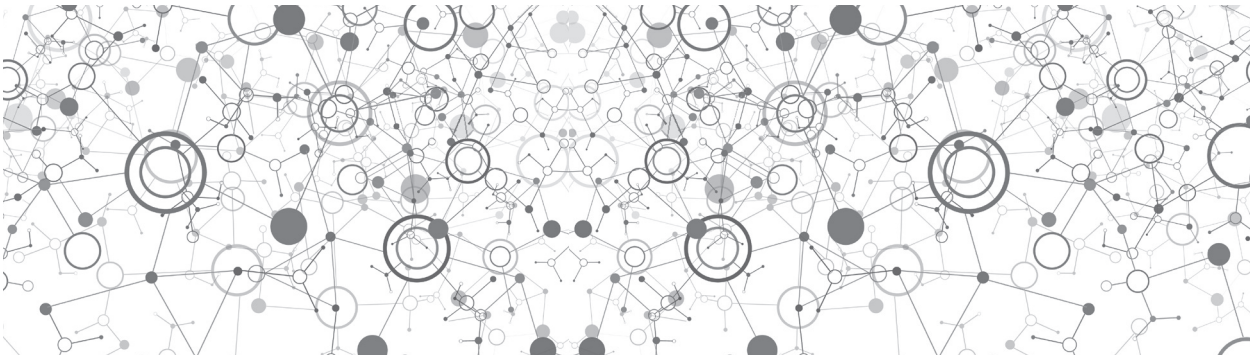
The SAGE Handbook of Learning



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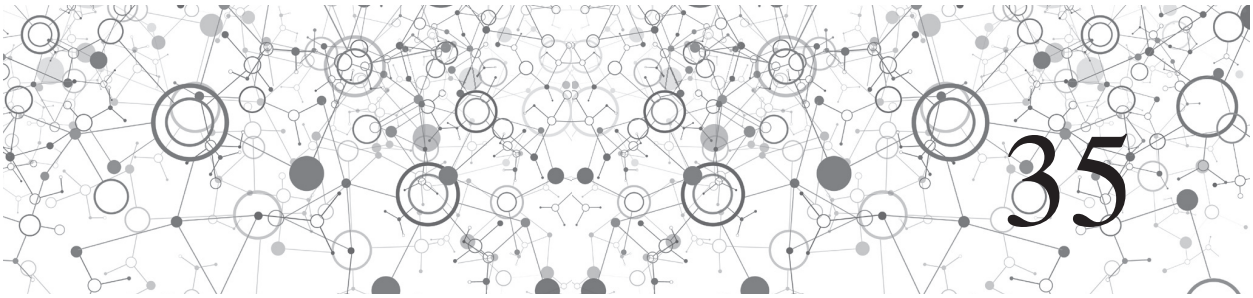

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Learning and New Media

Mary Kalantzis and Bill Cope

INTRODUCTION

'Learning' is the process of coming-to-know, be that the ontogenesis of knowing across the lifespan of an individual person, or the phylogenesis of social knowing. Learning is at times formal – a premeditated agenda in the institutions of education. At other times it is informal – an incidental aspect of lifeworld experience.

'Media' bridge the ontogenesis and phylogenesis of knowledge. To return to the etymology of the word, media are middle-objects, conditions or technologies that facilitate human communication, between one and one, one and many, or many or many. Media are agents of cultural 'between-ness'. They bridge spatial separations, so that people not in each other's immediate physical presence can connect. They bridge time, so ideas, information and cultural representations from another time (a minute ago or a century ago) can be re-heard and re-seen. Media, in other words, are material means for the production and distribution of meanings across space and time.

In this definition, media are as old as human drawing and writing. However, the forms of media have changed fundamentally across the long arc of human history. One such transformation, beginning half a millennium ago with the invention of print, was the mechanical reproducibility (Benjamin, [1936] 2008) of human communications. With it came a whole communicational infrastructure of typographic culture (Eisenstein, 1979) – books, libraries, newspapers, schools. The twentieth century saw a cascading series of transformations around photographic reproduction and its derivatives – cinema, television, photolithographic printing. In the twenty-first century, we now find ourselves in the midst of a new series of transformations, centred around the digitization of text, image, sound and data and the global interconnection of these digitized meanings through the medium of the internet. This latest phase in the development of media, we call 'new media'.

What make these 'new media' different? In the mass media of the twentieth century, journalists, television producers, radio announcers and authors were the producers of cultural and informational messages, a small creative elite in the 'culture industries' (Adorno, 2001), in the employ of a smaller controlling and owning elite. The consumers of their products were their readerships, audiences, patrons. Culture flowed from a few producers to many consumers. These media were driven by economies of scale – technologies of 'broadcast' to 'mass markets', shaping 'mass culture'. Their effect was to position the spoken-to-many in a particular relationship of knowledge and culture to the speaking-to-few.

These media relations were aligned with the epistemic relations of 'didactic pedagogy' (Kalantzis and Cope, 2012b). In the words of St Benedict, founder of the Western medieval monastic models of epistemic authority, that later became the modern university, and later still, the modern school, 'For it belongeth to the master to speak and to teach; it becometh the disciple to be silent and to listen'. The cognitive masters of the earlier modernity were the players in the 'culture industry' – and the teachers. Their disciples were readerships, viewers, listeners – and students. Authority 'belongs' to some, according to St Benedict. Quiescent epistemic acceptance 'becomes' the rest of us.

The new media and social media are by comparison 'participatory' (Haythornthwaite 2009; Jenkins, 2006). The balance of cultural and epistemic agency is transformed. Tweets and smart phone images become the news because everyone can be a reporter. No need to send a camera crew to a news event. (They'll get there too late most of the time, anyway.) Someone will be there to take a picture, or make a video, or tweet an observation, and share it with the world. The mass media of an earlier era is also displaced in this act of 'upload' by the participatory media of the social web. Everyone is a reporter now. And it's not just the big news. It's the micro news of the meal I am having, the people I am with, the thing-of-note I just saw or read on the web, and my opinions and my feelings of the moment. The old, hierarchical role divisions of cognitive and cultural labour are becoming blurred. Readers are simultaneously writers; viewers are simultaneously image makers. New reciprocities, new sociabilities emerge: to like in order to be liked; to follow in order to be followed; to friend in order to be friended – a discourse that is by turns, mutually affirmatory and narcissistically exhibitionist. In these new media everyone is a maker of meaning, culture and knowledge. The old divisions between creators and consumers are blurred. Creating and consuming cultural meanings are not even separate spaces, times, events. They are intertwined into each other in dialogical discourse.

Of course, the situation is not all good, only different and complicated. After all, these same new media that invite us to participate also watch our every move – cravenly in order to sell us stuff, or chillingly as they watch us with suspicion. They take our intellectual work and our lives and make money out of us. Divide today's Facebook or Twitter capitalization by the number of users and you'll be surprised what you're worth to them. You're doing the cultural and epistemic work. They're not paying you for the work you do, but your participatory fortune has become their monetary fortune.

So, new media have a different underlying cultural and epistemic logic from the broadcast or mass media of an earlier media. What are the possibilities for a corresponding 'new learning'? In this chapter we want to analyse the shape of an emerging 'new media' in order to create an account of a 'new learning' that uses these new media and that is appropriate to social conditions broadly created by these new media. The chapter draws upon and extends earlier writings of ours (Cope and Kalantzis, 2010, 2013), as well as our own research and development work creating and evaluating a new media/new learning environment, *Scholar*, with the support of a series of research and development

grants from the Institute of Education Sciences[1] and the Bill and Melinda Gates Foundation.

The opening premise in our argument is that new learning does not necessarily follow from new media. To return to the schools of didactic pedagogy and the foundations of mass-institutionalized education from the mid-nineteenth century, for the first time in human history, schools served as a publicly enforced site of socialization and knowledge transmission. Among the main epistemic artefacts of modern schools were teacher talk and factually or deductively definitive textbook content. Student response was framed in terms of right and wrong answers, either to the question the teacher was asking in class, doing an assignment or responding to questions in a test. Several centuries later, much schooling is still a variant of this didactic paradigm.

Then new media arrives in the classroom. And nothing changes because we soon shape these technologies into the time-tested image of didactic pedagogy. We throw away the printed books, and replace them with e-books, but these still position learners as consumers of content created by experts for their consumption. We create the 'flipped classroom' (Bishop and Verleger, 2013). But all this means is that we record the traditional teacher lecture so the students can still impassively listen to it, albeit now at any time they find convenient. And we check that students have remembered what they have consumed with computer quizzes, albeit more often now because they can be embedded into the e-books and adaptively adjust the questions to the response of the student. Nevertheless, all they do is replicate the old memory game that was the summative, selected response test.

Moreover, after half a century of application in traditional educational sites, the overall beneficial effects of computer-mediated learning remain essentially unproven. In his examination of 76 meta-analyses of the effects of computer-assisted instruction, encompassing 4,498 studies and involving 4 million students, John Hattie concludes that 'there is no necessary relation between having computers, using computers and learning outcomes'. Nor are there changes over time in overall effect sizes, notwithstanding the increasing sophistication of computer technologies (Hattie, 2009: 220–1). Warschauer and Matuchniak (2010) similarly conclude that technology use in school has not been proven to improve student outcomes, though different kinds of pedagogical applications of technology do. More recently, in a review of technology integration in schools, Davies and West (2014) conclude that although 'students … use technology to gather, organize, analyze, and report information, … this has not dramatically improved student performance on standardized tests'.

Technologies do not in themselves change anything in education. However, we also want to suggest that new media offer a number of pedagogical openings, or affordances. Changing the medium does not necessarily change the message. In finely grained analysis, Hattie reveals that although computers do not themselves lead to improved learning outcomes, specific applications of computers can. In a disaggregated view of the meta-analyses, Hattie concludes that certain uses do produce gains for learners, for instance when the student is afforded a degree of control or self-regulation in learning, when a diversity of teaching strategies is used, when peer learning is optimized and when teachers are highly competent in technology use (Hattie, 2009: 222–7). These modulations in the research evidence also reflect the wide range of applications of computers, across the spectrum of instructional design, pedagogical approach, epistemological frame and assessment/feedback mode. So the key is to explore differential effects on learner performance according to the exploitation of specific affordances in new media.

In this chapter, we are going to explore seven new learning affordances opened up by new media: ubiquitous learning, active

knowledge production, multimodal knowledge representations, recursive feedback, collaborative intelligence, metacognitive reflection and differentiated learning. None of these aspirations is new – many in fact, are in spirit as old as the progressive or authentic pedagogy of Rousseau, Montessori and Dewey. However, the new media facilitate an economy of effort that makes these ideals more pragmatically realizable than in the past. Not that the technology itself is intrinsically a catalyst for educational change. To reiterate, the very same technologies that offer these practical openings for educational transformation, can also be used to breathe new life into the most didactic of pedagogies, even intensifying the legacy processes of transmission of content, stimulus-response learning behaviour modification, and rigid standardized testing. For this reason, we want to explore some of the ways in which new media can bring to practical realization new learning.

1. UBIQUITOUS LEARNING

Ubiquitous learning means learning any time, any place (Cope and Kalantzis, 2009). Older versions of the idea of formal learning out-of-school included homework, self-paced textbooks and 'distance education'. Ubiquitous learning is a riff on the idea of 'ubiquitous computing' (Twidale, 2009). Once science fiction, with the rise of laptop computers, tablets and smart phones, ubiquitous computing is an idea that arrived a long time ago in a very ordinary and pervasive way – in every store, every workplace, and almost every home, handbag or pocket. But only recently in schools, if yet. And when it does arrive there, it is often in ways that hardly do justice to the dynamic knowledge potentials of new media.

Internet-mediated computing, and particularly 'Web 2.0' (O'Reilly, 2005), 'cloud computing' (Reese, 2009) and 'semantic publishing' (Cope et al., 2011a) technologies

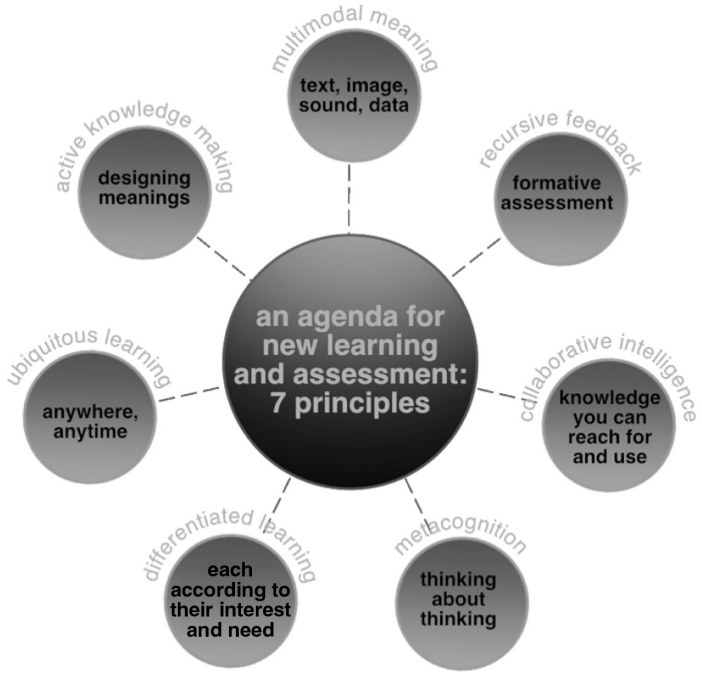

Figure 35.1 e-Learning ecologies: seven affordances

create possibilities for something that is more thoroughly transformative in education. The significantly new things that can be offered by ubiquitous learning environments range from student discovery of multimodal content originating from a variety of authentic sources, to intensive simultaneous interactions in which everyone in the learning community can be actively engaged, and far more responsive feedback and assessment systems.

Perhaps most significant, however, is that the traditional educational distinctions of time and space no longer matter. Before, the central point of all learning was necessarily confined to the four walls of the classroom, and the times delimited by the cells of the timetable. Ubiquitous learning means you can do all the stuff of traditional classrooms, and more, and anywhere, and anytime. Learners using ubiquitous computing technology are able to perform the same acts of knowledge-making and knowledge interaction – and new ones as well – inside the classroom as they can outside of the classroom.

Scale also disappears as a factor in learning – a class of three and a class of three thousand can be configured to work the same way, be that the video lecture, textbook and test routine of didactic pedagogy, or highly reflexive social relations of knowledge, including giving and receiving peer feedback, collaborative writing, and threaded discussions.

Does this spell the end of the traditional school? Not necessarily, because school is as good a place as anywhere to work in these technology-mediated ways. One thing will remain constant: society has devolved to schools the responsibility of keeping children in a relationship of duty-of-care during specific times in order to free parents up for work. However, its classrooms – more broadly conceived as learning ecologies – may alternatively have larger numbers of students than the historical norm, or fewer.

2. MULTIMODAL MEANING

The new media are multimodal. We can do all of text, still image, moving image and sound together now, on the one recording/transmitting device. In an earlier modernity, the book or the newspaper mainly consisted of typeset text. It was not until the application of the new technologies of photolithography in the mid-twentieth century that image and text could be easily brought together, which is why until then newspapers had no photos and books needed separate sections for 'plates' (Kalantzis and Cope, 2012a).

Digitization further inveigles text and image. Analogue film and television had very little writing, until digitization. Now news, business and sports channels stream written words over image over sound. The internet also brings it all together, where barely a page operates in a purely written-textual mode. It is not just that these modes are juxtaposed in digital media. They functionally depend on each other. They form a grammatical and structural unity: the comment that makes no sense without the image; the caption that points to criterial features in the image; the textual metadata that makes an image discoverable and links the preceding image to the next.

The grounding for this multimodality is practical, material, tangible, a product of industrial design even before reaching the consumer. Then once in the consumer's hands, meaning is a matter of manufacture. These modes are all made of the same material stuff, text and image of pixels, and one layer behind that, sound and manipulable data as well in common binary encodings. This is how we can manufacture all these meanings in the one recording and dissemination device. This device – a phone, a tablet, a laptop – becomes a cognitive prosthesis for the purposes of both representation (lending support to our thinking-for-ourselves) and communication (defying distance by connecting us through telepresent messaging-for-others).

Now that we have at hand the tools for fully multimodal knowledge representation, we can offer these to our learners. Our times require us to move beyond the handwriting book or the word processor. Instead, our learners should be working in the twenty-first-century world of web communications. This is a pedagogical imperative as well as a practical one, so students can represent their meanings independently and simultaneously in different modes – written, oral, visual, audio and dataset. Each mode complements the other – the diagram and the text, the oral and the written explanation, manipulable data and its synthetic summary. Each can say the same kinds of things as the other, and is also an irreducibly different mode of representation.

Much can be learned by moving backwards between modes, representing meaning in one mode then another – a cognitive process we have called 'synesthesia', extending by metaphor the meaning of a word whose origins lie in cognitive psychology (Kalantzis and Cope, 2012a: Chapter 7). Take the science experiment – the representation of its results can include words, diagrams, tables, dataset, and also a video demonstrating the experiment itself. Learning is deepened as students shift from one mode to another, making their meanings one way, then another complementary way.

3. ACTIVE KNOWLEDGE MAKING

The characteristic mode of acquisition of knowledge after the introduction of mass-institutionalized education in the nineteenth century involves the following configuration: a bureaucratic apparatus that prescribes content areas to be learned in the syllabus; textbooks that lay out the content; teacher recitation; teacher–student question and answer routines; filling out answers in workbooks; reading texts and answering comprehension questions; writing short texts to check what had been learned. The patterns of practice were predictable and straightforward.

This heritage classroom is, in essence, an epistemic architecture grounded in a communications technology. The communications technology is defined by the walls of the classroom, containing thirty or so children and where one teacher or one student can speak at a time. Here, teachers and textbooks present pithy concentrations of the world in the form of history, or grammar, mathematics, or whatever. These are essentially monologues, bodies of knowledge spoken in a singular, synoptic voice, whether the voice be that of the teacher or textbook author. Students read silently, write quietly, and avert their eyes from lateral 'copying' glances as they fill out their worksheets or respond to quizzes. These are almost solitary process, even when other learners are so close at hand. The aim is that facts are to be committed to memory and theorems learned from which unequivocal answers can readily be deduced. These memories and the application of the theorems can be measured in tests that have right and wrong answers, at the end of a lesson, or week, or a chapter, or a course.

In this knowledge architecture, students are primarily configured as passive knowledge consumers. The knowledge that is transmitted to them takes the form of a univocal narrative. It is declarative knowledge. The moral economy of this single-minded content transmission speaks to unquestioning compliance in the face of epistemic authority, lack of critical autonomy on the part of the receivers of knowledge, and an absence of epistemic and social responsibility. This may have been appropriate, perhaps, for an earlier era of industrial discipline and mass conformity.

It also aligned with the cultural logic of broadcast or mass media. In this old, cognitive-epistemic regime, the ability of the spoken-to-many to speak back was very limited – a carefully vetted letter to the editor, the occasional person who managed to get through to a talk-show host, just one at a time. Discursively, this relation was modelled in

response to the single student who answered the teacher's telling question on behalf of the whole class. For the vast majority of audiences (and students), these moments of participation were tokens, for rhetorical effect only. Media and discursive participation were at best vicarious.

The sensibilities, habits of mind and skills of heavily didactic pedagogy are not well aligned to the spirit and practical needs our times, with its intensively participatory new media. Going forward into the future, workers, citizens and learners will not be well served by these kinds of knowledge architectures. New media not only afford us the opportunity to create environments of participatory learning in schools, where learners are knowledge producers at least as much as they are knowledge consumers. Indeed, the new media also suggest we should do this, so education remains apt to our times and aligns with the media sensibilities of new learners.

So, for instance, learners will examine multiple sources (discovering texts with different perspectives, conducting their own observations, indeed acting as researchers themselves). They will collaborate with peers in knowledge production, as co-authors, as peer reviewers, and as readers and discussants of finished works shared by and with other learners. They will create always-original knowledge syntheses based on unique life experiences and perspectives.

In these ways, it is possible to use new media to supplement the predominantly hierarchical knowledge flows of our recent past (expert to novice, authority to authorized, teacher to student) with relations of lateral knowledge co-creation. This fits nicely with wider contemporary shifts in the 'balance of agency' (Kalantzis and Cope, 2012b), where consumers are becoming 'prosumers' with their customizable products and interfaces; where reading (in so far as it is a kind of consumption) is intermingled with writing (in so far as it is a kind of production) in the new media; where amateurs are barely distinguishable from professionals in web knowledge spaces like Wikipedia; and where the pleasure of the narrative in gaming is not simply vicarious as it is in television or cinema because now you are positioned as a character with shared responsibility for the story's ending.

4. RECURSIVE FEEDBACK

Old media were linear – the one-way flows of information and culture from television studio to viewer, from newspaper office to reader, from radio studio to listener, from movie lot to audience. New media are by comparison recursive. At the beginning of the computer age, Norbert Weiner attempted to capture the logic of self-adjusting systems, both mechanical and biological, with the concept of 'cybernetics' (Weiner, 1965 [1948]). The Greek *kybernetis*, or oarsman, adjusts his rudder one way then another, in order to maintain the course of the vessel. Whereas the communicative logic of the old media was linear (knowledge creator to passive knowledge consumer), new media is dialogical and recursive, to the point even where it is hard to distinguish creator and consumer. Feedback is pervasive. Web reputation and moderation systems add social filters to the feedback (Farmer and Glass, 2010). The 'quantified self' of ubiquitous devices provides continuous feedback on self in space and society, from walking directions, to exercise routines, to the social reach of a post.

Feedback systems in traditional schools were, like old media linear, starting with the curriculum and ending with the test. (The step after that in the curriculum was something different.) In this regime, the summative test is separated from learning – an at-the-end managerial thing, a retrospective judgement which can do little in an immediate sense to further learning. It also conceives knowledge in a peculiar way, using as it does quite different devices from the ordinary processes of engaging with knowledge and learning themselves. Assessment becomes a strangely

school-ish game in which students do things like discriminating atomized right responses from trick 'distractors', designed to look right but which are deceptively, deliberately not right. In recent decades, the obsession with testing for the purposes of institutional accountability has magnified everything that was problematic about these linear processes. New media technologies, however, mean that assessment does not have to be this way anymore (Cope et al., 2011b).

New media enables a renewed focus on formative assessment – assessment that is on-the-fly, and that makes in a detailed and constructive way a direct contribution to student learning (Black and Wiliam, 1998; Wiliam, 2011). In the era of social knowledge technologies, no learning environment should be without always-available feedback mechanisms – machine feedback and machine-mediated social feedback. Then, when it comes to summative assessment, all we need to do is present a retrospective view of student progress, using no more and no less than all the data collected in the formative assessment process. In fact, we might in the not-too-distant future be able to abandon summative assessment, and its perverse peculiarity as an artefact and its baleful institutional effects. And this because there is so much assessment going on, all the time – recursive feedback from so many perspectives, of everything the learner does in digitally mediated learning environments.

New media also facilitate a broader range of assessment modes. The machine itself can provide some feedback using natural language processing algorithms, and this feedback is computable. There is also the possibility of constant, machine-mediated human feedback, 'crowdsourced' (Surowiecki, 2004) from multiple perspectives – teacher, peers and self. Revealingly, we have shown in our research that the mean of two or more peers' assessments is remarkably close to the score of an expert rater (Cope et al., 2013). Teachers and learners are all assessing learning, and every one of their perspectives has distinctive value. In fact, as perspectives vary, the feedback may be more extensive, more thought-provoking, more rapidly provided and thus more valuable, than the most assiduous of lone teacher-markers. We can also moderate the various ratings and calibrate results via processes of inter-rater reliability, and the result may also be a more reliable assessment. One effect of distributing assessment responsibilities in this way is to make assessment processes explicit and remove the trickery. This is also to democratize assessment, where teacher and students are all measuring learning against the same criteria, in the same ways. Mixed with and moderated against a variety of assessment modes, there remains value in survey-based assessment, particularly if it is used for formative purposes. Recent advances in survey psychometrics, including computer-adaptive testing and diagnostic testing, also offer new potentials for this assessment mode (Chang, 2012, 2014).

The overall result of combining this information is a phenomenon that has been termed 'big data' in education, accompanied by the emerging educational subfield of 'learning analytics'. Leaders in this emerging area speak clearly to what they consider to be a paradigm change. Bienkowski et al. (2012, p. ix) point out that 'educational data mining and learning analytics have the potential to make visible data that have heretofore gone unseen, unnoticed, and therefore unactionable'. West (2012, p. 1) directs our attention to "'real-time" assessment [with its] … potential for improved research, evaluation, and accountability through data mining, data analytics, and web dashboards'. Behrens and DiCerbo (2013) argue that:

> technology allows us to expand our thinking about evidence. Digital systems allow us to capture stream or trace data from students' interactions. This data has the potential to provide insight into the processes that students use to arrive at the final product (traditionally the only graded portion). … As the activities, and contexts of our activities, become increasingly digital, the need for separate assessment activities should be brought increasingly into question. (2013, p. 9)

Chung traces the consequences for education in these terms:

> Technology-based tasks can be instrumented to record fine-grained observations about what students do in the task as well as capture the context surrounding the behavior. Advances in how such data are conceptualized, in storing and accessing large amounts of data ('big data'), and in the availability of analysis techniques that provide the capability to discover patterns from big data are spurring innovative uses for assessment and instructional purposes. One significant implication of the higher resolving power of technology-based measurement is its use to improve learning via individualized instruction. (Chung, 2013, p. 3)

DiCerbo and Behrens (2014, p. 8) conclude:

> We believe the ability to capture data from everyday formal and informal learning activity should fundamentally change how we think about education. Technology now allows us to capture fine-grained data about what individuals do as they interact with their environments, producing an 'ocean' of data that, if used correctly, can give us a new view of how learners progress in acquiring knowledge, skills, and attributes.

Learning analytics is also expected to do a better job of determining evidence of deep learning than standardized assessments – where the extent of knowing has principally been measured in terms of long-term memory, or the capacity to determine correct answers (Knight et al., 2013). As Behrens and DiCerbo (2013; DiCerbo and Behrens, 2014) characterize the shift to big data, we move from an item paradigm for data collection with questions that have answers that can be current and elicit information, to an activity paradigm with learning actions that have features, offer evidence of behavioural attributes, and provide multidimensional information. How, raising our evidentiary expectations, can educational data sciences come to conclusions about dimensions of learning as complex as mastery of disciplinary practices, complex epistemic performances, collaborative knowledge work and multimodal knowledge representations? The answer may lie in the shift to a richer data environment and more sophisticated analytical tools, many of which can be pre-emptively designed into the learning environment itself, or 'evidence-centred design' (Mislevy et al., 2012; Rupp et al., 2012).

So what might we achieve with these modes of assessment that extensively use new media? One effect may be to reframe the assessment question from 'how did we do?' to 'how are we doing?' – 'we' being the learner, the class, the teacher. Assessment's primary reference point would not then be a managerial focus on results (framing our assessment question in the past perfect tense), but a formative focus on progress and improvement (framing our assessment question in the present continuous tense).

Moreover, as well as being able to measure individual work, we can measure social interactions and peers' contributions to others in the form of the feedback they have provided. In other words, we can assess learning interactions as well as learning artefacts. We can also build recursive feedback – feedback whose value is weighted by feedback on feedback, and ratings that are moderated by inter-rater reliability calculations. We can, in other words, calibrate crowdsourced assessment so it is increasingly reliable, and perhaps even more so than the expert marker assessment in isolation.

We could even take a more audacious step, in the direction of a 'no failure' educational paradigm, where you can keep taking on feedback until you are as good as good is supposed to be. This is by way of contrast with the distribution of students across a bell curve, where the few can succeed only because most are destined to be mediocre or fail. A culture of mutually supportive constructive feedback not only models the ideals of a knowledge economy where teamwork and networked collaborations are more valuable than ever; assistance helps the stronger as well as the weaker. It sets community standards, where the weaker see models in the works they review that are stronger and the completed works of peers published to a web portfolio. And, in feedback-on-feedback and the measurement of constructive interactions,

peers are offered help credits rather than being rewarded with the beating-the-other-person credits of the normal distribution curve.

5. COLLABORATIVE INTELLIGENCE

Traditionally, schooling has been based on the idea of individual intelligence, where intelligence itself is narrowly conceived as personal memory and the mechanical skills of deduction. The human mind, however, is an intrinsically social thing (Gee, 2013 [1992]). Our cognitive capacities reside in the language we have inherited and the ways of seeing we have learned. Intelligence is our capacity to reach for always-available social memory and to apply available logics and computational tools. It is what we can do together in communities of practice. Today, through ubiquitous computing and the social web, externalized memory and computational tools are accessible that have historically unprecedented power. At the same time, work, public and community life is more manifestly energized by collaborations. In the new media, peer-to-peer collaborations, from Wikipedia to the video library that is YouTube, are the product of massive social collaborations. So much for the culture of closed book examinations or isolated, individualized student work. The new media have made these ideas and practices anachronistic.

As students increasingly do their school work in new media environments, instead of memory work we can focus our evidentiary work on the knowledge artefacts that learners create in digital media – a report on a science experiment, an information report on a phenomenon in the human or social world, a history essay, an artwork with exegesis, a video story, a business case study, a worked mathematical or statistical example, or executable computer code with user stories. These are some of the characteristic knowledge artefacts of our times.

In the era of new media, learners assemble their knowledge representations in the form of rich, multimodal sources – text, image, diagram, table, audio, video, hyperlink, infographic, and manipulable data with visualizations. These are manifestly the product of distributed cognition, where traces of the knowledge production process are as important as the products themselves – the sources used, peer feedback during the making, and collaboratively created works. These offer evidence of the quality of disciplinary practice, the fruits of collaboration, capacities to discover secondary knowledge sources, and create primary knowledge from observations and through manipulations. The artefact is identifiable, assessable, measurable. Its provenance is verifiable. Every step in the process of its construction can be traced. The tools of measurement of artefacts are also expanded – natural language processing, time-on-task, peer- and self-review, peer annotations, edit histories, navigation paths through sources. In these ways, the range of collectable data surrounding the knowledge work is hugely expanded.

Our evidentiary focus may now also change. We no longer need to seek elusive forms of evidence, for example the traditional constructs such as the 'theta' of latent cognitive traits in item response theory, or the 'g' of intelligence in IQ tests. In the era of digital we don't need to be so conjectural in our evidentiary argument. We don't need to look for anything latent when we have captured so much evidence in readily analysable form about the concrete product of knowledge work, as well as a record of all the steps undertaken in the creation of that product.

We also need to know more than individualized, 'mentalist' (Gergen and Dixon-Román, 2013) constructs can ever tell us. We need to know about the social sources of knowledge, manifest in quotations, paraphrases, remixes, links, citations, and other such references. These things don't need to be remembered now that we live in a world of always-accessible information; they only need to be aptly used. We also need to know

about collaborative intelligence where the knowledge of a working group is greater than the sum of its individual members. We now have analysable records of social knowledge work, recognizing and crediting for instance the peer feedback that made a knowledge construct so much stronger, or tracking the differential contributions of participants in a jointly created work.

In these ways, artefacts and the processes of their making may offer sufficient evidence of knowledge actions, the doing that reflects the thinking, and practical results of that thinking in the form of knowledge representations. As we have so many tools to measure these artefacts and their processes of construction in the era of new media, we can safely leave the measurement at that. In these ways then, new media and its associated 'big data' learning analytics may shift the focus of our evidentiary work in education, to some degree at least, from cognitive constructs to what we might call the 'artefactual'. Where the cognitive can be no more than putative knowledge, the artefactual is a concretely represented knowledge and its antecedent knowledge processes.

6. METACOGNITION

Metacognition is a means to think more deeply, at a higher level of abstraction. It also produces efficiencies in thinking and learning. Conceptualization at higher levels of abstraction broadens the scope of application and transfer for ideas and understandings. There is a growing literature on the significance of metacognition in learning (Bereiter, 2002; Bransford et al., 2000).

Processes of metacognition align with the logic of new media. James Gee argues that computer games demand meta-level thinking about the semiotic domain – it is not enough to play the game; to play it well you have to develop an understanding of its design principles and underlying architecture (Gee, 2003). New media cannot be 'read', page after page; they require an understanding of navigational schemes and information architectures.

Meanwhile, in education, didactic pedagogy operates within a flat epistemic world of single-layered, cognition: information that can be remembered, routines by means of which correct answers can be deduced, and correct application of concepts. Metacognition adds a second layer of thinking, of the same order as the navigational architectures of new media. This layer consists of a meta-understanding of the nature of disciplinary practice. This layer is generative, supporting transfer of understanding across contexts, including contexts not yet encountered. It also supports mnemonic work, using devices to assist recall (tags, annotations, codings, bookmarks) that speak to general levels of meaning.

As an instance of media supported learning, we take the example of student peer reviews of written science arguments. In revising their arguments in the light of peer feedback, a learner may be asked to analyse whether a claim is adequately supported by evidence, and thus to consider the nature of the relationship of claims and evidence in science. This creates a dialectical play between first level cognition (thinking about climate change or hydraulic fracking, perhaps), and a second order of reflective thinking about the ways in which valid scientific claims must be supported by evidence (Cope et al., 2013). In this formative assessment process, students externalize and analyse their written representations of science against specific criteria, becoming more analytic in their science thinking (Driver et al., 2000). Munford and Zembal-Saul (2002) summarize the metacognitive benefits to students: opportunities to learn not only content but also about disciplinary theories and processes, including an understanding of the role of documentary knowledge representations and social interaction in the process of knowledge construction; engagement with discourse that renders learners' understanding and thinking visible, thus providing a valuable tool for reflection and assessment; and support for developing

different ways of thinking and enhancing understandings of disciplinary ideas.

7. DIFFERENTIATED LEARNING

Mass media built mass audiences, to whom were transmitted mass culture. Culture moreover, was homogenized, assumed to be uniform and, to the extent that it was possible, made uniform by the mass production and distribution of newspapers, television, radio and best-selling books. The logic of mass production produced with it cultures of mass consumption. This was intrinsic to the economies of scale that characterized the systems of cultural production and distribution in the era of mass communications.

Today, there are no such economies of scale in the media. Every Facebook feed, every Twitter stream, is uniquely customized for and by the user to suit their interests, identity, and place in the world. Big contributors (famous people, companies, large movements) get equal billing with friends, colleagues and the smallest of minority interests. Diversity is everything. Divergence – of identity, taste, affiliation, stance, interest – is the norm. In the era of new media, our persons are becoming more different.

Heritage classroom communication architectures are like the old, mass media. They are oriented to one-size-fits-all transmission of identical content. The teacher speaks to the middle of the class, which means that what they are saying is not understandable for some students and boringly obvious for others. Progressing through the textbook, all students need to be on the same page at the same time. And when it comes to the test, there is just one set of right answers – 'standardization' is made a virtue. This arrangement is premised on a homogenizing knowledge focus and learning pace. Homogenization, however, is a premise that fails as often as it succeeds.

Few would disagree nowadays that differentiated learning is better. But it is harder work than homogenizing teaching. It is more of a logistical challenge for the teacher. It requires that you are a better teacher, with a broader repertoire of strategies, and superb classroom management skills.

New media make differentiated instruction more feasible. Learners can be doing the same thing at their own pace, or they can be doing different things according to their needs or interests. Such is the objective of adaptive, personalized or differentiated instruction which calibrates learning to individuals (Conati and Kardan, 2013; Shute and Zapata-Rivers, 2012; Walkington, 2013; Wolf, 2010).

This becomes all the more feasible once the teacher has an immediate view of where they are up to in a project status screen. Indeed they can click right into the student's work and see their most recent keystroke. Moreover, positioning the student as a knowledge producer affords more space for student voice, interest, experience and localized relevance. In general terms, the intellectual project might be the same, but the topics may vary. Or, where the aim is collaborative knowledge creation, every student might be working on one distinctive piece in a jigsaw puzzle of class knowledge that is later disclosed when it is published and shared with the class community. Instead of forcing homogeneity, such a classroom operationalizes the principle of productive diversity or the complementarity of differential knowledge and experiences. Students might go on to cite each others' works as knowledge sources, as distributed expertise. Such a learning ecology is one that harnesses learner identities, deepens their sense of engagement, and increases their motivation to devote time to task and engage with others in their knowledge community.

Then assessment becomes a somewhat different process than in the past, not measuring capacities to remember identical things or correctly deduce the same answers, but measuring higher order comparabilities and equivalences between knowledge artefacts which may in substance be different. In this assessment regime, you don't have to be the

same to be equal. At this point, managing learner differences may become easier than one-size-fits-all teaching.

Computer-mediated learning environments are now available whose intrinsic mechanism and advertised virtue is divergence – variously named as adaptive or personalized learning (Conati and Kardan, 2013; Koedinger et al., 2013; McNamara et al., 2012; McNamara and Graesser, 2012; Wolf, 2010). In these learning environments, recursive, dynamic, recalibrating systems are the new norm. Such environments are unstandardized by design. The data they generate are dynamic because they are built to be self-adjusting systems. They are difference engines.

CONCLUSION

None of the seven ideas that we have outlined in this paper is new to the theories or practices of education. In fact, each of them has its origins in pedaogical propositions that have frequently been made, in one form or another, since the first moments of modern, mass-institutionalized education.

The moment of new media is a moment of profound social transformation. 'Disruptive' is a word often applied to new information and communications technologies, to the point at times where the word is almost a cliché. However, we would not want to disrupt traditional schooling simply for disruption's sake. It is simply, pragmatically, to keep education relevant to our changing times. When we turn our attention to the new media, for every moment of mendaciousness on the part of the new media behemoths, we also see glimpses of new social possibility. As it is with new media, so it is with new learning. For every distressing moment where technologies reproduce the worst of didactic pedagogy, there are other moments where something powerfully generative is happening – liberating, even. The agenda now is not just to use new media in learning. It's to do powerfully reflexive pedagogies, and in so doing to open out new social relations of knowledge and culture.

NOTE

1 US Department of Education Institute of Education Sciences: 'The Assess-as-You-Go Writing Assistant: A Student Work Environment that Brings Together Formative and Summative Assessment' (R305A090394); 'Assessing Complex Performance: A Postdoctoral Training Program Researching Students' Writing and Assessment in Digital Workspaces' (R305B110008); 'u-Learn.net: An Anywhere/Anytime Formative Assessment and Learning Feedback Environment' (ED-IES-10-C-0018); 'The Learning Element: A Lesson Planning and Curriculum Documentation Tool for Teachers' (ED-IES-lO-C-0021); and 'InfoWriter: A Student Feedback and Formative Assessment Environment for Writing Information and Explanatory Texts' (ED-IES-13-C-0039). Scholar is located at http://CGScholar.com

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