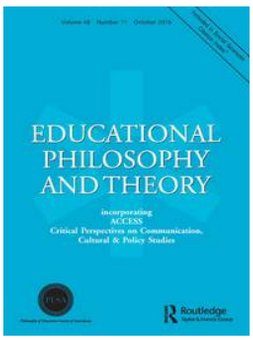

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EDITORIAL
Educational Web Science

Information Pollution?

There is an explosion of data unlike any point in human history that looks likely to continue at exponential rates. This data takes a variety of forms and increasingly involves new concordance of image, sound and text. Education at all levels will need to encourage a critical literacy of search and discrimination of these mountains of data. These new information skills need to be based upon an understanding of the developing ecology of the Internet and the possibilities it affords. At the upper levels, this will require techniques for scientific data management with an accent of data sharing, data management systems, data curation, storage and preservation as well as a broad understanding of the types of digital resources available. As the US National Information Standards Organization (NISO) puts it: 'From metadata collection and cataloging data sources, to identification, discovery, and preservation, best practices and standards are still in their infancy'.[1] The discipline of education, in this regard, has a new mandate and needs to look carefully at curricula and at the new emerging field of Internet Studies (see Dutton, 2013).

Information overload or data saturation, sometimes also known as 'infotoxication' is a concept that has been around since the 1960s. The problem has intensified since the 1980s with email spams, electronic notifications, instant messaging and the marketization of databases. Social media and in particular Facebook and Tweeting have now provided automatic 'reminders' of what many would regard as trivial information clogging the blogosphere especially as users now are capable of being producers as well as consumers, a fact that often results in a low ratio of knowledge to information. Khabsa and Giles (2014) estimate that:

> at least 114 million English-language scholarly documents are accessible on the web, of which Google Scholar has nearly 100 million. Of these, we estimate that at least 27 million (24%) are freely available since they do not require a subscription or payment of any kind.

The ease of duplication and transition across the Internet and its radical decentralization to the individual user has brought about a social addiction to easy reach and instantaneous information that many commentators suggest actually alters the thought processes impeding memory, obstructing deep thinking and compromising the ability to weight evidence, determine truth and make sound judgments. The attention economy (Goldhaber, 1997) is a term that has emerged to specify an

economic approach to the problem of attention considered as a scarce resource and employs various forms of economic analysis to help solve problems of the management of information. The struggle for global attention is one logic at the heart of digital culture that treats the consumer's attention as a resource to be bought and manipulated generating a distorting influence on what is important while often highlighting the trivial. The cult of the new and 'going viral' has the potential to increase the educational significance of YouTube culture for good and for bad. 'Gangnam Style' by the Korean musician Psy has had over two billion views. Kony 2012 by Invisible Children, a video produced to stop Joseph Kony and African militia leader and indicted war criminal has been viewed over 100 million times.[2] These are early signs that we are entering what I call 'the epoch of digital reason' (Peters, 2014, in press) that operates on very different principles than text-based cultures.

The dimensions of the deluge of date are difficult to estimate. Fox, Hey, and Trefethen (2011) ask the question 'Where does all the Data Come From'? and they report:

> A recent report by McKinsey Global Institute … reports that there are 30 billion pieces of content shared on Facebook every month, that the US Library of Congress had collected 235 terabytes of data by April 2011 and that 15 out of 17 sectors in the US have more data stored per company than stored by the US Library of Congress….

Data takes many different forms and it is clear that video content is becoming a new and significant form within society. The social use of the Internet provides platforms for education that generate more video content than at any other point in human history.

> Flickr, the photo sharing site now hosts over 4 billion images. These images are generally family photographs, holiday snaps and the like. However, the increasing demand for digital image storage is a growing concern as we turn to healthcare and the medical images that are now a standard part of our healthcare systems.[3]

The problem is not just of storage, retrieval, processing and archiving. More than ever, it is a problem of understanding the nature of the Internet and the Web in order to maximize their use and come to terms with their pervasiveness in all aspects of life.

The Emergence of Web Science

The notions of 'web science' and 'Internet studies' are very recent fields. In 'Web science: a new frontier' Shadbolt, Hall, Hendler, and Dutton (2013) put the argument for web science:

> During the past 20 years, humans have built the largest information fabric in history. The World Wide Web has been transformational …. Although most people are not formally trained in its use, yet it has assumed a central role in their lives. Over the past few years, there has been a growing recognition that the ecosystem that is the Web needs to be treated as an important and

> coherent area of study—this is Web science. It is 'science' in the original and broad sense of the term—science as the quest to build an organized body of knowledge. As such, it will need to embrace engineering—the Web is an engineered construct, a set of protocols and formalisms. It will need to embrace the human and social sciences—the Web is a social phenomenon whose vast scale has produced emergent properties and transformative behaviours….[4]

Web science studies, experiments and analyzes the form and structure of the Web. Shadbolt et al. (2013) argues that we need more research on the topology and dynamics of the Web if we are to understand its emerging form and its properties. They note that one of the difficulties is that large amount of the Web's content and structure are created dynamically at the point at which users link to websites. They also suggest that new research that looks to the future evolution of the Web as an engineered platform and as a generic computational architecture is required, including issues of scalability, guaranteeing high levels of performance, security, real-time adaptability, resilience and mobile communications.

Web science must also take account of the Web as a social construct and the huge yet to be felt effects on education both in terms of the emerging architecture of networks of knowledge but also the logics of user-generated content, peer production and peer-to-peer philosophy and experimental forms of educational co-creation.

> The use of Web-based applications such as social media, online social networking and wikis, for example, has facilitated peer production, crowdsourcing, widespread network effects, new organizational forms and a general 'deformalization' of organizations. These developments blur state–societal boundaries. They support a move towards 'open-book' governance, transparency and open data initiatives. These hold the promise of co-production and co-creation of government services.[5]

The approach from web science is to understand that the Web *ecosystem* is a composite open and dynamic system of humans and machines—referred to by Tim Berners-Lee as 'social machines' a term that signals collective intelligence and motivates web users to collaboratively use and develop collective resources (Hendler & Berners-Lee, 2010). Education web science needs to examine, analyze, utilize and experiment with Internet-based forms of collective intelligence—a long-term development that runs counter to ideologies of individualism in educational policy, testing and assessment.

The emphasis on the Web as a digital ecosystem provides a theoretical approach that can harness understandings of natural ecosystems and also explore its mathematical basis. O'Hara, Contractor, Hall, Hendler, and Shadbolt (2013) in their monograph *Web Science: Understanding the Emergence of Macro-Level Features on the World Wide Web* argue that 'we need to place Web Science research in the context of emergence, the notion that phenomena visible at larger scales emerge out of interactions that occur at smaller scales, usually at much lower levels of complexity'. They go on to suggest that the research road map of Web Science must comprise at least five relevant perspectives:

1. *Computational:* With the emergence of the linked data Web and Semantic Web, a key challenge is how to find, browse, explore and query data, rather than documents, at scale…
2. *Mathematical.* Billions of Web pages are dynamically generated, existing for the period of a particular query or transaction; modelling this transient or ephemeral Web is an urgent requirement…
3. *Social.* The dynamics and drivers of people's use of newly emergent forms of the Web remain unclear. Yet these will have implications for our understanding of key sociological categories such as kinship, gender, race, class and community and vice versa, as they play out online…
4. *Economic.* Web 2.0/Web 3.0 create many opportunities for users to generate content and share it in self-forming networks, and these need to be modelled in economic terms of incentives and rationality…
5. *Legal/regulatory.* The law, currently reactive to hyperfast Web evolution, should surely lead the intellectual agenda and interact and respond to economic, social and technological influences. The present intellectual property, data protection, torts and policing regulatory regimes, established in the offline world, have to be fit for purpose in the Web 2.0/Web 3.0 environment… (p. 111)

They argue that the study of the Web needs to focus on the role of the Web in communication and practice with an emphasis on characteristics that have direct significance for forms of education that are based on openness, collective intelligence and the logics of digital systems:

1. *Collective intelligence*. Light rules of co-ordination between collaborators can lead to the emergence of large-scale, coherent resources (such as Wikipedia). We need to understand, from a technical point of view, how to enable collective intelligence as well as to outline the socio-economic reasons for which individuals participate in collective endeavour, the legal frameworks governing the resources created, the policy levers that work in this space and the ethical limits to the use of such policies.
2. *Openness*. The Web is a complex mixture of open, public areas and closed, private zones. There are arguments for both, for instance, innovation can be fostered both by information and data sharing, and by protected intellectual property rights. We need to understand which stance is appropriate when….
3. *Dynamics*. The Web is changing at a rate which may be greater than our ability to observe it; we need to instrument the Web, log it and identify trends.
4. *Security, privacy and trust*. All economic, social and legal interactions are based on certain assumptions that individuals can verify identities, rely on the rules and institutions governing the interactions, and be assured that certain information will remain private. These assumptions are challenged by the Web …, yet — as recent security revelations concerning the US NSA and the UK GCHQ show … trust in the infrastructure and in the treatment of one's communications and data will always be an extremely important factor in the growth and development of the Web.

5. *Inference and information processing*. The amount of information on the Web is enormous and growing exponentially (it is a major challenge to measure it, never mind to assess how much of it is useful or original). In addition, it comes in a huge range of formats from a vast number of disparate sources. Given this radically decentralized heterogeneity, methods are needed to browse, explore and query the Web in contextually sensitive ways at scale (pp. 112–113).

One of the most important issues for educational web science is the significance of web science for theories of cognition and cognitive development. While the marriage between cognitive science and web science is only one dimension of the new science it does indicate ready applications to educational web science.[6]

The Mind as Distributed Cognition

The 2014 Summer School in Cognitive Sciences was called 'Web Science And The Mind' that was held at the Universite du Québec à Montreal in July 7–18.[7] It suggested that 'Cognitive Science and Web Science have been converging in the study of cognition: (i) distributed within the brain; (ii) distributed between multiple minds; (iii) distributed between minds and media' and focused on four themes:

1. Homologies and analogies between minds and databases.
2. Interactions between individual minds and distributed databases.
3. Interactions between multiple minds and distributed databases.
4. Analysis of organization and activity in minds and distributed databases.

The conference website suggested the shorter version based on the following:

1. The Social Web
2. The Data Web
3. The Extended Mind
4. The Global Brain

All of these categories have a direct link to education and pedagogy through the concept of the so-called 'extended mind' which investigates collective memory, extended cognition, open thinking, social informatics and learning with others (Clark, 2008; Clark & Chalmers, 1998). The extended mind is based on the view that human cognition literally comprises states, properties instances and processes beyond the boundary of the learner. Variations of this hypothesis talk of 'embedded cognition' or 'embodied cognition'[8] and even of 'socially extended cognition' (Menary, 2013). The new view is a philosophical argument about *active externalism* suggesting that the environment plays an active role in driving cognitive processes: 'the human organism is linked with an external entity in a two-way interaction, creating a *coupled system* that can be seen as a cognitive system in its own right'[9] and beyond the outer limits of this thesis, we can talk of a socially extended cognition (where my mental states are partly constituted by the states of other thinkers) and an 'extended self' (where the self outstrips the boundaries of consciousness).[10] The extended mind is different from collective intelligence that emerges from the complexity of self-organizing systems (Heylighen, 2011). The 'global brain', by contrast, is a concept of the worldwide

network as part of an intelligent, self-organizing system based on the history of organicism, encyclopaedism, emergentism and evolutionary cybernetics (Heylighen & Bollen, 1996).[11] These emerging web concepts clearly demonstrate the kind of territory educational web science will investigate in the future.

The history of distributed cognition indicates that there have been a range of different and sometimes conflicting approaches to the mind, for example, as mentioned above, embodied cognition, the extended mind and enactivism.[12] Smart (2012, 446) explores the notion of the Web-extended mind and new opportunities for Web-based forms of cognitive extension that may 'depend on forms of socio-technical co-evolution in which social forces and factors play just as important a role as do the processes of technology design and development'. Yes, the web-extended mind still faces problems over the differences between intensional and extensional logics. Existing systems on the Web cannot approach human-level intelligence because it cannot yet capture in a formal system that complexity of natural language (Bringsjord & Govindarajulu, 2012). Yet, clearly as perhaps, the defining technological system of the twenty-first century, the Web, from its beginnings as linked hypertext documents has evolved as a universal platform for data and computation transforming questions concerning intelligence and cognition, and education and learning. Now, more than any other time in the past, we need a philosophy that explores the Web as the universal medium for education. We need also to seriously consider the adjunct notion of educational web science.

Notes

1. http://www.niso.org/news/events/2014/virtual/data_deluge/.
2. See https://en.wikipedia.org/wiki/Kony_2012.
3. http://grids.ucs.indiana.edu/ptliupages/publications/Where%20does%20all%20the%20data%20come%20from%20v7.pdf.
4. http://rsta.royalsocietypublishing.org/content/371/1987/20120512.full.
5. http://rsta.royalsocietypublishing.org/content/371/1987/20120512.full.
6. Educational web science is different from 'web science education' see e.g. http://webscience-education-workshop.blogs.usj.edu.lb/.
7. http://users.ecs.soton.ac.uk/harnad/Temp/AbsPrelimProg3.htm.
8. see http://plato.stanford.edu/entries/embodied-cognition/.
9. See Clark & Chalmers, 1998, at http://consc.net/papers/extended.html.
10. See David Chambers' presentation https://www.youtube.com/watch?v=ksasPjrYFTg and an interview with Clark and Chambers at http://www.newphilosopher.com/articles/interview-david-chalmers-and-andy-clark/.
11. See The Global Brain Institute at https://sites.google.com/site/gbialternative1/.
12. See http://www.hdc.ed.ac.uk/.

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