Educational innovation, learning technologies and 'virtual culture potential'

David Riley
Imperial College Centre for Educational Development, Imperial College of Science, Technology and Medicine
email: d.riley@ic.ac.uk

Learning technologies are regularly associated with innovative teaching but will they contribute to profound innovations in education itself? This paper addresses the question by building upon Merlin Donald's co-evolutionary theory of mind, cognition and culture. He claimed that the invention of technologies for storing and sharing external symbol systems, such as writing, gave rise to a 'theoretic culture' with rich symbolic representations and a resultant need for formal education. More recently, Shaffer and Kaput have claimed that the development of external and shared symbol-processing technologies is giving rise to an emerging 'virtual culture'. They argue that mathematics curricula are grounded in theoretic culture and should change to meet the novel demands of 'virtual culture' for symbol-processing and representational fluency. The generic character of their cultural claim is noted in this paper and it is suggested that equivalent pedagogic arguments are applicable across the educational spectrum. Hence, four general characteristics of virtual culture are proposed, against which applications of learning technologies can be evaluated for their innovative potential. Two illustrative uses of learning technologies are evaluated in terms of their 'virtual culture potential' and some anticipated questions about this approach are discussed towards the end of the paper.

The challenge of recognizing and anticipating educational innovation

Innovative teaching is one of the key themes of *ALT-J* and a matter of considerable practical concern to lecturers embracing learning technologies. Many innovations, however, are digital variations on previous practices that date back to the times when numbers and letters were first inscribed, when literacy became a concern, and formal education was invented as the solution. This paper explores the notion that learning technologies could require us to be innovative in a more fundamental sense and will force us to review our cultural assumptions about education itself. The question addressed here is how we might recognize, or better still anticipate, profound innovations that could result from the use of learning technologies.

A low-pass cognitive-cultural filter

A premiss of this paper is that we need to filter out the high frequency 'noise' of technological and educational change, whilst attending to the lower frequencies and themes running through human cognitive and cultural evolution. It is assumed that our ability to appreciate and compose across the full dynamic range of educational innovation will be enhanced by an awareness of these underlying themes.

A theory of human evolution that is admirably suited to the purpose is outlined next. The theory begins with an account of hominid evolution several million years ago and culminates in a cultural critique of education as we know it today. This theory has been further elaborated by two educationists concerned with the impact of computational technologies on innovation in mathematics curricula. Their conception of an emergent 'virtual culture' provides the inspiration for this paper and a device that may prove fruitful in the search for innovation in education.

A theory of cognitive and cultural co-evolution

The psychologist Merlin Donald claimed in his landmark book (Donald, 1991) and subsequent precis (Donald, 1997) that the human mind co-evolved in close interaction with both brain and culture over millions of years. He postulated three major cognitive transitions with each cognitive step-change being marked by the development of novel and increasingly hybrid forms of representation and by the subsequent rise of more complex human cultures.

Episodic culture

According to Donald, early hominids possessed a chimpanzee-like brain that was brilliant at event-perception, capable of subtle social interactions, and sensitive to the significance of environmental events. He claims, however, that episodic recall was poor and environmentally driven rather than readily self-triggered at will. He describes this culture as 'episodic', with limited scope for the voluntary recall of events, for the rehearsal and purposive refinement of skills and the expression of knowledge.

Mimetic culture

Donald's first biophysical and cognitive transition was a breakthrough in motor and mimetic skills, permitting the development of body language as a form of representation and communication. This change, he says, occurred around one and a half million years ago as *Homo erectus* appeared. The resulting mimetic culture was based on the new-found capability for self-triggered rehearsal and for voluntary representational acts that facilitated sociocultural development. Skilled tool-making, gesture, dance, mime and ritual became possible through embodied performance with the capacity for iconic representation leading to more abstract forms of symbolic but pre-linguistic representation.

Mythic culture

Donald's second transition resulted from changes to human biological and cognitive structures affecting motor skills, mimesis and symbolic representation. They enabled lexical invention and contributed to the development of oral language. He argues that speech and narrative forms emerged some 300,000 years ago, following physical and cognitive adaptations of the brain, the nervous system and the human vocal apparatus. The resulting mythic culture was a hybrid, interweaving inherited episodic and mimetic capabilities with the new ones of storytelling, more flexible symbolization and the potential for abstraction away from specific events and performances.

Theoretic culture

Instead of a biophysical change in memory and cognition, Donald's third transition marked a technological change around fifty to thirty thousand years ago, in the Upper Palaeolithic. People produced inscriptions for the first time and externalized symbolic memory, initially in images and later in numerical and written systems. The resulting theoretic culture was founded on external memory records that were created, interpreted and applied by a 'literate class' with responsibilities for commerce, governance, legal codes, religion and health.

He suggests the demands of numeracy, literacy and the maintenance of specialist discourse communities were such that formal education became a necessary component of the emerging theoretic culture. Over time, education enabled the sharing and dissemination of these literacies whilst reinforcing theoretic culture through the invention of sophisticated and specialized symbol systems. Contemporary mathematics, science and technology are fruits of this culture, as are the arts and humanities. Technologies for externally storing and sharing symbol systems proved to be remarkably potent as *Homo sapiens* took culture beyond the biological limits of individual memory, mental reasoning and oral transmission.

With respect to modern information and communication technologies, Donald treats these as significant developments falling within the scope of theoretic culture. He notes that they enhance the storage, communication and display of symbol systems and symbolic representations and discusses the cognitive and cultural impact of a 'global electronic information environment'.

A critique of theoretic culture

Donald's inclusion of modern technologies within an established theoretic culture has been challenged by David Shaffer and James Kaput (1999), who believe there has been a fourth cognitive transition triggering the emergence of a 'virtual culture'. They suggest that Donald overemphasized the importance of memory and external symbol *storage* functions in theoretic culture and underestimated the significance of external symbol *processing*. Shaffer and Kaput argue that the advent of computational technologies constitutes a major cognitive transition bringing culturally unprecedented forms of dynamic and interactive representation, and giving rise to the qualitatively new virtual culture.

The educational implications of a virtual culture

Shaffer and Kaput used their conception of an emergent virtual culture to argue that it places additional and novel demands on people's representational abilities, and hence on education. They argue that mathematics curricula will need to be changed if they are to satisfy the symbol-processing needs of a virtual culture.

In their view, the aims of mathematics curricula should be to:

- promote 'generative fluency', that is, students' ability to learn varieties of representational systems (see also Kaput, 1998);
- provide opportunities to create and modify representational forms;
- develop skills in making and exploring virtual environments;
- emphasize mathematics as a fundamental way of making sense of the world;
- offer a more embedded and situated mathematics, that builds on meaning and places less emphasis on exact computation and formal proof – except for students who require these specialized skills.

In other words, Shaffer and Kaput say that learning to read and write symbols is no longer sufficient for students of mathematics. A virtual culture requires people who are able to 'read and write' symbol-processing for representational purposes. Thus, an education system that developed to support the internal symbol-processing needs of theoretic culture should adapt and grow to support the external symbol-processing needs of virtual culture.

Virtual culture and the challenge of educational innovation

The above account of human biological and cultural evolution is stimulating but surely a new and different stage in human culture should be universal in its reach and impact? If Shaffer and Kaput's claim of a virtual culture is reasonable, their arguments about mathematics curricula should be generalizable across most, if not all, curricula. Readers are invited to judge for themselves whether they believe computationally based technologies are having such a deep impact in their own fields and whether curricula are changing or whether they should change as a result.

This paper proceeds on the assumption that Shaffer and Kaput's conception of virtual culture is insightful and therefore could be of value in evaluating the innovative potential of learning technologies. I will regard the use of learning technologies for symbol storage and display to be characteristic of a theoretic culture and unlikely to be culturally innovative. In contrast, I regard the use of learning technologies for autonomous symbol processing and interactive representations to be characteristic of a virtual culture and more likely to be culturally innovative. For instance, students posting an essay on an intranet or sending emails to a tutor are using the digital equivalents of earlier systems. These practices are digital in their implementation but rely on the communication and sharing of symbols and hence are typical of theoretic culture. The use of online multiple-choice tests with automated feedback for tutors and students takes advantage of machine computation and of hybrid, interactive representations. This is indicative of an educational practice belonging to virtual culture.

Virtual culture potential

To structure and take forward these ideas, I introduce the notion of 'virtual culture potential' and provide a working definition of virtual culture as an assemblage of four diagnostic practices:

1. the processing of external symbol systems on interactive, computational devices;
2. the use of these devices for representational purposes in human communications;
3. the representation of entities, events and environments that are material, imaginary or abstract;
4. the use of multiple and hybrid forms of representation – the juxtaposition and interweaving of representational forms typical of episodic through to virtual cultures.

This assemblage of practices makes it possible to characterize uses of learning technologies in terms of their alignment with, and potential to further, virtual culture. Applications of learning technologies that entail all four practices should be ascribed a high virtual culture potential whilst lower potentials are indicated if these practices are absent or less well developed. For instance, both the applications of learning technologies shown in Table 1

Evaluation criteria for virtual culture potential of applications of learning technologies	Learning technologies, educational applications and match with criteria	
	Geographic information system [GIS] Spatial variability of soil nitrate-N	Dynamic modelling system Nitrogen fluxes in an agro-ecosystem
(1) The processing of external symbol systems on interactive, computational devices	Yes	Yes
(2) The use of these devices for representational purposes in human communication	Yes	Yes
(3) The representation of entities, events and environments that are material, imaginary or abstract	Yes	Yes
(4) The use of multiple and hybrid forms of representation: the juxtaposition and interweaving of representational forms typical of episodic through to virtual cultures	Yes	Yes

Table 1: Evaluation of the virtual culture potential of two applications of learning technologies

illustrate high levels of virtual culture potential. This potential would be reinforced by the integration of the two learning activities using a composite spatial and temporal modelling system (MacEachren, 1995).

Learning activities such as those illustrated in Table 1 would have been impracticable before computers became available and few environmental scientists or geographers would have imagined educational projects of this kind. Yet, in the wider world, it no longer seems strange that decision-makers should consult epidemiological models or global climate modellers (Bloomfield, 1986; Macmillan, 1989). Nor does it seem exceptional that interactive computer simulations should seamlessly represent the past, the present and a range of imaginary futures whilst serving the worlds of science and politics as twenty-first-century oracles.

Reflections on virtual culture potential

This paper has strayed close to the abstract, theoretical and speculative limits of respectability for a journal such as *ALT-J*. The time has come to acknowledge and address a few anticipated criticisms of the notion of 'virtual culture potential' as it has been advanced in this paper.

Firstly, whilst Donald's theory is widely acknowledged, it is merely one of several theories of the evolution of the human mind (Mithen, 1996; Plotkin, 1997), and I can neither support nor refute his particular account. Instead, it is regarded as a valuable source of inspiration for myself and for Shaffer and Kaput who made the crucial distinction between the importance of symbol-storing and symbol-processing technologies. This distinction and their notion of virtual culture could prove to be fruitful in identifying opportunities for educational innovation even if Donald's theory is found to be wanting in some respects.

Secondly, the distinction between symbol storage and symbol processing is simplistic, in that running an email or intranet system entails considerable information-processing. However, I believe the computations that are embedded within such systems and that are transparent to users are not germane to the educational issues and approach expressed in this paper.

Thirdly, what is new in this paper? The privileging of computation is not new; diSessa (2000) discusses at length his ideas about computers, learning and literacy, whilst acknowledging the early influence of Seymour Papert. It seems to me, however, that Donald's ideas and their derivatives have a broader cultural sweep than those of diSessa, who restricts much of his thinking to the notion of programming in the mathematical sciences and related fields. The challenge of combining or integrating interactive and narrative representational forms is, for instance, an issue gaining attention in the humanities (IGCC, 2001) and sits more comfortably within Shaffer and Kaput's notion of a virtual culture than within diSessa's frame of reference.

The notion of computing to represent and communicate similarly differs from the approach explored by Brna, Baker and Stenning (1999) in a conference on communicative interactions and the development of students' modelling skills in mathematics and science. Virtual culture affords the wider educational sweep and highlights the activity of modelling to represent and to communicate, rather than the activity of communicating in order to model.

Conclusions

This paper has developed a notion of 'virtual culture potential' by building on the earlier work of Donald, Shaffer and Kaput. The notion is advanced for its heuristic possibilities in recognizing the potential of learning technologies to trigger profound educational innovations.

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References

Bloomfield, B. P. (1986), *Modelling the World: The Social Constructions of Systems Analysts*, Oxford: Basil Blackwell.

Brna, P., Baker, M. and Stenning, K. (eds) (1999), 'The roles of communicative interaction in learning to model in Mathematics and Science', unpublished proceedings of the C-LEMMAS Conference, Ajaccio, Corsica, April 1999.

diSessa, A. A. (2000), *Changing Minds: Computers, Learning, and Literacy*, Cambridge, MA: MIT Press.

Donald, M. (1991), *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition*, Cambridge, MA: Harvard.

Donald, M. (1997), 'Precis of origins of the modern mind: three stages in the evolution of culture and cognition', *Behavioural and Brain Sciences*, 16 (4), 737–91. Also: *ftp://ftp.princeton.edu/pub/harnad/BBS/.WWW/bbs.donald.html* (accessed October 2001).

IGCC (2001), 'The International Game Cultures Conference 2001', University of the West of England, *http://humanities.uwe.ac.uk/Gamesculture/index.htm* (accessed October 2001).

Kaput, J. J. (1998), 'Representations, inscriptions, descriptions and learning: a kaleidoscope of windows', *Journal of Mathematical Behaviour*, 17 (2), 265–81.

MacEachren, A. M. (1995), *How Maps Work*, New York: Guilford Press.

Macmillan, B. (ed.) (1989), *Remodelling Geography*, Oxford: Basil Blackwell.

Mithen, S. (1996), *The Prehistory of the Mind: A Search for the Origins of Art, Religion and Science*, London: Phoenix.

Plotkin, H. (1997), *Evolution in Mind: An Introduction to Evolutionary Psychology*, London: Penguin Books.

Shaffer, D. W. and Kaput, J. K. (1999), 'Mathematics and virtual culture: an evolutionary perspective on technology and mathematics education', *Educational Studies in Mathematics*, 37 (2), 97–119.