

Teaching: Traditional versus Turing

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Abstract

The computer has been present in its various forms in primary school for over thirty years, yet teaching remains traditional. The term 'information and communication technology' reveals educationalist's inadequate conception of what is truly a change in the medium of instruction. A focus on the "technology" has finessed the question asked by Alan Turing in 1950 about the relationship of the computer to the human mind. In primary education its relationship is to rapidly maturing uniquely human minds. In this context the word 'computer' also has unfortunate connotations in that it implies the mechanisation of mentation at the heart of primary schooling. Turing teaching as a term is introduced to shift focus from ever-changing technology to the nature of the medium and its relationship to a curriculum designed for those rapidly maturing minds. Media are categorised as Talk, Text, and Turing according to their relationship with the mind. Each of these 3Ts imposes a particular teaching method on educators, notably on the literacy and numeracy at the core of primary education. Text-based teaching is considered 'traditional,' its method imposed by pre-computer text media. Its reference is the set of proposals published in 2013 for the English national curriculum. Turing teaching, not to be conflated with progressive education, seeks to maximise the potential of the new medium to transform education. Its basis is in a new view of the evolution of the human capacity for technology, technicity. This theoretical framework offers support for Papert's intuition that making objects open to public inspection is more "felicitous" for learning than verbal instruction. This view runs counter to the cultural perception that language is humanity's highest cognitive capability. Technicity is consistent with fundamental scientific principles, in contrast to the naïve presumption about language and the social brain. It also offers an explanation of how technology provides us with control over the environment. This framework, in combination with the window that written language opens into the workings of the mind, is used critically to examine the validity of traditional teaching method in numeracy and literacy. Turing's concept possesses the cognitive power, now embodied in the knowledge and technology that computer science offers, to transform learning in the primary phase if method is matched to the medium.

Keywords

Technology, technicity, primary education, educational medium, teaching method

INTRODUCTION

In his 1950 *Mind* paper, Alan Turing speculated on the relationship of the computer to/with the human mind. For maturing minds in primary school this is a crucial question. In the torrent of new technology the mind has been sidelined as education is exhorted to try to integrate each new information and communication technology. Connectivity, social networking, has encouraged a techno-centric and conservative trend. Given the timescale of the computer in education, it will be useful (through the well documented English experience) to retrace the pathway that has led to the cur-

rent situation. Thereafter the key terms will be defined so that meanings may be shared. This includes introduction of the concept of technicity and disambiguation of the definition of a Turing machine. On this foundation, the learning modes, the 3Ts, may clearly be defined. Traditional teaching is clarified by reference to the English national curriculum, guidance offered to teachers, and the people who formed it. However, it should be noted that the subject-oriented curriculum gives a misleading impression of primary school, where teaching is integrated into themes. Nonetheless separation of the core, literacy and numeracy, is necessary for the discussion of teaching mode and method in the light of what is on offer from computer science.

Path to present

In 1983 micro-computers made their first official entry into English primary schools, accompanied by training material (MEP 1983). They were promoted in a programme that focused on new technologies, motivated by economic considerations. Academic debate was polarised: Skinnerian influenced programmed learning and drill & skill, computer as tutor; versus a Piagetian and AI influenced constructivist approach typified by Logo microworlds and programming: computer as tutee (Papert 1980). In practice the dominant use was continuous with the extant audio-visual aid tradition: a tool to enhance learning; now characterised by the interactive whiteboard. Some five years later, for the first time in over one hundred years, the British government imposed a National Curriculum on English schools (Graham & Tytler 1992). Traditional in form and content, it included a new 'subject' called Information Technology. The advent of the internet saw a middle C. ICT remained in subsequent revisions (QCA 1999, 2010) until 2012 when, although the subject remained compulsory, schools became free to develop their own curriculum (DfE 2012). Never quality controlled, children's attainment varied widely, (Cartwright & Hammond 2007). Prior to its disapplication in 2012, there had been debate about school ICT. Alexander (2010), focussing on information saw it as part of the language domain; Rose (2009), took it as a skill for life. ICT capability as an essential skill prevailed in the revised curriculum (QCA 2010). The Royal Society argued for computer science in response (Furber 2012). This polarisation both contrasts with and complements experience at the opposite end of Europe. The teacher-originated Bulgarian national curriculum saw computers as a new medium, and sought to teach children all the possibilities of the computer within the normal activities for their age by a project oriented approach (Ilieva & Ivanov 1999, 2001, Ilieva 2010). However, as it was not obligatory the outcome was similar to that in England. Where children did achieve better results than with traditional media, the reaction was dismissive. No serious consideration was given to the computer as a medium for teaching the core skills. In England, National Strategies for literacy, 1998, and numeracy, 1999, later the Primary Strategy (DfES 2006) extolled traditional and specifically excluded computer-based methods. Rose (2006), reflecting government policy, recommended phonics for early reading. Calculators remained contentious in numeracy (Williams 2008). Ministers, motivated by the international comparisons that connectivity make increasingly available, and with the support of the academic establishment, have been firm on this issue. At the time of writing, the DfE (2013) has put a draft national curriculum out to consultation that not only excises ICT in favour of computing but promotes traditional method.

SOME THEORETICAL ISSUES

Science is littered with theoretical notions that appeared reasonable in the past. The classic is the geocentric/heliocentric view of the solar system and Galileo's conflict with the established view. Unlike the physical sciences, education does not pretend to have a scientific basis, a situation bemoaned by Piaget (1971) and reiterated by Papert (Harel & Papert 1991). Alan Turing's vision of a computer provided a new context within which to think about intelligence, but there is no theoretical standpoint

from which to reconsider teaching and learning. Curriculum and method are based on tradition and philosophy: craft and opinions. In such a situation, it is difficult to conduct research that provides results that lead to development.

Technicity

Natural language is given pride of place in the curriculum. The cultural presumption is that language is the crowning cognitive capability of the human species (Dunbar 2004a, 2004b), despite evidence of the dominance of technology (Diamond 2005). Alexander (2010), reflecting Vigotsky (1962), prioritised language and oral discourse in primary education. Papert disagreed (Harel & Papert 1991). His intuition was that constructing an object open to public inspection was more “felicitous” for learning. Ó Dúill (2012) offered support for Papert by proposing that the uniquely human capacity for technology, which he named technicity, is, like language, an evolved adaptation. Technicity makes elemental information present in brains for over 500 million years available to cognition. Typified by line and colour (Hubel 1995), this makes possible the arts and science. It leads to visual conceptualisations such as the Turing machine. Consistent with principles of brain evolution, child development and primary school curriculum, the technicity proposition crucially conforms to the second law of thermodynamics. The key to its adaptive power is the availability of low entropy information to cognition. This is why scientific thought provides greater control over the environment than its naïve linguistic counterpart. Technicity clarifies the cognitive distinction between naïve and scientific thought (Bransford et al 2000). Technicity is discussed at greater length in Doyle & Ilieva (2013).

Turing machine

The Turing machine, along with the Carnot cycle, is probably the most important visualisation in the history of science. It is not, as Hopcroft and Ullman (1979) tried to suggest, a formal mathematical entity but as real a mechanism as the piston and cylinder of the Carnot cycle. Turing’s model was himself, pencil/eraser in hand and notebook to hand. He read, wrote or erased or moved back and forth through the text, his state of mind changing according to its ‘table of instructions’ and current state. It is as much a model of a primary school child doing sums, though it doesn’t get them wrong. We now have a situation that puts into that child’s hands not a pencil and paper but the Turing machine. Its relationship to thought is very different from that of a textbook: a problem for educators who have tradition alone to rely on.

Traditional teaching

Given the conflicts of philosophies in education is necessary to be precise about the meaning of the term ‘traditional teaching’ used here. Comparison with progressive education is in no way implied. Traditional method refers to the teaching medium in use, the medium that Alan Turing employed, and teaching method associated with it. Turing was taught traditionally. The draft English national curriculum proposals for primary school mathematics (DfE 2013), in precluding calculator use until children can do sums mentally and on paper, characterises traditional teaching. The same is true of literacy, which is also recognisably as of Turing’s schooldays. It is presumed by its contributors that this approach, well taught, guarantees educational quality. For thirty years it has provided the context for computer-use in schools.

Primary minds

Children arrive in primary school with language, a prior evolutionary adaptation to technicity (Pinker 1995), already available. Technicity is in the process of coming on stream. Its first manifestation is in the scribbles that children invest with meaning: an attempt to express something in mind for which they as yet have no effective output channel (Gardner 1980, Anning & Ring 2004); see also Bloom (1993) on child lan-

guage development. Drawings are composed from line and angle information. Drawings are naïve engineering representations of critical features. This non-verbal communication, which is not art, is used by school to represent the cognitive aspect of language (literacy) and for place-value numeral arithmetic. The primary phase of education is co-terminal with major neural maturation, which it helps to sculpt.

THREE T'S

Any medium used in education makes specific mental and physical demands on the student and offers specific advantages. Three are available: verbal instruction (talk), the book (text), and the computer (Turing). They will be considered in that order.

Talk

This medium uses the evolved adaptation of speech to transmit information not obvious in context (Bloom 1993) from teacher to student. It demands a shared language with meanings held in common. Its socio-verbal nature has been well described by Vigotsky (1962). No external medium, no extension to the phenotype, is involved. This mode is reliant only on mental and physiological capacity: memory and a capacity for discourse and to convert words into action. This teaching method was available to our Neanderthal cousins. Children enter kindergarten equipped for verbal learning with spoken language complete. Rote learning is based on the belief that memorisation and recall is a measure of learning. It is exploited in exercises such as memorising oral number facts and times tables. Requiring no extension to the phenotype it is immediately available and knowledge is always in mind. Talk in its purest form may only operate at the level of naïve thought bound to perception.

Text

This medium is graphic technology. Text is cognitively more powerful than speech. In school text is primarily writing. Writing converts language, in its cognitive aspects, into an object open to inspection, opening a window onto the way the mind works (Pinker 2008). Text-technologies that mirror mental operations are more powerful than those based on perception. A nice example is the notation of number. The language of number has a zero and the count is to nine. Register is changed on the count of ten: nineteen (19) to twenty (20). Mirroring the mind, Hindu-Arabic numerals are cognitively more powerful than percept-based Roman notation, hence the rapid advance in mathematics after their adoption. Note: their graphic forms are language-independent. The same is true of geometry. Text, created from information in the brain's structure is universal, unlike speech. Text has a significant drawback: Skills of decryption, encryption and animation skills must be learned before information may be accessed. Text requires a long apprenticeship in literacy and numeracy, which then becomes the core of primary education in literate societies. Unfortunately for the learner, being an inactive extension to memory, the medium can provide no assistance in the learning process. Text is formally a Turing tape.

Turing

The term Turing emphasises the relationship of the computer to the mind. From one viewpoint the Turing medium can model mental processes; from another it can be digital multimedia platform. In discussing core skills, only the former is relevant. The difference from text is that the medium has the capacity to assist the learner. Words are no longer cast in stone, awaiting a competent reader. The medium is interactive. Thus, unlike with a book, a child need not wait for teacher: the medium can offer immediate feedback. Text prioritises reading, a consumer activity. Turing media facilitate the creative act of writing, including programming. Text passively records knowledge, awaiting an animator. Turing media may animate the knowledge stored. This means that Turing media may be tuned to the knowledge base of the

learner and, vital in the primary school, to children's state of neurological development.

RECONSIDERING THE 3 R'S

Reading, writing and arithmetic are at the core of primary schooling. Commentators like Alexander (2010) have noted that the apprenticeship in literacy and numeracy takes excessive time from a child's schooldays. For children with learning difficulties it dominates their school experience. Many remedies for this have been proposed. Some failed, vide Downing (1967), others are still in classrooms, e.g. Dienes blocks. Today's approach (DfE 2013) is for the administration to impose traditional teaching method. Where is this method flawed and can Turing teaching provide a remedy?

'rithmetic

A four function calculator may be bought for less than one Euro. A ubiquitous Turing tool that children see constantly in use, including by their teacher, does it inhibit or aid number capability? Tradition asserts the former. Is it correct? Current method progresses from talk and physical counting to text using place-value numerals. Does it help or inhibit? The language of number is congruent with place-value numerals. Counting in tens is not: carry on an abacus is inelegant compared with an odometer. It is possible to teach arithmetic to a child who cannot count using a calculator. This knowledge can then be applied to organise counting. The reverse is not possible: a child well-taught traditionally failed to transfer knowledge to organising LEGO bricks.

Technicity offers an explanation: Counting tens, finger counting, bundles up at five or ten. This is a perception-based naïve number notion. Numerals, which come alive on a calculator, being congruent with the working of the brain as shown by number language, provide a scientific understanding. Traditional method leads to cognitive conflict that, in less able learners, is resolved in favour of perception and finger counting. Coupled with rote learning of number facts, it leads to difficulty with and dislike of mathematics. The calculator complements thought. Dienes blocks inhibit it. Turing teaching offers to resolve this conceptual confusion by removing countables and using the power of interactive numerals to assist the learner. At issue is how best to teach number using the capabilities of the calculator: numbers as friends.

Reading and 'riting

Literacy is also beset with conceptual confusion. There is a perception, based on the apparent derivation of orthography from phonology, that speech is the foundation of the written. Taylor (2008) shows this not to be so. The computer speech engineer cannot generate prosody from text: the information is not there. Technicity points to writing as a separate expressive stream cf. sign language. This is consistent with Bloom (1993); Adams (1994) finding that experience with text is the best correlate of reading success; and Jenkins (2000) work on the core sounds of English. The naïve concept that writing should represent speech leads to ill-conceived method such as the initial teaching alphabet (Downing 1967) and synthetic phonics (Rose 2006). All fail because they presume a standard pronunciation. Received Pronunciation, as used in the Oxford English Dictionary, poorly reflects orthography: 'English' is rendered with an initial 'l' and a letterless schwa. Phonics asks children to learn an accent that gives a false guide to spelling. The problem is not in the internationally standard written language but in its spoken diversity. The Turing medium opens the option of writing rather than reading from the start. A keyboard requires only letter recognition and makes few motor control demands. Computer speech technology could provide a text-to-sound system that preserved the individual letters, their weight, and the spaces between words; and which would be intelli-

gible. An entrée to interactive writing was once offered by Logo. Programming with words and numbers entered at the keyboard resulted in action, giving immediate feedback on spelling and meaning. Writing is more powerful than speech because it is of lower entropy. It better represents the cognitive aspects of language. The Turing teaching approach asks that educationalists rethink literacy and consider how the new medium may best be deployed to reduce the appalling level of illiteracy in developed societies.

TOWARDS TURING TEACHING

Now that the arguments for Turing teaching have been rehearsed the 'how' question arises. The history of technological advance points to inevitability. Unfortunately, the absence of a scientific foundation for education both makes research problematic and acts as an inhibiting factor, hence the theory excursion. The research difficulty is significant: the medium transition invalidates comparisons as, e.g. PISA, they are based on progress within traditional method. The first step is not, as computerists believe, to teach computer science: it is to teach children mastery of the medium.

Mastering the medium

It is self-evident that to make effective use of a medium it is necessary to master it. Therefore, the first essential step in beginning the transition to Turing teaching is to systematically teach children how to use the possibilities the computer offers. This process will begin when children first enter primary school, cf. mastery of text. It will be taught using activities appropriate to the age of the children; and will support the disciplines of the existing curriculum. There will be a significant difference in method, however. The Turing medium is intrinsically a medium for creation not consumption. The Turing medium is intrinsically interactive so exercises that practice skills, later to be marked by teacher, will not be required. The Turing medium has the capability to assist the learner by signalling errors and indicating corrections. This means that a project oriented approach to mastery is the better option than the classic classroom exercise book. In Bulgaria a national ICT curriculum (Ilieva & Ivailov 1999, Ilieva 2010, Ilieva & Doyle 2013) designed along these lines is in place.

CONCLUSION

The issue of primary teaching method in a computer rich culture is highly complex. This paper can only scratch the surface. It has been necessary to adopt a theory laden approach because change of medium implies a transition and retrospective research is the only possibility. In the glare of technology, the focus on medium and method is necessary. Technicity, with its entropy foundation, is a powerful cognitive tool that could only be alluded to. Recognition that products of technicity are more powerful than language and that they open a window onto the working of the mind is the conceptual advance needed to cut the philosophical knots that bind educational thought. Thirty years on it is timely to shift focus from technology to thought: to seek for an answer to the question Turing posed. In the light of school failure, to reject his challenge and continue to impose traditional method is tantamount to child abuse.

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Biography



Mícheál Ó Dúill, is an experienced educationalist in the primary and special needs fields, where thinking beyond craft traditions is essential. A psychology and engineering background led to an interest in language and technology. Questioned about entropy by his university admissions tutor, he has an abiding interest in the power of the simple. Realisation that the word is not enough and that we don't know how we can draw led to the proposition that humans evolved a unique technological capability – technicity.

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