSE grade across all subjects compared to control groups. So why has this evidence had so little impact in any of the major curriculum or staff development programmes over the last 25 years? A billion pounds spent on curriculum online to buy gadgets, 25 million on an online assessment system that was scrapped because it was not fit for purpose. Now a wholesale rewrite of ICT in terms of Digital Literacy, ICT and Computer Science. The political symbolism of technology always seems to trump any rational approach to real change based on hard evidence. Is there new substance to the revision of the curriculum or is it simply more new clothes for the emperor?

What about a **computational** abstraction? Logically it is abstraction in the context of computation but what does that mean? A lot of searching for a definition of computational abstraction comes up with many references to "Computational Thinking". A definition of computational thinking should provide insight into the term computational abstraction. It seems most writers want to emphasise that it is NOT about computer programming or indeed anything technological in the practical sense.

"Computational thinking is a new problem solving method named for its extensive use of computer science techniques" [6]

and

"Conceptualizing, not programming. Computer science is not computer programming. Thinking like a computer scientist...requires thinking at multiple levels of abstraction" [7].

One thing that is striking is that there is a clear attempt to separate the academic process from practical learning. Design and technology was similarly "abstracted" to the "design process", effectively an abstract problem solving algorithm that could be applied to almost any context. It is tempting to want to keep such academics as far away from the practical learning process as possible.

We certainly do want to develop cognitive excellence but in secondary schools we need to get to it from where children are at age 11 and that is largely concrete cognition. Children at age 11 are not just small adults. They understand the world differently and have different motivations and emotions. In the secondary school target age group most of the research, from Piaget to Papert,[8] points to the importance of stepped progression for INDIVIDUALS in developing their formal operational thinking and its link to abstract learning. The ability to think about abstract concepts emerges during the formal operational stage which for most children is in lower secondary school. This means getting the balance right between concrete operational thinking and formal operational thinking for INDIVIDUAL children, something that a generic programme of study will never achieve.

The ability to solve problems creatively requires formal operational cognition but the problems children are interested in tend to be concrete and practical in their own world. What interests adults rarely has the same impact on most children.[9] The freedom to be creative in an emotionally motivating context reinforces as well as extends knowledge and understanding. A false dichotomy between creativity and knowledge is unhelpful as is similar polarisation of the curriculum into learning facts vs learning process, academic vs practical. These are not either ors, they are boths with the importance of being able to feed off each other in ways that promote creative thinking. Over-emphasis of one at the expense of the other is likely to be at best inefficient and at worst positively harmful.

In terms of abstraction, physics requires thinking at multiple levels of abstraction and so does mathematics. To be creative in these subjects requires high levels of knowledge and understanding that is founded in concrete experience. Probably any science based problem solving method could be described in terms of abstraction. The cornerstones of computational thinking, pattern recognition, analysis/reductionism and replicable procedures (algorithms) have been well-established in the scientific method before computers made computer science popular. So what makes computational thinking really unique?

Wing (ibid) goes on to say that it complements and combines mathematical and engineering thinking and that it is about ideas, not artifacts. It seems very difficult to pin down the uniqueness of computational thinking though without contextualising it in computer technologies. And perhaps this is the power of computing in the curriculum. It is a new context to which children relate well and that provides concrete tools for systematic problem solving to help children move from concrete to formal operational thinking. This brings us nicely to the Trichotomy of Digital Literacy, IT and Computer Science because if it is about motivating creative thinking, why do we need these labels? But before we do this let's revisit the KS3 Programmes of Study in the light of the cognitive development of 11-14 year olds.

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Use and evaluate is easy for 11-14 year olds. Numpty Physics [10] is a problem solving game where the player draws objects on the screen that then take on the properties of those objects in the Earth's gravity. Playing the game is using a computational abstraction - well probably hundreds of them. It encourages creative solutions to an abstraction of a set of real world problems. So use is straightforward. What about evaluation? Evaluate it against what criteria? Was it fun? Is it accurate? What advantages does it have over a physical rather than a software model? Without some sort of commentary on the statement in terms of the evaluation criteria it is impossible to tell.

Design (and by implication, making) is the difficult bit. What would you give as examples of real-world problems and physical systems? Certainly coding Numpty Physics is well beyond high school levels for ordinary children. Even simple things like an oscillating pendulum require an understanding of A level maths and physics to design and make a reasonable computational abstraction. If we are to interpret this on face value it is far, far too difficult for the vast majority of children in the 11-14 age range. It's not about rigour, high expectations or any political mantra, it's simply down to the empirical evidence. In no country in the world, not even the highest PISA performers, do average children operate at the level of A level physicists at the age of 14. Of course if we define real-world problems and physical systems with trivial simplicity we can do it. Maybe designing the solution to a Numpty Physics stage? But that is hardly a computational abstraction, it is a mechanical engineering abstraction done on a screen. Teachers' interpretation of the words will be the key.

For a simple computational abstraction take a LOGO program to draw a square: REPEAT 4 [FORWARD 100 LEFT 90], an abstraction of a box, a real world object. But is that what most people would interpret from what the KS3 programmes of study says? Are the Emperor's New Clothes an Armani Suit or a piece of sticking plaster? What do the words actually mean? In the words of Humpty Dumpty to Alice, [11] "It Means just what I choose it to mean". Without any real consensus on interpreting the words this is the reality. This is why all the expensive initiatives that buy new hardware or reorganise the curriculum are doomed to failure if there is not a step change in teachers' competences in using digital technologies to their potential.

So what about Digital Literacy, ICT and Computer Science as discrete domains? What is Digital literacy? JISC [12] is succinct with "by which we mean those capabilities essential for living, learning and working in a digital society". Wikipedia [13] - Digital literacy is the ability to effectively and critically navigate, evaluate and create information using a range of digital technologies. This sounds remarkably similar to the coverage of the former National Curriculum programmes of study for ICT so why the distinction between Digital Literacy and ICT? And if computer science is more about computational thinking than programming why is programing so dominant in the new programmes of study? The confusion is not helped by the introduction of this trichotomy. It reinforces entrenchment of the secondary curriculum into an already unmanageable range of academic subject silos with micropolitical interests fighting tooth and nail for their own corners. While the intention is to match curriculum time to expertise, pre-16, there has been limited success when it comes to technology. It also has the downside of confronting children with increasing fragmentation and incoherence. In the case of Digital Literacy, ICT and Computing it is unclear that there is the expertise currently to confidently differentiate them and this is of far greater importance than labels and structures.

The empirical proof of digital literacy is to use digital technologies as a natural support to creativity in lessons across the curriculum. This is a central aim of the HandsonICT project. What is the point in developing digital literacy (ICT or computing skills) if it never gets deployed effectively because of deficiencies in teacher competence? Companies with digitally literate staff deploy the use of digital tools routinely in their work. No-one at work in any such company sits down and handwrites a two hour essay any more and pretty well anyone who is really educated and digitally literate can learn anything they need to for free from the internet. If you doubt that then you are probably not digitally literate. So why do we continue to have such low expectations of our average 13 year olds? Why are we wasting time worrying about subject demarcation when we have few successful strategies that enable teachers to be confident to support children to routinely use contemporary technologies in support of their work in all their subjects? Surely this is fiddling while Rome burns.

Whether deploying digital technologies enhances learning as measured in knowledge based handwritten exams or not is a red herring. The way we work in schools should reflect the way the most effective people work outside. Do these people go on training courses every time a new application emerges? No. It is simply assumed that they will know how to learn and adapt to new tools, at least in task based cultures. Is it not ironic that education, the sector preparing young people to operate in a hi-tec world, has such problems with any level of technological change in its own most expensive resource? As a specific example, we get the DfE collecting data in Word documents that should be through web forms. It’s hardly leading by example. What does this say about digital literacy and ICT skills of the adults responsible for developing the same in the children?

Most of the countries in the Far East envy the scope for creativity in our schools[13] yet we seem to aspire to kill it in favour of the "rigour" of subject cramming all too prevalent in those countries. In his book The Accidental Mind [14], the neuroscientist David J. Linden explains how emotions organize our memories, we remember things that are linked to our emotions and that is why contexts relevant to us as individuals matter when it comes to learning. Creative contexts for learning feed our emotions and amplify our ability to remember, especially long term. It is therefore even more important to breakdown rather than reinforce the secondary subject barriers in order to increase the scope for creativity to flourish and in the secondary curriculum that requires a change of culture in teachers. In the words of Seymour Papert (ibid) "The battle is about a challenge from new technologies and from new theories of learning that threaten to overthrow the accepted structure of school, the idea of curriculum, the segregation of children by age and pretty well everything that the education establishment will defend to the bitter end." Perhaps not just the educational establishment, politicians and journalists are just as likely to support “reforms” that actually further entrench what they knew when they were at school. They have become successful and so what they experienced must be the right way. New approaches to continuing staff development are needed. Approaches that integrate it with day to day work and technology has the potential to do this.

Einstein [(15)] famously said that insanity is doing the same thing over and over and expecting a different result. This insanity is the real enemy of promise. What has been called reform over the last 25 years is anything but. It is generally a reinforcement of things we know don't make a significant difference, dressed up as the Emperor's New Clothes for political effect. The politicians that complain about the intransigence of the education professionals are just as responsible with their own policies and inability to think creatively in an unfamiliar context that is often not as intuitive as they think it is[(16)]. Learning facts is easy to present and inexpensive so it is attractive to politicians.

Facts are important just as grass is important in a game of football but concentrating only on the grass is missing the point. It is time to start basing policy on the wealth of evidence from neuroscience about how the brain actually works and to back it with the empirical evidence from eg the CASE project of what actually raises attainment. Use this and technology to enable change in the teaching workforce. Computational thinking might be part of that by providing a motivating context to help accelerate cognitive development but we need more than obscure technical words if it is to contribute to a rise in standards that goes beyond computing technology itself. We need to change the teachers.

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Some more relevant quotes attributed to Einstein but possibly originating from others.

- The only thing that interferes with my learning is my education.
- Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world.
- Logic will get you from A to B. Imagination will take you everywhere.
- All religions, arts and sciences are branches of the same tree.
- Intellectuals solve problems, geniuses prevent them.
- Information is not knowledge.
- We can't solve problems by using the same kind of thinking we used when we created

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them.

- If we knew what it was we were doing, it would not be called research, would it?
- It is the supreme art of the teacher to awaken joy in creative expression and knowledge.
- Any man who reads too much and uses his own brain too little falls into lazy habits of thinking.
- It's not that I'm so smart, it's just that I stay with problems longer.