Learning technology through three generations of technology enhanced distance education pedagogy

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Abstract

This paper updates earlier work in which we defined three generations of distance education pedagogy. We then describe emerging technologies that are most conducive to instructional designs that evolve with each generation. Finally we discuss matching the pedagogies with learning outcomes.

Keywords: distance education pedagogy, distance education technology, generational change, cognitive-behaviourist pedagogy, constructivist models, connectivist pedagogy

Introduction

This paper expands on an earlier work, *Three generations of distance education pedagogy* (Anderson & Dron, 2011) by describing the technologies and the synergetic results of using effective pedagogy in combination with emerging technologies – to create powerful learning opportunities. Unlike earlier classifications of distance education (Garrison, 1985; Nipper, 1989; Taylor, 1995), which were based solely on the technology used, this analysis focuses on the pedagogy that defines the learning experiences encapsulated in the learning and instructional designs. The three generations of technology enhanced teaching are cognitive/behaviourist, social constructivist and connectivist. The paper looks at recent developments in emerging educational technology and discusses the ways in which these tools can be used and optimized to enhance the different types of learning that are the focus of distance education theory and practice.

Technology enhanced education, like all other technical-social developments, is historically constituted in the thinking and behavioural patterns of those who developed, tested and implemented what once were novel systems. The designs thus encapsulate a world view (Aerts et al., 1994) that defines its epistemological roots, development models and utilized technologies – even as the application of this world view evolves in new eras. For example, industrial and scientific thinking propelled the development of industrial models of distance education aptly described by Peters (1988). Recursively, the technologies we create and use also come to influence our world or as the quib attributed to Marshall McLuhan aptly states "we shape our tools and thereafter our tools shape us".

The past century witnessed the fastest and greatest evolution of technical capacity known in human history with profound consequence to all human activity. Though hardly an original observation, it is interesting to note that distance education evolved from a Gutenberg-era print and mail system to one that supports low-cost, highly interactive learning activities that span both time and distance with equal facility. Significantly, the constraints of the correspondence model simply did not allow educators to employ highly interactive educational models and processes.

Educators have always had profoundly ambiguous and often suspicious relationships with technology. The late Boston scholar Father Stanley Bezuska assembled a series of humorous quotes (see http://www.slideshare.net/committedsardine/funny-predictions-throughout-history) illustrating the doomsday predictions of teachers as they have been forced to deal with educational technologies. For example, in 1928, the *Rural American Teacher* lamented, "Students today depend upon store-bought ink. They don't know how to make their own. When they run out of ink they will be unable to write. This is a sad commentary on modern education." And in 1950, the *Federal Teacher* cynically predicted that "ball point pens will be the ruin of education!" (as cited in Thornburg, 1992) . No doubt, noting the futility of trying to predict the impact of technologies on teaching, modern educational pundits are more likely to disguise deep animosity to technology by putting technology in a more subservient role to that of pedagogy. Thus we hear the familiar line that "technology is just (or only) a tool". Such a cavalier attitude denies the professional responsibility to use available tools both effectively and efficiently. Can one imagine a surgeon willingly performing an operation with a Swiss Army knife and arguing that the tool doesn't matter, that it

was his skill and use of the tool that created effective practice?

However, it is not productive to argue from a polar opposite perspective, either. We have all seen instances where very powerful technology cannot be used, or is put to ineffective use, because the learning activities, evaluation method or outcomes expected – the educational pedagogy – neutered that technology.

We've argued earlier that for optimal performances, the pedagogy and the technology must create an engaging and compelling dance (Anderson, 2009). The technology is the music setting the tempo, the beat, the timbre and the compelling melodies. The pedagogy defines the choreography, directing the dancers sweeping motions, graceful extensions and enduring embraces. Together, technology and pedagogy reveal and develop our human creativity and responsiveness and allow us to learn effectively and enjoyably. Indeed, though the authors of this paper are not in complete agreement about this, it is possible to think of pedagogies (considered as the processes and methods used in an attempt to bring about learning) as technologies, integral parts of a technological assembly that must work together with all of the other technologies to bring about a successful outcome (Dron, 2012).

To help us bring chronological order to the large number of technologies used in distance education, it has been common to think of development of technology as occurring in three (or more) overlapping generations (Bates, 2005; Garrison, 1985; Gunawardena & McIsaac, 2004; Nipper, 1989) While there are small differences between these different perspectives, they broadly agree on the dominant technological forms that define each generation. The first generation of distance education technology was one of postal correspondence. This was followed by a second generation defined by the use of mass media including television, radio and film. Third generation distance education introduced interactive technologies, mostly networked and involving multiple participants interacting with one another – first audio, then text, video, web and, most recently, immersive conferencing. It is less clear what defines so called fourth and even fifth generation distance education technologies except for a use of intelligent data bases (Taylor, 2001) that create "intelligent flexible learning" or that incorporate Web 2.0 and semantic web technologies.

It should be noted that none of these generations has been eliminated over time, but rather the repertoire of options available to distance education designers and learners has increased. As Kelly observes, few (if any) technologies have ever actually disappeared (Kelly, 2010). What happens is that, as new technologies become available the range of adjacent possibilities enabled by technologies continually increases (Kauffman, 2000). This notion helps to explain the dance of pedagogy and other technologies and brings some coherence to the otherwise fuzzy concept of affordances (Conole & Dyke, 2004; Gibson, 1977; Norman, 1990) by describing the ways that not only do technologies differentially present opportunities to those that use them but also open up new possibilities that did not exist before. Not only do technologies not die, but new ones incorporate the old: as Arthur argues, technologies evolve not through adaptation but by assembly, incorporating pieces of earlier designs (Arthur, 2009). All past generations of distance education technologies, as well as the pedagogies that dominated their use, remain in effective use today.

Distance education, as practiced today, does not follow a single paradigm worldview, rather, as Dills and Romiszowski (1997, p.18) described the field of educational technology, distance education is "a loose confederation of fields that are quite independent of each other and yet that are not merely different aspects of the same field". These paradigm discussions often ignite into controversy especially when standards organizations attempt to define quality in distance education. Different generations of pedagogy describe, define and defend divergent notions of quality (for example the need for peer-to-peer interaction) while sharing many common descriptions (such as opportunities for some type of student-student, student-content or student-teacher interaction).

In an earlier work (Anderson & Dron, 2011), we examined each of these generations of distance education pedagogy through the lens of the familiar community of inquiry model (Garrison, Anderson & Archer, 2000a, 2000b) examining the social, cognitive and teaching presence associated with each. In this paper, we focus on typical learning activities associated with each pedagogy and examine the affordances (Conole & Dyke, 2004; Gibson, 1977) and potential of emerging technologies to support and enhance each generation. We will see that the ubiquitous capacity of the Internet is creating very profound opportunities for enhancing the effectiveness and efficiency of all three pedagogical models.

Cognitivist/behaviourist pedagogy

Cognitive and behaviourist (CB) pedagogies focus on the way in which education was predominantly defined, practiced and researched during most of the 20th century. Behavioural learning theory is based on the notion that learning occurs when learners adopt new behaviours or demonstrate a change in behaviour as the result of an individual's response to stimuli. Note that in this definition the focus is on the individual and the necessity for measuring actual behaviours and not attitudes, intentions or capacities.

This first generation of distance education pedagogy gave rise to a new profession – that of the instructional designer – a professional who designed learning activities that would be enacted by students alone, or with an instructor, at a time, and/or place apart from the designer. Instructional systems theories developed to guide creation of often directed and tightly orchestrated "events" and the learning results were rigorously assessed generally using positivist research paradigms and methodologies. Behaviourist notions

are especially attractive in training (as opposed to educational) contexts as the learning outcomes associated with training are usually clearly measured and demonstrated behaviourally.

From behaviourist pedagogy emerged the cognitive learning theories that focus on how processing within the individual brain effects comprehension, understanding, storage and retrieval of information. Cognitive pedagogies arose partially in response to a growing need to account for motivation, attitudes and mental barriers that may only be partially associated or demonstrated through observable behaviours – yet they are directly linked to learning effectiveness and efficiency. Cognitive models are based on a growing understanding of the functions and operations of the brain and especially of the ways in which computer models are used to describe and test learning and thinking. Much research using this model proceeds from empirical testing of multi-media effects, cognitive overload, redundancy, chunking, short- and long-term memory, and other mental or cognitive processes related to learning (Mayer, 2001). Although learning was still conceived of as an individual process, its study expanded from an exclusive focus on behaviour to changes in knowledge or capacity that are stored and recalled in individual memory. The tradition continues with the successful application of experimentally verified methods like spaced learning (Fields, 2005) and applications of brain science, as well as more dubious, scientifically unsound and unverifiable learning style theories (Coffield, Moseley, Hall & Ecclestone, 2004) that achieved popularity towards the end of the twentieth century and that still hold sway in many quarters today. The locus of control in a CB model is very much the teacher or instructional designer. Such theories provide models of learning that are directly generative of models of teaching.

It is notable that CB models gained a foothold in distance education at a time when there were only very limited technologies available that allowed many-to-many communication. Audio teleconferencing was perhaps the most successful means available but came with associated costs and complexity that limited its usefulness and scalability. The postal service and publication or redistribution of messages was very slow, expensive, and limited in scope for interactivity. Methods that relied on one-to-many and one-to-one communication were really the only sensible options because of the constraints of the surrounding technologies.

Learning activities associated with cognitive–behaviourist models

The instructional design models associated with the CB generation of distance education hold great sway in skills training markets. Unlike the craft models of classroom based teaching, CB models developed "scientific models" that guided the development, application and assessment of learning. The most popular of these instructional design models became known as a generalized instructional systems design that is instantiated in Dick and Carey's (1985) model of instructional design.

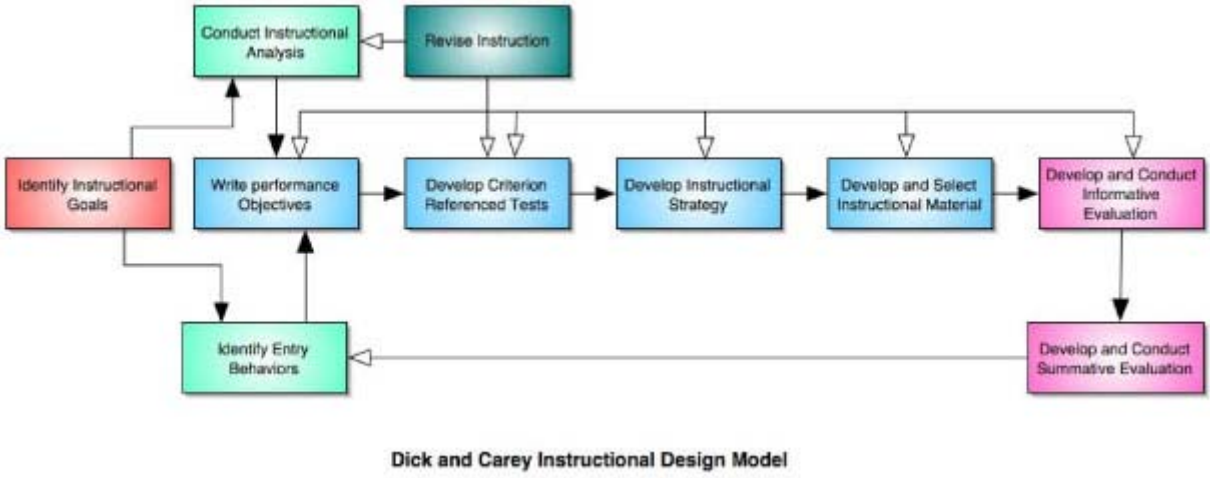

Figure 1. Dick and Carey (1985) model of instructional design (image from Clark, D.R., 2004). The Art and Science of Leadership. Retrieved http://nwlink.com/~donclark/leader/leader.html)

Although not rigorously bound to the linear sequencing of activities as implied in Figure 1, CB-based distance education is often developed in the suggested order and all but the evaluation phases are done before interaction with students and perhaps with teachers. The model begins with designers selecting instructional goals. Instructional designers identify goals in discussion with subject matter experts with an eye to finding deficiencies in learners' behaviour that can be rectified by new learning. CB based learning models and learning activities that are net-based dramatically increase the transparency of these activities – opening them to analysis, visualization and remediation by both instructors and the learners themselves. This openness becomes a key component of all net-based pedagogy but has a larger impact when applied to the activities of individual learners, which when delivered with earlier technologies (notably printed correspondence) left almost no means to observe, much less understand actual learner behaviour. This is particularly salient when applied to a new generation of large scale MOOCs (Massive Open Online Courses)

such as those provided by Udacity, Coursera and edx, where the application of analytics tools can provide a great deal of significant data about how learners are interacting with and using content.

CB pedagogy relies on the use of high quality text and usually multi-media learning content. The effort and cost of "developing and selecting instructional materials" continues to plummet in response to lower cost tools for recording audio and visual (pod, video and screen casts), creating graphics (chart, graphing and visualization tools) and producing animations. Although debate still rages over the necessary degree of professional adherence to high "production standards" in educational media, it is clear that materials produced by designers, teachers and even students are being used to supplement if not totally replace commercial-quality media production.

The Internet greatly expands the capacity and affordability of most of these instructional design and production activities through its capacity to document and create artefacts of discussion, observations and agreements amongst members of the development team. Wedman (1989) in developing strategies to overcome subject matter and teacher resistance to CB models of design argues for the creation of "tangible products" that mark movement through phases and serve as objects for reflection, evaluation and ongoing guidance of the process. For example, Wedman recommends the creation of brainstorming lists of possible goals, documentation of subject matter priorities, flow charts, gathering of lists of instances and non-instances of appropriate behaviours and more. If we consider the logistics of this collaborative teamwork, taking place at a distance in pre-Internet days, we can envision only a largely underused and mostly inaccessible, file of papers – not an effective tool set.

Today each of the instructional design activities (see figure Figure 1) is enhanced by a host of Web 2.0 tools. Of primary use are distributed text tools such as Google Docs, DropBox and wikis. Prior to the Internet, collaborative work consisted of annotating and re-working the efforts of others with long delays between edits. Modern systems allow multiple authors to edit text and owners to manage multiple versions, turning back to previously overwritten work if required. These edits may be made in real time or asynchronously. As importantly, collaborative work and negotiation is not confined to text. Collaborative graphic tools, concept and mind mapping tools allow graphic representations of ideas and processes. Voice tools operating synchronously (Skype) or asynchronously (Voice Thread) allow for richer forms of interaction, enhancing social presence among collaborators. Finally, the coordination of distributed content producers requires considerable skill of at least one project manager. Low cost distributed project management tools allow teams to design, create, produce and distribute content at costs much lower than in pre internet days.

Since high quality content defines CB models of distance education, its effective management and control is extremely important. The costs to construct and maintain currency of high quality content creates a need for distance education student numbers/courses to be much larger than for comparable campus courses (Bates, 2005; Rumble, 2004). Thus, explaining the generally lower costs per student of the world's mega universities – almost all of which make extensive use of CB distance education pedagogy. Large student numbers preclude economic sustainability in countries with smaller populations and those with large numbers of well-established campus universities. In these contexts, the capacity to re-use content created by others is compelling – if not without its challenges.

The Internet provides the infrastructure for multiple ways of sharing content that is the key to quality CB pedagogy. There are a variety of types of distribution models that have evolved to allow for publication, search and retrieval of content. The first were learning object repositories (Connexions, ARIADNE) that stored digital learning objects and the metadata allowing them to be discovered and legally shared. Learning object "referatories" (MERLOT, SMETE) store and evaluate just links to objects. Open courseware repositories (OERCommons, WikiEducator) store learning objects that are aggregated and supplemented with detailed objectives and, often, assessment activities, thereby creating full courses. Finally, both institutions and disciplinary bodies are establishing repositories of scholarly content (often papers, monographs and data sets) that can be used as content in educational contexts. The importance of Creative Commons licensing with its capacity for allowing the sharing, while retaining copyright, cannot be underestimated as an enabler of effective distribution and sharing.

Unfortunately, repositories and mass material re-use has not yet met its potential. In a detailed quantitative study of most of the major repositories (Ochoa & Duval, 2009) identify the "contributor problem": How can contributors be motivated to upload and share their content? This problem remains unresolved, as the technical barriers fall. However, though the repository-oriented approach has not been a huge success, there is more high quality and reliable learning material than ever available across the Internet, not necessarily in purpose-built repositories but authored and hosted everywhere from blogs to Facebook to YouTube and content management systems. Perhaps of deeper concern is the reluctance of distance educators to consume and customize content already created by others. Many content developers define and pride themselves on the production of quality content – not by the consumption and customization of works that they did not produce.

The final affordance of the net – with tremendous, if as yet little demonstrated capacity to improve CB distance education pedagogy – is learning analytics. Building on its forbears, adaptive hypermedia and intelligent tutoring systems (Brusilovsky, 2001) and drawing heavily from related fields such as data mining and web analytics, learning analytics seeks to identify patterns affecting learning in a wide range of

online sources. Unlike traditional adaptive hypermedia and intelligent tutoring systems that (in most instances) work on a known closed corpus of material, learning analytics is intended to be employed across multiple, known and unknown activities and interactions internally within an educational system and across the net, mining information about patterns of behaviour in order to extract useful information about learning which can then be applied to improve the experience. In this model, CB pedagogy may be adapted to service the unique learning needs, style, capacity, motivation and goals of the individual learner. Thus adaptive CB based distance education systems strive to create instructional designs that change and morph in response to individual learner's needs and behaviours. Building from earlier work on user modelling and adaptive systems, these individual attributes are stored in a user model that drives algorithms controlling the presentation style, speed, content, difficulty and other aspects of the learning content. Sophisticated user models are not static, but respond to changes in the learning context (a host of personal, content and situational variables). Finally, there is increasing attention paid to providing access and editing capabilities to the learners themselves to the learning model that is driving learning sequences presented to them. These Open Learning Models (Bull & Kay, 2010; Kay & Kummerfeld, 2006) increase learner control and understanding of the system. Open models can also be used by teachers and other support staff to better understand and respond to individual learner needs, although there are potential and as yet unresolved issues with making such models intuitive to understand and control effectively. An important source of data to constructing the model is the user's current and past activities with content in the learning context. Harvesting, analyzing, and directing appropriate responses to learner activity and goals is known as learning analytics or the older term of educational data mining. In a review of data mining over the past ten years (Baker & Yacef, 2009) identify ways in which analytics can also be used to study the effect of educational interventions including automated or human tutorial support, student services, and use of resources such as libraries; thereby removing the blindness that has to date prevented educators from viewing and learning directly from distance student behaviours.

From the brief examples above we can see how technologies and especially the Net afford multiple ways in which CB pedagogies and related instructional designs are enabled, enhanced and made more cost effective. As MOOCs and other large-scale variants of the CB-model become more prevalent, we look forward to dramatic increases in the availability of high quality, affordable content, coupled with enhanced capacity for designers, teachers and even learners to customize that content for maximum learning.

Social-constructivist pedagogy of distance education

CB models are inherently focused on the individual learner. While there is a tradition of cognitive-constructivist thinking that hinges on personal construction of knowledge, largely developed by Piaget and his followers (Piaget, 1970), the roots of the constructivist model most commonly applied today spring from the work of Vygotsky (1978) and Dewey (1897), generally lumped together in the broad category of social constructivism. Social constructivist pedagogies are focused on groups of learners, learning together with and from one another. Social-constructivist *distance* education pedagogies, not coincidently, developed in distance education in conjunction with the development of affordable many-to-many communication technologies. Beginning primarily in the 1980s and flowering in the 1990s, rather than transmitting information, technology became widely used to create opportunities for both synchronous and asynchronous interactions between and among students and teachers. Michael Moore's famous theory of transactional distance (1989) noted the capacity for flexible interaction to substitute for structure in distance-education development and delivery models. A number of researchers noted the challenges of getting this mix of potential interactions right (Anderson, 2003; Daniel & Marquis, 1988).

Social-constructivism does not provide the detailed and prescriptive instructional design models and methodologies of CB driven distance education. Nonetheless, there is a need for coherency among underlying psychological and philosophical assumptions, and the goals and design criteria for learning activities, if pedagogy is to evolve beyond the philosopher's chair and into the real world of distance education. Wilson (1996) defines social constructivist learning contexts as places "where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities (p. 5). Social-constructivist pedagogy acknowledges the social nature of knowledge- its creation in the minds of individual learners but its instantiation in the practice and culture of groups. Teachers do not merely transmit knowledge to be passively consumed by learners; rather, each learner constructs the means by which new knowledge is both created and integrated with existing knowledge. Although there are many types of social constructivism (Kanuka & Anderson, 1999), all of the models have, more or less, common themes, including the importance of:

- New knowledge as building upon the foundation of previous learning
- Context in shaping learners' knowledge development
- Learning as an active rather than passive process,
- Language and other social tools in constructing knowledge
- Metacognition and evaluation as a means to develop learners' capacity to assess their own learning
- A learning environment that is learner-centred and recognises the importance of multiple perspectives
- Knowledge needing to be subject to social discussion, validation, and application in real world contexts (Honebein, 1996; Jonassen, 1991; Kanuka & Anderson, 1999).

The need for social construction and representation of multiple perspectives necessitates the development of cohorts and social activities and increased "learner centeredness" within distance education, as opposed to individual studies that follow organizational or disciplinary models of instruction. As Greenhow, Robelia, and Hughes (2009) and others have argued, learning is located in contexts and relationships rather than merely in the minds of individuals. Beyond these defined needs for social interaction in learning, social-constructivist theories of learning are less prescriptive and not as easily translated into theories of teaching as their CB forebears. They do, however, leave more room for negotiation about learning goals and activities among teachers and students.

Emerging technologies and Constructivist Models

Social-constructivist models only began to gain a foothold in distance education when the technologies of many-to-many communication became widely available, enabled first by email and bulletin boards, and later through synchronous technologies, the World Wide Web and mobile technologies. While such models had been waiting in the wings for distance education since Dewey or earlier, their widespread use and adoption was dependent on the widespread availability of robust supporting technologies.

These technologies were first used to create distance education that mimicked campus classrooms. Audio conferencing, from the early 1970s, allowed students and teachers to engage in real time conversations distributed across geographic distance. These remote classrooms were later enhanced by video images (video conferencing), shared writing and display spaces (smartboards), and feedback mechanisms including polling and text chat (web conferencing). However, each of these synchronous advantages came at an obvious cost to distance learners and teachers – that being the loss of freedom associated with a commitment to meeting at a common time. Time constraint issues are especially important to distance students, most of whom are juggling employment and family concerns in addition to their formal course work. Equally challenging are issues of time synchronization across large geographic regions. In our graduate education courses at Athabasca University we rarely have a synchronous web conferencing session that doesn't involve someone participating in the middle of the night from their geographic home base. The challenges of synchronous interaction in constructivist-based models generated the need to create rich opportunities for dialogue and collaboration in asynchronous contexts. Since the 1970s and especially since the massive expansion of net-based tools in the 80s and 90s, the threaded discussion has become the staple means of learning dialogue in constructivist distance learning models. Recently asynchronous voice has become available as used in threaded list discussions especially for language learning (Stonebrink, 2008) and more recently for collaborative annotation of media in tools such as VoiceThread (Goa & Sun, 2010).

Data mining and learning analytics are not only used to support independent study based on CB models but are being utilized to support and enhance group work. For example Cocea & Magoulas (2010) describe a system that creates student groups based upon individual learning styles and preferences. Other tools are being built and tested that help groups learn from and respond effectively to their own interactions. Perera, Kay, Koprinska, Yacef and Zaiane (2009) describe their TRAC system that mirrors learning group activity to "extract patterns and other information from the group logs and present it together with desired patterns to the people involved, so that they can interpret it, making use of their own knowledge of the group tasks and activities" (Perera et al., 2009).

Network analysis tools are also emerging as powerful ways for teachers to monitor learning groups and identify potential or emergent problems among learners. For example the popular LMS Moodle has both built in, general and special purpose plugins that help teachers and other group members understand individual and group behaviours. Standard Moodle analytics allow teachers to view contributions or activities of individual learners. General analytic tools such as Google Analytics allows educators to see where students are spending their time, where they are arriving from, which browser tools they use and their entry and exit pages to the site. Finally, dedicated network visualization plugins such as SNAPP allow graphic identification of the threaded discussion contributions and replies amongst students and teacher (see Figure 2). The SNAPP network graph shows quite clearly the types of interactions that are not revealed except by careful reading of the threaded lists from which they are extracted.

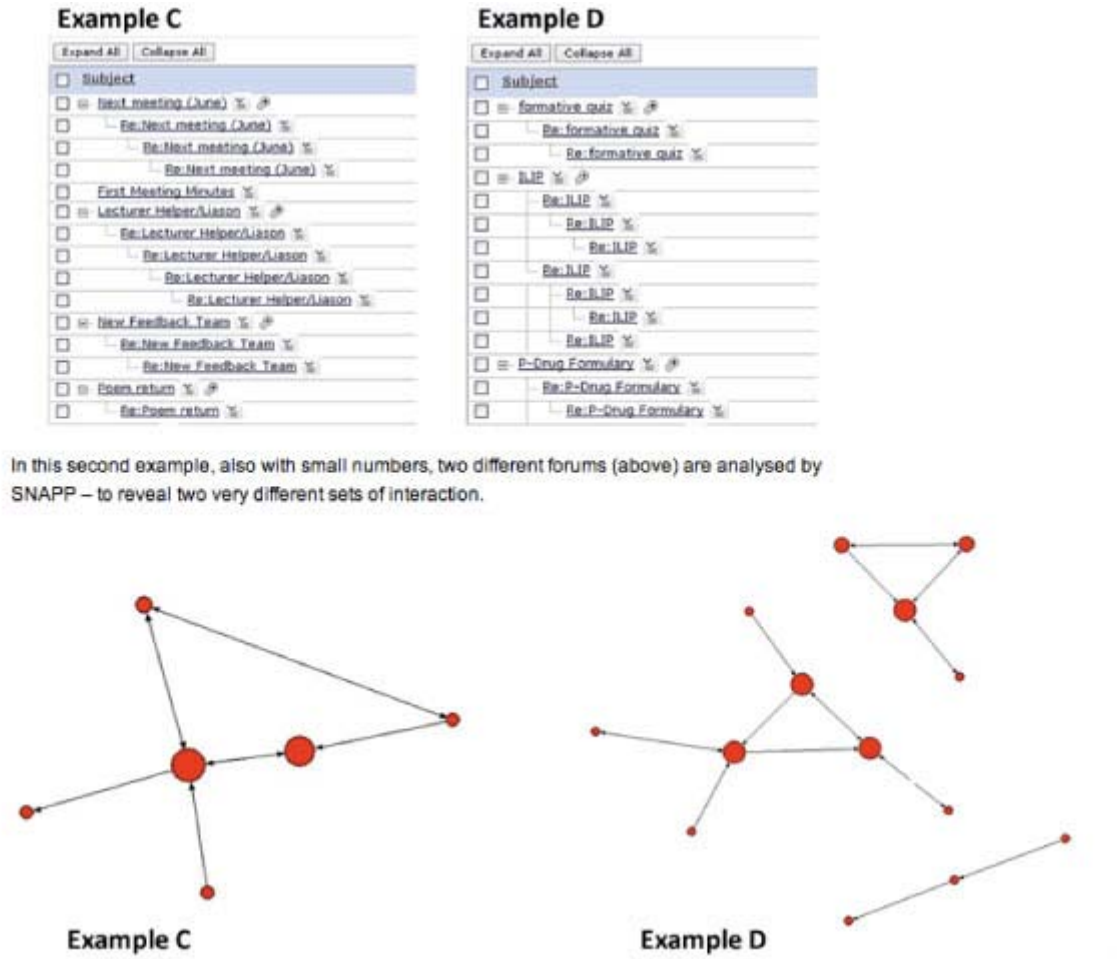

Figure 2. SNAPP Graphics of threaded discussion from SNAPP site at University of Wollongong at http://research.uow.edu.au/learningnetworks/seeing/interpret/index.html

Constructivist pedagogies use the diversity of viewpoints, cultural experiences and the potential for divergent opinion that is best realized through interactions with group members from other cultures, languages and geographies. Distance education has always had an advantage over campus-based constructivist programming because of its geographical reach. Now however, these international groups can be created and learning activities encouraged with much greater ease due to the capacity to expose, coordinate, orchestrate and archive activities on the Internet. It is relatively easy for a distance education designer to use social networks to establish contacts with remote teachers and learners and to suggest or participate in global learning projects, special events, distributed data collection and other forms of "virtual mobility".

Constructivist distance education pedagogies moved distance learning beyond the narrow type of knowledge transmission that could easily be encapsulated in media through the use of synchronous and asynchronous, human communications-based learning. Thus, Garrison (1997) and others could argue that constructivist-based learning, with rich student-student and student-teacher interaction, constituted a new, "post-industrial era" of distance education. However, this focus on human interactions placed limits on accessibility and produced more costly models of distance education (Annand, 1999). Ironically, constructivist models of distance education began sharing (and even celebrating) many of the affordances and liabilities of campus-based education, with potential for teacher domination, passive lecture delivery, and restrictions on geographic and temporal access. Naturally, technological affordances of most relevance to constructivist pedagogies focus on tools to support effective establishment, operation and trust building within groups. The technologies that support rich social presence, including full range of audio, video and gestures, are associated with enhanced trust development and increasing sense of group commitment (Cyr, Hassanein, Head & Ivanov, 2007; Finkelstein, 2006; Rourke & Anderson, 2002).

Connectivist pedagogy of distance education

The third generation of distance education pedagogy emerged recently and is known as connectivism. Canadians George Siemens (Siemens, 2005a, 2005b, 2007) and Stephen Downes (2007) have written defining connectivist papers, arguing that learning is the process of building networks of information, contacts, and resources that are applied to real problems. However, like behaviourist/cognitivist and social constructivist models, there are several variations and flavours of the general model that might include those relating to networks of practice (Wasko & Faraj, 2005), networked learning (De Laat, 2006), and

emergent Learning (Kay & Sims, 2006), and it draws heavily from fields such as distributed cognition (Pea, 1993), constructionism (Papert & Harel, 1991) and communities of practice (Wenger, 1998). Connectivism was developed in the information age of a networked era (Castells, 1996) and assumes ubiquitous access to networked technologies. Connectivist learning focuses on building and maintaining networked connections that are current and flexible enough to be applied to existing and emergent problems. Connectivism also assumes that information is plentiful and that the learner's role is not to memorize or even understand everything, but to have the capacity to find, filter and apply knowledge when and where it is needed. Connectivism assumes that much mental processing and problem solving can and should be off-loaded to machines, leading to Siemens' (2005a) contentious claim that "learning may reside in non-human appliance". Thus, connectivism places itself within the context of actor-network theory, with its identification of the indiscriminate and overlapping boundaries between physical objects, social conventions, and hybrid instantiations of both, as defined by their initial and evolved application in real life (Latour, 1993).

While a great many speculative and theoretical papers have been written on the potential of connectivism (see for example special issue on Connectivism in IRRODL, 2011, edited by Siemens and Conole), most reports of experience so far are equivocal and cater to a wide and often ill-defined diversity of learner needs. There is a clear need for a richer means of establishing both networked and personal learning environments that offer appropriate levels of freedom, control and constraint (Dron, 2007) when needed in both pedagogical and organizational terms. The crowd can be a source of wisdom (Surowiecki, 2005) but can equally be a source of stupidity (Carr, 2010), with processes like preferential attachment that are as capable of leading to the Matthew Principle (where the rich get richer and the poor get poorer) and rampant bandwagon effects as to enabling effective, connected learning. We also note the criticism of connectivism as being merely an extension constructivist pedagogy and those who argue that it is not really a complete theory of learning nor of instruction (Wade, 2012). However, taken as a family of theories rather than one particular flavour, there are some general principles that help to distinguish this from previous pedagogical generations of distance learning: distributed cognition; collective intelligence distributed across a network; a multiplicity of tools, methods and goals; an emphasis on an individual and the individual's connections; an assumption of ubiquitous social connection; a decentralization of teaching roles; a focus on creation in a social context as an active constituent of learning.

Instructional designs for connectivist learning, are as yet only loosely described and still evolving. Two essential characteristics though define connectivist pedagogies. The first is the need to gain high levels of skill using personal learning networks that provide ubiquitous and on demand access to resources, individuals and groups of potential information and knowledge servers. The second is the focus on creation, as opposed to consumption, of information and knowledge resources. As we shall see, the revised listings of Bloom's (1956) cognitive taxonomy place creation at the highest level of cognitive processing assuming understanding, application, and evaluation as component pieces of the creative process. There are also strong parallels with constructionist approaches that emphasize creation as playing a central role in the construction of knowledge (Papert & Harel, 1991).

Connectivist technologies

Unlike earlier pedagogies, Connectivist pedagogy explicitly relies on the ubiquity of networked connections – between people, digital artefacts, and content, and thus can be described as a network centric pedagogy and thus may be the first native distance education pedagogy, without previous instantiation in classrooms. Without ubiquitous network accessibility connectivist models of distance education cannot operate. As we have seen in the case of the earlier generations of distance learning, technology plays a major role in determining pedagogy, but in connectivist models the technology defines the pedagogy.

Effective connectivist learning experiences demand that learners have the tools and the competencies necessary to effectively find, sort, evaluate, filter, reformat and publish content on the net. These capacities rely on effective tools, high skill levels and a developed sense of network efficacy. Given the variety of connectivist tasks, individual and group skill levels, and contexts of application it follows that there is no single tool that makes easy use of these affordances. Rather, individuals and groups are helped to create and continuously augment, adapt and use a personal learning environment (PLE). There are many definitions of a PLE and Mohamed Amine Chatti (2010), in connectivist fashion, has published a slide show of many of the most popular definitions. Graphically, Scott Leslie (2008) has aggregated a collection of visual diagrams of PLEs by a variety of web pundits. From these definitions one can extract that a PLE is not just a single application, but rather an environment or context. It is populated by tools for filtering, sorting, creating, aggregating and publishing. The PLE is also social, providing means to follow, query, and reflect upon topics with significant others as well as the undifferentiated crowd. We are in a time of very rapid development of web based tools and social networks, thus connectivist educators make efforts to expose themselves and their students to new tools and hone their capacity to experiment, trial, adapt and discard individual tools. Of course, the most valuable tool to creating and maintaining a PLE is the network itself. Tweets, blog posts, aggregated trend listings and other signs and recommendations are used to enhance individual PLEs.

In choosing appropriate technologies for any instructional design or pedagogically based learning activity, it is important to choose tools that match the proposed learning goals and activities. Unfortunately, for those

looking for simple instructional recipes, connectivist designs usually have soft and emergent characteristics that defy simple matching of need with affordance. In their description of their Theory of Emergent Learning (TEL) Kay and Sims (2006) note that individual learners (in addition to designers) are responsible for defining their own learning objectives and activities. They further contend that:

- the very uncertainty and lack of predictability of learning outcomes will be the key factor that adds value to a learning community
- emergent systems will provide the necessary triggers to enhance knowledge and understanding
- emergent learning will be one of the critical triggers to unleash individual creativity (p. 411).

Thus, learners and teachers who are quick to try out and explore new components of the PLE's may also experience the financial and temporal costs associated with continuously shopping for, using and configuring new tools. Conversely, they may realize the impact of locking into comfortable or first experienced applications.

The second key defining characteristic of connectivist pedagogy is the import placed on creating, sharing and publishing learner artefacts. Connectivist learning designs, like constructivist ones, often involve collaborative or cooperative work between many learners. However, contribution often grows beyond the group to further encourage collaboration across time and space. Wikis are ideally suited for this type of learning activity as privacy settings can be adjusted as needed, contributions can be tracked and reverted if necessary, and most importantly, the growing artefact serves as an evergreen resource for connectivist learning. This resource may be used to engage learners in current and future iterations of the course and those who have completed their course work obligations.

Beyond the tools of creation instantiated within a PLE is an understanding of the technical and legal means to distribute work, while maintaining appropriate privacy levels and not infringing on the copyright nor plagiarizing the work of others. Distance learners are now accustomed to operating in the protected spaces of learning management systems created and secured by a learning institution. In such environments control of access to content, including content that is created by learners, is usually decided by the institution. Normally at the end of the course student content is deleted or access denied – even to its creators. Copying and reposting content outside of these protected spaces is not allowed, and thus, students come to expect a level of privacy and control – set and enforced by others. However, connectivism focuses on making connections with content, individuals and groups- including those who are not members of the formal class. Thus publishing and distributing content to a very small subset of possible learners can be seen as an unhelpful restriction on the learning and distribution rights of students. Further, some of the potentially most valuable and focused discussions and artefacts relevant to any course of study, were likely created by students in past iterations of the course. These too, should be made accessible in connectivist designs.

The question of right to publish versus a right to privacy cannot be set through institutional, department or course structure. Some students, due to legitimate concerns over stalking and other legal issues, wish to have little or no net presence. For others, creation of a vibrant and extensive net presence is a personal goal and one that they see as central to their current and future career and social goals. The only solution to the privacy dilemma is to let each student and teacher set the level of access that they feel is most appropriate for them and more explicitly for the nature of the content being distributed. The Elgg social networking system, in particular, has very fine tuned permissions such that a student can choose from a wide variety of access levels for sharing information. For example, students may choose to make personal information and content open to the world (including search engines), confined to logged in members of institutional servers, limited to members of groups (classes or departments) or collections (my students, chess players) or strictly accessible by only a single teacher or friend. Institutions using such systems have obligations to protect and archive data contributed by users and to insure that its distribution adheres to the settings placed upon it by its creator(s). Privacy concerns are also being recognised by the social networking giants. For example, Facebook has developed richer permission sets (lists) and groups to enable finer grained privacy control while Orkut has followed an Elgg-like model of permission-setting on individual objects and Google Plus's Circles functionality mimics it almost exactly, albeit without the extra value provided by formal groups that Elgg's system allows.

Connectivist designs also involve the discovery of and contribution to new learning communities. Learners are encouraged to make themselves, their contributions and their personal learning environment accessible to others. Thus, connectivist learning networks often create and rate bookmarked resources that others find useful, document their learning accomplishments via blogs, and share their discoveries and insights via micro blog feeds. In this manner they create and sustain learning networks that begin at the course level, but grow and evolve as the course of studies ends.

Finally, networked analytics have a growing role in all three generations – including connectivism. Analysis of networks created by students both within and outside of formal education, allows learners to learn from the activities and efforts of "the crowd" and of selected subsets. Constructivists and connectivists see learning as a profoundly social activity (Vygotsky, 1978; Wenger, 1998) and that social activity is increasingly taking place in networked contexts (as evidenced by the millions of hours of time spent by individuals in social networking platforms such as Facebook). Benefitting from social activities and learning within these complex contexts, connectivism relies on more than the classic contructivist group

discussion: though strongly social in focus, the emphasis is far more on the individual's connections with others than with group processes designed to enhance or engender learning. Connectivist methods need tools that allow multimedia interactions; that operate as well in synchronous modes as in asynchronous modes; and that allow us to find, track, aggregate and assess these conversations for relevance to our individual and collective learning needs. Network analytics are the frontier of connectivist tool development as they help connectivist learners to:

- Search through and across vast amounts of content and persons;
- Appreciate the value and use of knowledge and knowledge objects;
- Understand the cultural, geographic, and political biases of knowledge representation;
- Sort the relevant from the irrelevant; and
- Highlight our own contributions.

The highly divergent and distributed nature of connectivist modes of learning makes it considerably harder to apply analytics than in the more contained contexts of CB and social constructivist models. There is no central course, few common materials, no central binding point where interactions can be observed apart from each individual learner. Perhaps ironically, the most visibly social form of pedagogy is, at heart, entirely focused on the individual learner.

Aligning pedagogical designs and technologies

We conclude this chapter with a discussion of the types of knowledge and learning that are most aligned with each of the generations of distance education described above. "The greater the compatibility between an ID model and its contextual, theoretical, and philosophical origins, the greater the potential to generate effective instruction" (Gustafson & Branch, 1997). Of critical concern is the type of learning or knowledge that is the primary goal of the educational experience. To examine the type of knowledge most appropriate for each pedagogical generation we turn to the canonical work of Bloom and his colleagues and a more recent revision of his Cognitive Taxonomy. While Bloom's model has often been criticized as being an armchair theory that does not do justice to the complexity of the learning domain (Moore, 1982; Sugrue, 2002), and it is certainly an oversimplification to suggest (as he does) that a learner must move from the base of the pyramid to the top, the taxonomy has sense-making value in helping to distinguish the kinds of learning that are involved in the complex behaviours of coming to know something. The bottom three of Blooms original levels of learning – acquiring knowledge, coming to understand something or some process and applying that knowledge to a context – are clearly within the domain of CB pedagogies. Moving up to the analysis, synthesis and evaluation levels brings us to the need for social perspective. This is often acquired through group and networked interactions characteristic of constructivist and connectivist pedagogical models. Anderson and Krathwohl (2001) revised Bloom's 1956 model of the cognitive domain in two important ways. First they made the domain levels more easily translated into learning activities by changing the descriptions to verbs describing activities learners are involved in while working at each level. Second, they expanded and raised the level of "synthesis" to the more general notion of creating. Creation can be entirely original or as is more usual, creation involves the building upon, reinterpretation and contextualized application of older ideas to new contexts. Creation, the highest level of cognitive functioning usually requires mastery of the lower levels but, in addition, requires at least a small flame of creativity and insight.

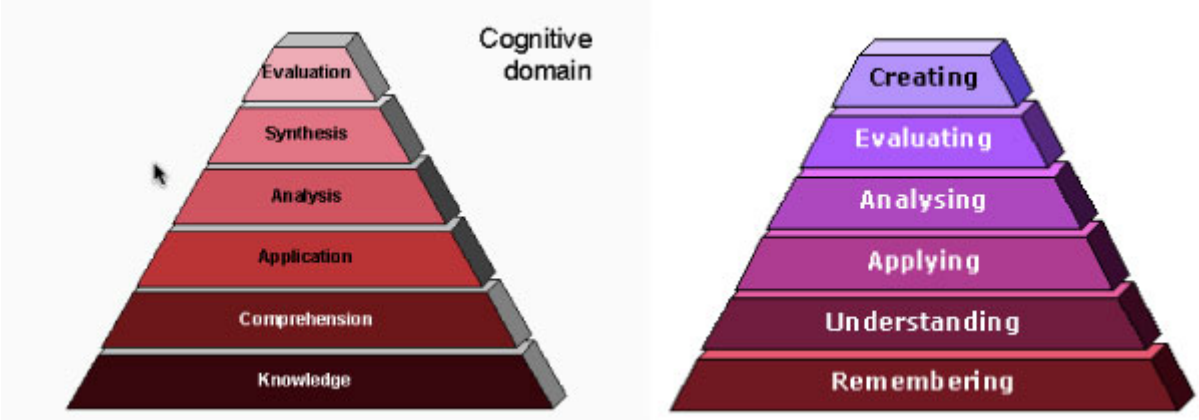

Figure 3. Bloom's Taxonomy (and revised version) of the Cognitive Domain from Atherton (2010)

Obviously the focus of connectivism with its inherent demand for students to create and distribute for public review and augmentation, fits well with the final creation level of the revised taxonomy. However before jumping to the conclusion that all learning should be of a connectivist nature so as to achieve these highest levels of cognitive functioning, one must remember the cost and efficiency of each pedagogical model in relationship to the educational outcomes expected. There are many domains of knowledge in

which creation of new knowledge is of much less importance than remembering and being able to apply existing knowledge. To take an obvious example, safe driving requires that one must remember and follow the rules of the road while operating a vehicle. Instinctively being able to keep to the correct side of the road, yield to others when required and understand the laws of physics that apply when turning sharply are more important than creating new rules! Having said that, the ability to think creatively, to respond to new and unforeseen dangers, and to be able to learn new behaviours as vehicles and laws change are important skills in advanced driving so, even in the case of such a simple competence, there is space for multiple levels of learning. In addition, most new knowledge creation (as illustrated by the familiar diagrams in Figure 3) is based upon a broad base of facts, understandings, analysis and evaluations – which, in some cases, is better learned through direct instruction than by trial and error or other personal construction. It is worth remembering the arguments from Kirshner, Sweller, and Clark (2006) that "minimally guided instruction is less effective and less efficient than instructional approaches that place a strong emphasis on guidance of the student learning process" (p. 75). But again this quote challenges us to differentiate among instances where the goal of instruction is to develop capacity or metacognative skills, to become self-directed, or to gain a deep understanding of how one learns. Finally it challenges us to remain cogniscant of the need for individuals to be personally involved in the development of their own learning networks.

A final look at types of learning is provided by a quick review of Bloom's less well-known taxonomy of affective domains (Krathwohl, Bloom & Masia, 1973). The affective domain begins with willingness to receive and then to respond. This is followed by the ability to construct a value network that leads to informed ethical behaviour that is open to affective response and change induced by others. Quite obviously such valuing is best done through social interaction (constructivism and connectivism) and is informed by interactions among people with varied perspectives and values.

Conclusion

We have seen how different models of teaching and learning have evolved when the technological affordances and climate were right for them or, perhaps more accurately, were unable to evolve until their adjacent possibilities were made available. Cognitive–behaviourist pedagogical models arose in a technological environment that constrained communication to the pre-Web, one-to-one, and one-to-many modes; social–constructivism flourished in a Web 1.0, many-to-many technological context; and connectivism is at least partially a product of a networked, Web 2.0 world of social and participatory media and the read/write Web. It is tempting to speculate what the next generation will bring. Some see "Web 3.0" as being the Semantic Web, while others include mobility, augmented reality, and location awareness in the mix (Hendler, 2009). It is clear that we are in stage of rapid technological development and profound new discoveries of life and learning in connected contexts. The emergence of collective understanding formed by the selective use and analysis of the networks, sets, behaviours and activities within which we engage promises much deeper understanding of our knowledge construction and application. It seems at least possible that the next generation of distance education pedagogy will be enabled by technologies that make effective use of these collective entities.

Distance education has evolved through many technologies and at least three generations of pedagogy, as described in this paper. No single generation has provided all the answers, and each has built on foundations provided by its predecessors rather than replacing the earlier prototype (Ireland, 2007). To a large extent, the generations have evolved in tandem with the technologies that enable them. As new technological affordances open up, it becomes possible to explore and capitalize on different aspects of the learning process. For each mode of engagement, different types of knowledge, learning, and contexts must be applied. This demands that distance educators and students be skilled and informed to select the best mix(es) of both pedagogy and technology. Although the prime actors in all three generations remain the same – teacher, student, and content – the development of relationships among these three increases from the student-content interactions of cognitive-behaviourist models to the critical role of student–student interaction in constructivism, and finally, to the deeply networked student–content-teacher interrelationship celebrated in connectivist pedagogies, in which students become teachers and teachers become students, with interaction mediated through the persistent digital artefacts that all create. We have seen a generational shift from one where content mediated between sage and pupil, to one where a teacher became a guide, to one where the teacher is a co-traveller, perhaps a role model but no longer the sole creator or guide in the learning experience.

We conclude by arguing that all three current (and future) generations of distance education pedagogy have an important place in a well-rounded educational experience. Connectivism is built to some degree on an assumption of a constructivist model of learning, with the learner at the centre, connecting and constructing knowledge in a context that includes not only external networks and groups but also their own histories and predilections. At a finer granularity, both constructivist and connectivist approaches almost always rely to a greater or lesser degree on the availability of the stuff of learning, much of which (at least, that which is successful in helping people to learn) is designed and organized on CB models. The web sites, books, tutorial materials, videos, and so on, from which a learner may learn, all work more or less effectively according to how well they are designed and implemented. Even when learning relies on entirely social interactions, the various parties involved may communicate knowledge more or less effectively. It is clear that, whether the learner is alone, part of a learning community or a learning network, learning

effectiveness can be greatly enhanced by applying, at a detailed level, an understanding of how people can learn more effectively: Cognitivist, behaviourist, constructivist, and connectivist theories each play an important role.

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