While educational theory is often construed by graduate students as a necessary evil of little practical use, and frequently required by professors and research committees, the value of theory in education development and design (Anderson, 2004b) is summed up by Kurt Lewin’s (1952) famous quote, “there is nothing so practical as a good theory” (p. 169).

I begin this chapter with a short personal anecdote. During the summer of 2003, I saw a flood of new web-based information and communication technologies providing opportunities to create learning activities in formal education. I became obsessed with the notion that there must be some sort of rational law that would help educators and instructional designers decide when to use which particular technology. Moreover, the mere fact that a technology is popular for personal or business use provides little evidence that it will be useful in educational contexts—a notion instantiated by the phenomenal growth of Facebook! In addition, I was worried (and still am) that the adoption of any new technology is hard work and will likely have unanticipated consequences. It is imperative, therefore, to identify theoretical constructs to guide technology-enhanced interventions.

I was drawn to thinking about technologies in the context of Moore’s (1989) description of educational communications as being made up of student-student, student-content, and student-teacher interactions. We had already written (Anderson & Garrison, 1998) about three other possible interactions...
— teacher-content, teacher-teacher, and content-content — but continued to focus on the ones most relevant to a learning-centric view, those that involved students. Figure 3.1 demonstrated how these three student interactions were more or less equivalent. Through the creation of very high-quality levels of any one type of interaction, it would be sufficient to produce a high-quality learning experience. If this was the case, the other two interactions could be reduced or even eliminated, with very little impact on learning outcomes or learner attitudes. If true, this “learning equivalency theory” could be used to rationalize expenditures in one area, yet allow for time and money savings in the other two. I further speculated that “more than one of these three modes will likely provide a more satisfying educational experience, though these experiences may not be as cost- or time-effective as less interactive learning sequences” (Anderson, 2003).

![Figure 3.1 Learning interactions](image)

The problem with this “theory” rests on Popper’s (1968) claim that a good theory is one that can never be proved true, but should be capable of being proved false. To disprove this theory would deny its contribution to the education field as only an interesting hypothesis and rubric for course designers. Bernard et al. (2009) established a set of protocols to conduct a meta-analysis of distance education studies designed to validate these contentions and concluded that,
“when the actual categories of strength were investigated through ANOVA, we found strong support for Anderson’s hypothesis about achievement and less support for his hypothesis concerning attitudes” (p. 1265). Thus, Anderson’s (2003) “equivalency theory” gained some empirical support, and has helped researchers to research, and practitioners to design and deliver, effective and efficient interventions, demonstrating that large and small theories associated with learning and teaching can serve to explain and to inspire. In the rest of this chapter, I review older and newer theories of learning that I find of most interest and value in my own thinking and practice, and I hope this overview helps the reader to understand and act effectively in the complex online learning environments that we are creating.

HISTORICAL THEORIES OF EDUCATIONAL TECHNOLOGY

Good theories stand the test of time and continue to be of use because they help individuals understand education and act appropriately. These theories are useful today because emerging technologies and practices are often applied to the same challenges and problems that inspired educators and researchers working with older technologies, technologies that, while now established, were once emerging (chapter 1).

As stated by Larreamendy-Joerns and Leinhardt (2006, p. 568), “the visionary promises and concerns that many current educators claim as novel actually have a past, one whose themes signal both continuities and ruptures.” In their review of educational technology research and its application to online learning, these authors defined three views or visions that propel educational technology use and development. These are: the presentational view, the performance-tutoring view, and the epistemic-engagement view.

The presentational view focuses on theory and practice to make discourse and visualizations clearly accessible to learners. Theories of multimedia use focus on the cognitive effects of selecting and transmitting relevant images and words, organizing these transmissions effectively, and ensuring that the messages delivered through multiple channels do not interfere with each other or with the cognitive processing of the learners (Mayer, 2001). Much of this work benefited from studies of brain activity, and an increased understanding of the complex ways in which individuals process presentations to create learning expositions in most effective ways. A current example of this is view can be found in the study of short video segments frequently used in massive open online courses (MOOCs) and the Khan Academy video episodes (Giannakos, Chorianopoulos,
Ronchetti, Szegedi & Teasley, 2013). The performance tutoring view derives its roots from the feedback, reinforcement, and theory of behavioural psychology.

SOCIAL CONSTRUCTIVISM

The epistemic engagement view of learning identified by Larreamendy-Joerns and Leinhardt (2006) has been the most recent educational vision driving educational technology. This vision focuses on the evolutionary propensity for curiosity, discovery, sharing, and understanding for the skillful use of tools, and it is most closely associated with social constructivist learning theories. Constructivism has long philosophical and pedagogical roots associated with the works of Dewey, Mead, and Piaget. Like many popular theories, constructivism has been defined and characterized in various ways. However, all forms of this theory share the understanding that individuals’ construction of knowledge is dependent upon individual and collective understandings, backgrounds, and proclivities. Debate arises, however, over the degree to which individuals hold common understandings, and if these understandings are rooted in any single form of externally defined and objective reality (Kanuka & Anderson, 1999). As much as constructivism is present in the current educational discussion, it should be noted that it is a philosophy of learning and not one of teaching. Despite this incongruence, many authors have extracted tenets of constructivist learning and from them developed principles or guidelines for learning design contexts and activities. Among these are the following: that active engagement by the learners is critically important, and that multiple perspectives and sustained dialogue lead to effective learning. Social constructivist theories have focused on the role of scaffolds provided by both human and nonhuman agents that assist more able or knowledgeable learners or teachers to prompt and support learners in acquiring their own competence (Vygotsky & Luria, 1981).

Constructivists also stress the contextual nature of learning, and argue that learning happens most effectively when the task and context are authentic and hold meaning for the learners. Constructivist learning activities often focus on problems and require active inquiry techniques. These problems often work best when they are ill-structured, open-ended, and are deemed “messy.” Such problems force learners to go beyond formulaic solutions to develop capacity for effective problem-solving behaviours across multiple contexts.
COMPLEXITY THEORY

Complexity theory, or more recently, the “science of complexity,” arose from the study of living systems, and it has been attracting interest among a variety of disciplines. Perhaps the most familiar examples of complexity theory are those drawn from evolutionary study, where organisms adapt to and even modify complex environments, creating unusually stable, yet complex systems. In such systems one component of an ecosystem cannot be understood in isolation from the context or total environment in which it lives (for further discussion of this, see chapter 2). Complexity theory teaches educators and researchers to look for emergent behaviours that arise while autonomous yet interdependent organisms interact. In particular, educational theorists examine and attempt to predict “transformations or phase transitions that provide the markers for growth, change, or learning” (Horn, 2008, p. 126). Complexity theorists are often at odds with positivist researchers and educators, who attempt to eliminate or control all the variables that influence learning. Rather, complexity seeks to create learning activities to allow effective behaviour to emerge and evolve, and ineffective ideas to be extinguished. Conversely, complexity theorists seek to understand features of the environment; especially the social or structural norms or organizations created that resist overt or covert attempts at self-organization. McElroy (2000) noted that “the point at which emergent behaviours inexplicably arise, lies somewhere between order and chaos” (p. 196). This sweet spot is known as the “edge of chaos,” where systems “exhibit wild bursts of creativity and produce new and novel behaviours at the level of the whole system . . . complex systems innovate by producing spontaneous, systemic bouts of novelty out of which new patterns of behavior emerge” (McElroy, 2000, p. 196).

Implications of complexity theory for learning and for education operate on at least two levels. At the level of the individual learner, complexity theory, like constructivist theory, supports the learner’s acquisition of skills and power such that he or she can articulate and achieve personal learning goals (chapters 8 and 9). By noting the presence of agents and structures to support and impede the emergence of effective adaptive behaviour, individual learners are better able to survive in occasionally threatening and very complex learning environments, and even to influence them.

At the organizational level, complexity theory highlights the social structures created to manage learning. When these management functions begin to inhibit the emergence of positive adaptive behaviour, or give birth to behaviours that are not conducive to deep learning, educators can expect negative results.
Organizational structures are intended to enable learners to surf at the “edge of chaos,” and not to eliminate or constrain the creative potential of actors engaged at this juncture. Further, this understanding can guide creation and management of these complex environments, not with the goal of controlling or understanding learning, but intending to create systems in which learning emerges rapidly and profoundly. Complexity theory also encourages educators and researchers to think of learning contexts (classrooms, online learning cohorts, and more) as entities themselves. Such entities can be healthy, sick, emerging, growing, or dying, and these characterizations can help researchers and educators improve them. By thinking at the systems level, reformers search for interventions, tools, and languages that promote healthy adaptation and produce healthy human beings.

Finally, complexity theory helps us to understand and work with the inevitable unanticipated events that emerge when disruptive technologies are used in once stable systems (Christensen, 1997). Learning to surf this wave of equal opportunity and danger (and do it masterfully) becomes the goal of educational change agents.

The teaching and learning theories derived from pre-Internet visions for technology-enhanced learning and related theories of learning still resonate with and add value to educators and researchers today. However, it is important to examine theories that have been developed since the rise of the web and which have deliberately exploited the affordances of this new context for teaching and learning.

NET-AWARE THEORIES OF LEARNING

The Internet (or net) context created an environment that is radically different from pre-net contexts, but carries with it evolutionary genes from previous cultures and technologies. There are three affordances of the web that define its value for teaching and learning (Anderson & Whitelock, 2004).

First, the net offers the capacity for powerful, yet very low-cost, communications. This capacity forms the platform upon which epistemic-engagement visions of learning are instantiated. Communication may occur in synchronous, asynchronous, or near-synchronous (e.g., text messaging) modes and may be expressed through text, voice, video, and immersive interaction modes (i.e., any combination of the media). Communication artifacts can be stored, indexed, tagged, harvested, searched, and sorted. All of this capacity is available at low or affordable cost. Net communications can be one-to-one, one-to-many,
or involve many, with very little cost differentiation among the three modes. Communication has also ceased to be expensive, geographically restricted, or privileged (i.e., it is available to those individuals with hearing, movement, or visual disabilities, and it is not limited to those with expensive production facilities). Finally, communications affordances can be used in a multitude of ways. The emergence of social networking tools, for example, affords learners the opportunity to self-organize, to seek and share questions, understandings, and resources outside of the formal virtual or campus classroom, thus creating learner-organized tutoring and support opportunities (see chapters 8 and 9). This capacity creates opportunities for many forms of collaborative informal and lifelong learning (Koper & Tattersall, 2004; Wenger, Trayner & de Latt, 2011).

Second, the net created a context of information abundance. From YouTube videos to wide-scale distribution and production of Open Educational Resources (OER), the net provides learning content with many different display and presentation attributes. Such content exists in many formats, and often uses multimedia to enhance presentational value. Most exciting is the capacity for learners and teachers to add user-created content and to edit and enhance the work of others using produsage production modes (Bruns, 2008). “Produsage” is a combination of the words “production” and “usage,” and it refers to user-led content creation, consumption, and active production online. As important as scaling content is the power of effective search and retrieval methods. Current online search engines make this task surprisingly fast and accurate. The transition from scarcity to abundance introduces massive amounts of information and choice, challenging students and instructors to develop their judgment, comparison, and evaluation skills.

The third affordance is the development of active and autonomous agents, which are free to gather, aggregate, synthesize, and filter the net for content and communications relevant to individuals and groups of learners and teachers. In Dron and Anderson (2014) we discussed this capacity for knowledge generation through distributed machine cognition as “collective” affordances to enhance formal and informal learning. The educational semantic web is rapidly emerging, with serious methodological (Doctorow, 2001) and epistemological (Kalfoglou, Schorlemmer, & Walton, 2004) challenges to its emergence. An increasing number of applications utilize autonomous agents (Liemhetcharat & Veloso, 2012; Sato, Azevedo, & Barthès, 2012) to induce and support learning. The most visible of these applications are the search-engine algorithms used to find and retrieve online content, products, and services. Most search engines,
for example, work through active monitoring on online traffic patterns, with regard to the links and collective actions of users, and their algorithms produce an intelligent guess as to the searcher’s desired result. Agents monitoring these searches extract additional information used by marketers and social researchers to further understand our collective ideas, choices, and interests (Tancer, 2008). Researchers and educators studying interventions in online learning environments are increasingly making use of such algorithms for learning analytics (chapter 6).

While net-based agents will continue to add value to visions for educational technology practice and research, being in awe of stunning technical affordances does little to direct teaching and learning. For this reason, I discuss two recent theories that may help explain the practice of networked learning online.

**HEUTAGOGY**

Hase and Kenyon (2000) developed the heutagogical theory of learning, named after the Greek word for self. This theory has roots in self-directed learning, and specifically renounces the teacher dependency associated with both pedagogy (the study of teaching) and andragogy (the study of teaching adults). Heutagogy extends control to the learner and sees the learner as the major development and control agent in his or her learning (Hase & Kenyon, 2007; Blaschke, 2012). The self-determinism that defines heutagogical approaches to teaching and learning is seen as critical to life in the rapidly changing economy and cultures that characterize postmodern times. As Hase and Kenyon (“Heutagogy,” 2000, para. 6) note, “heutagogy looks to the future in which knowing how to learn will be a fundamental skill given the pace of innovation and the changing structure of communities and workplaces.” This future demands that education move beyond instructing and testing for learner competencies, and toward supporting learners in a journey to capacity rather than competency. Capacity includes being able to learn in new and unfamiliar contexts. Older models of competence test only the time-dependent achievement of the past. Instructional design for heutagogical learning veers away from prescriptive content to an exploration of problems that are relevant to the learner (chapter 8 and 9). The instructor becomes a facilitator and a guide in learners’ interactions with varied resources to resolve problems and to gain personal understanding. Heutagogy thus emphasizes self-direction and focuses on the development of efficacy in utilizing the online tools and information available.
CONNECTIVISM

The second recent network-centric theory was first developed by George Siemens, who coined the term “connectivism” (2005) and laid out principles to define connected learning. Specifically, Siemens argued that “competence [is gained] from forming connections” and the “capacity to know more is more critical than what is currently known” (Siemens, “Connectivism,” 2005). The metaphor of the network, whose nodes consist of learning resources, machines to store and generate information, and people, is one that dominates connectivist learning. Learning occurs as individuals discover and build connections between these nodes. Learning environments are created and used by learners to access, process, filter, recommend, and apply information with the aid of machines, peers, and experts within the learning network. In the process, learning expands based on the power of the network to create and personalize knowledge, connections, and artifacts of those within it. Being able to see, navigate, and develop connections between nodes is the goal of connectivist learning. Rather than learning facts and concepts, connectivism stresses learning how to create paths to knowledge when it is needed. Siemens also argues that knowledge, and indeed learning itself, can exist outside the human being—in the databases, devices, tools, and communities within which a learner acts. A goal of connectivist learning is to create new connections, regardless of formal education systems, to expand upon and build learning networks. Connectivist theorists are primarily interested in allowing and stimulating learners to create new learning connections. In the process, learners are expected to increase the pool of expertise and resources that they can draw from, to increase social capital, and to curate valued resources.

Connectivism also sees the need for formal education to expand beyond classrooms and bounded systems that manage learning:

Learning . . . occurs in communities, where the practice of learning is the participation in the community. A learning activity is, in essence, a conversation undertaken between the learner and other members of the community. This conversation, in the Web 2.0 era, consists not only of words but of images, video, multimedia and more. (Downes, “A Network Pedagogy,” 2006, para. 4)

Though connectivism has yet to become widely accepted as the learning theory for the digital era as envisioned by Siemens (2005) and Downes (2006), there is an increasing engagement in the field with ideas associated with connectivism. Verhagen (2006) argued that connectivism is a theory of curriculum, specifying
the ultimate goal of education and the methods learners use to interact with learning materials, rather than a theory of learning. Kerr (2007) criticized this theory by stating it offered nothing new in learning theory that is not accounted for in earlier works, such as complexity theory and constructivism. Kop and Hill (2008) identified two problems with the theory: the lack of a substantive role for the instructor and the extensive requirements placed on the learner who would need to be capable of and motivated sufficiently to engage in self-directed learning. Finally, Clara and Barbera (2014) noted that the theory is unable to explain a range of significant learning phenomena.

GROUPS, NETS, AND SETS

Dron and Anderson (2014) expanded the discussion of social networks and interactions within formalized education; specifically to differentiate three important but substantively different contexts in which connectivist learning is employed.

The first of these learning contexts is the familiar group. Groups, typically referred to as “classes” in formal education systems, are secure places where students aggregate (face-to-face or online) and proceed through a series of independent and/or collaborative learning activities. Groups tend to be housed in closed environments with strong leadership from an instructor or group owner, and, in formal education, might be temporally bounded by an academic term. These synchronized activities result in learners supporting each other, and levels of trust can be built such that learners collaboratively engage, support, and critique each other. In well-organized groups, considerable social, cognitive, and teaching presence is developed to create a community of inquiry (Garrison & Anderson, 2003). However, groups are also noted for the development of hidden curricula, constrictive and occasionally coercive acts, groupthink, and teacher dependency (Downes, 2006).

A second form of aggregation is called the network. Networked learning activities expand connectivity beyond the learning management system (LMS) to allow learners, alumni, and the general public to engage in formulating networked learning opportunities (see chapter 9). Network membership is much more fluid than that of groups, where leadership is emergent rather than imposed and networks easily expand or contract as learners use the network to solve problems. Networks are less temporally bonded and may continue to exist long after formal study terminates.

The third aggregation we call the set. Sets are created by a shared interest or characteristic, and can be of enormous value in education. For example, when
an instructor polls a classroom (using a show of hands or clickers), this method helps determine the set of students who correctly understand a concept. More recently wikis have had the ability to aggregate and extract knowledge from the set of individuals with interest/expertise in any topic. Learning in sets involves aggregating and synthesizing the myriad activities that occur in online environments. The application of knowledge gained by these aggregations can cause particular challenges for learning. For example, searching very large aggregations of resources online (such as with Google, YouTube, or Flickr), and filtering these resources for perceived value or use permits learners to selectively mine the activities of thousands of individuals. These types of filtering can be socially magnified through collaborative resource tagging services, such as citeulike.org and diig.com, or through systematic curation websites, such as Pinterest or Learnist. Sets face challenges as well: contagion, crowd stupidity, filter bubbles, and privacy invasion are possible tribulations. However, sets also allow learners to benefit from traces, recommendations, and activities of others. It is through the digital traces of others that learners may formulate connected pathways to accessible online learning resources. This discussion of groups, nets, and sets continues to expand for educational purposes as learning activities capitalize on the use of collective intelligence and teaching the crowd (Dron & Anderson, 2014).

THRESHOLD CONCEPTS

Throughout my career, I have been working and struggling with teachers as they learn to integrate emerging technologies and pedagogies into their practice. It always seems to be hard work and results are not always either as I had hoped or planned. Thus, I end this chapter with a brief overview of theories designed to help both adopters and change agents working with emerging technologies in education.

The growing literature on “disruptive” technologies introduced by Christensen (1997) continues to be discussed in education. Although the notion that everything new is disruptive has resulted in overuse of the term, and the value of the theory for predictive use has been questioned (Lepore, 2014), there is little doubt that many of Christensen’s descriptions resonate with the educational sector. In fact, Christensen has written two books directly applying his disruptive technology theories to education (Christensen, 1997; Christensen, Horn, & Johnson, 2008). Readers may, however, be less familiar with the notion of ‘threshold concepts.’
The theory of threshold concepts identifies attributes that impact teaching and learning issues: “Threshold concepts are ‘conceptual gateways’ or ‘portals’ that lead to a previously inaccessible, and initially perhaps ‘troublesome’, way of thinking about something” (Meyer & Land, 2005, p. 373–74).

Of particular interest is the notion that changing one’s approach and behaviour, and thus one’s design, through the application of emerging technology involves instructors wrestling with very significant “threshold concepts”—what Ross and Collier call “messiness” in chapter 2. McGowen (2012) identified two such thresholds that instructors must experience:

First they may have a preconception that technology is merely an add-on, not an integral part, of teaching; and, second, they believe that they should know exactly what they are doing before using new technology in the classroom, resisting a period of experimentation, or even play, that others find helpful when teaching with technology. (p. 25)

Meyer and Land (2005) identified four characteristics of threshold concepts:

**Transformational.** The ideas of learner centeredness, produsage of content, extensive sharing with peers and other features of the current generation of emerging technologies force a transformation of teachers from source of information to facilitator of learning (chapters 5, 11). The technologies also spill out beyond professional practice to both support and challenge activities in many other social, political and commercial activities.

**Integrative.** Following from complexity theory, new adopters find that the use of emerging technologies tends to open new possibilities while making others redundant. Only through deeper understanding can educators learn to change parts of their environment to integrate with the changes induced by the use of emerging technologies and practices.

**Irreversible.** Learning to teach (as we were taught to teach or observed other teachers) forced us across threshold concepts. Teaching effectively with emerging technologies, likewise, forces educators to relearn, to reconceptualize, and to abandon obsolete practices.
Troublesome. Emerging technologies and practices, like any substantive change, challenge older ways of doing things, which are often defended by the vested interests of learners, instructors, and institutions.

Thus educators as both adopters and change agents need to overcome challenges to disruption and be ready to cross over their own “threshold concepts” as well as those of their colleagues and students, “resisting constraints of thought and action” (chapter 2).

CONCLUSION

This brief overview is intended to illustrate how learning and learning designs that use emerging technologies can be enhanced via the lens of theory. A historical theoretical lens allows us to conceptualize how learning and teaching interactions affect outcomes. Much of our understanding of how and why learning happens and the best ways to design effective learning activities is enhanced when we work from theoretical models. The net, with its affordances, seems to speed up and accentuate many of the ideas found in online learning theories.

However, as much as theories add value, these same pedagogical foundations also need to evolve to account for networked affordances, digital disruptions (Christensen et al., 2008), and unanticipated consequences (Taleb, 2007). We are witnessing the birth and refinement of learning theories that work under the assumption of the ubiquitous net. Like online and networked cultures, these learning theories borrow from and expand pre-net ideas to consider how our teaching and learning practices support new ways in which knowledge is created, shared, and refined.

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