Abstract
This chapter is designed to give an overview of some of the traditional and new learning and instructional theories that guide the effective development and deployment of emerging technologies in education. Theories force us to look deeply at big-picture issues and grapple with the reasons why our technology use is likely to enhance teaching and learning. This chapter provides an overview of various visions for the use of educational technology and learning theories associated with those visions, and concludes with a brief look at three modern, Net-centric theories of learning.

Creating a new theory is not like destroying an old barn and erecting a skyscraper in its place. It is rather like climbing a mountain, gaining new and wider views, discovering unexpected connections between our starting points and its rich environment. But the point from which we started out still exists and can be seen, although it appears smaller and forms a tiny part of our broad view gained by the mastery of the obstacles on our adventurous way up. (Albert Einstein, in Einstein & Infield, 1938, 158–9)

Introduction
In this chapter I outline some of the most relevant established and emerging learning, pedagogical, and educational theories that both inspire and guide our interest in exploiting emerging technologies.
for distance education applications. While educational theory is often construed by graduate students as a necessary evil of little practical use, required by professors and thesis committees, I have written elsewhere about the value of theory in education development and design (Anderson, 2004b). 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 began to see a flood of new Web-based information and communications technologies that could be used to create learning activities in formal education. At that time, 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. In addition, I was worried (and still am) that the adoption of any new technology, in traditional contexts, is hard work, often disruptive, and will likely have unanticipated consequences. Thus, I was searching for theoretical constructs to guide interventions.

I was drawn to thinking about the 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 the other three 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. I created the diagram shown in Figure 2.1 and then had an insight: perhaps these three student interactions were more or less equivalent. Creating very high-quality levels of any one type of interaction would be sufficient to create a high-quality learning experience. If this was the case, the other two interactions could then be reduced or even eliminated, with little or no 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 “high levels
of 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).

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. I had little idea how to disprove this theory and thus thought its contribution to the field might at best be as an interesting hypothesis and as a rubric for course designers. I was thus very pleasantly surprised to read that Bob Bernard (Bernard et al., 2009) and his colleagues at Concordia University, had thought deeper than I, and had established a set of protocols that allowed them to conduct a meta-analysis of distance education studies designed to validate my contentions. As usual, the number of control group studies in distance education is limited and thus so are the results. However, Bernard et al. (2009) 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.”
Thus, my “equivelancy theory” gained some empirical support, and
from e-mails I have received from distance educators in a variety of
countries, I know the theory has helped both researchers to research
and practitioners to design and deliver cost-efficient and learning-
effective interventions.

The remainder of this chapter reviews some of the older and newer
theories 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 emerging world of online education 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 us understand and act appropriately. These theories are use-
ful today because emerging technologies are often applied to the same
challenges and problems that inspired educators and researchers work-
ing with older technologies, technologies that, while now established,
were once emerging (chapter 1). As aptly stated by Larreamendy-Joerns
and Leinhardt (2006), “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 a fascinating review of educational technology research and its
application to online learning, Larreamendy-Joerns and Leinhardt
(2006, p. 568) define 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 that make
our discourse and especially our visualizations more clearly acces-
sible to learners. Theories of multimedia use focus on the cognitive
effects of selecting and transmitting relevant images and words, or-
ganizing these transmissions effectively, and insuring that the mes-
sages delivered through multiple channels do not interfere with each
other or with the cognitive processing of the learners (Mayer, 2001).
Much of this work benefits from studies of brain activity, and our
increasing understanding of the complex ways in which we process
“presentations” helps us to create these presentations in most effective ways.

The performance tutoring view derives its roots from the feedback, reinforcement, and theory of behavioural psychology. More recently, social constructivist theories have focused on the role of scaffolds provided by both human and non-human agents that assist more able or knowledgeable learners or teachers to prompt and support learners in acquiring their own competence (Vygotsky & Lauria, 1981).

**Constructivism**

The epistemic engagement view of learning has been the most recent educational vision driving educational technology. Engagement is most closely associated with constructivist learning theories. Currently the most popular approach to learning that is guiding both researchers and educational practitioners is a set of theories collectively known as constructivism. Constructivism has long philosophical and pedagogical roots and has been associated with the works of John Dewey, George Mead, and Jean Piaget. Like many popular theories, it has been defined and characterized by many — often with little consistency among authors. However, all forms of constructivism share an understanding that individuals construct knowledge that is dependent upon their 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 touted as driving 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 tenants of constructivist learning and from them developed principles or guidelines for the design of learning contexts and activities. Among these are: that active engagement by the learners is critically important, and that multiple perspectives and sustained dialogue lead to effective learning. 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 messy, forcing learners to go beyond formulaic solutions and to develop their capacity to develop 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 has been attracting esoteric interest among a very wide variety of disciplines for the past two decades. Perhaps most familiar examples of complexity theory are those drawn from evolutionary study, where organisms (over time) 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 an example, see chapter 10). Complexity theory teaches us to look for the emergent behaviours that arise when autonomous, yet interdependent organisms interact with each other. In particular, theorists look for and attempt to predict “transformations or phase transitions that provide the markers for growth, change, or learning” (Horn, 2008). Complexity theorists are often at odds with positivist researchers and educators who attempt to eliminate or control all the variables that affect a learning transaction. Rather, complexity seeks to create learning activities that allow effective behaviour to emerge and evolve and ineffective ideas to be extinguished. Conversely, complexity theorists seek to understand features of the environment, and especially the social or structural norms or organizations we create that resist either overt or covert attempts at self-organization. McElroy (2000) notes that “the point at which emergent behaviours inexplicably arise, lies somewhere between order and chaos” (p. 196). This sweet spot has been called 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 6 and 9). By noting the presence of agents and structures that both support and impede the emergence of effective adaptive behaviour, individual learners are better able to influence and indeed survive in often threatening and always complex learning environments.

At the level of organization of either formal or informal learning, complexity theory highlights the social structures that we create to manage that learning. When these management functions begin to inhibit the emergence of positive adaptive behaviour or give birth and sustain behaviours that are not conducive to deep learning, we can expect negative results. Organizational structures should help us to surf at the “edge of chaos,” not function to eliminate or constrain the creative potential of actors engaged at this juncture. Further, this understanding can guide us to create and manage these complex environments not with a goal of controlling or even completely understanding learning, but with a goal of creating systems in which learning emerges rapidly and profoundly. Complexity theory also encourages us to think of learning contexts (classrooms, online learning cohorts, etc.) as entities themselves. These entities can be healthy or sick; emerging, growing, or dying. By thinking at the systems level, reformers search for interventions that promote healthy adaptation and the emergence of cultures, tools, and languages that 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 all three of these pre-Net visions for technology-enhanced learning and related theories of learning still resonate with and add value to educators and researchers today. However, to paraphrase the syllogism that “the Net changes..."
everything,” I next turn to theories that have evolved since the development of the Web and deliberately exploit the affordances of this new context for teaching and learning.

**Net-Aware Theories of Learning**

The Net context creates an environment that is radically different from pre-Net contexts, yet of course carries evolutionary genes from previous cultures and technologies. In 2004 Denise Whitelock and I edited a special edition of the *Journal of Interactive Media in Education* that focused on the educational semantic web (Anderson & Whitelock, 2004). In the introduction to this issue, we provided an overview of three affordances of the Web, which I still believe define its value for teaching and learning. The first is the capacity for powerful yet very low-cost communications. This capacity forms the platform upon which “epistemic-engagement” visions of learning are instantiated. This communication may be engaged in synchronous, asynchronous, or near-synchronous (as in text messaging) modes. Communications may be expressed through text, voice, video, or even immersive interaction modes. These communication modes can also be combined in many creative ways. Communication artifacts can be stored, indexed, tagged, harvested, searched, and sorted. All of this capacity is available at low or (at least in parts of the world) affordable cost. Finally, net communications can be one to one, one to many, or many to many, with very little cost differentiation among the three modes. Thus, educators have moved away from a world in which communication was expensive, geographically restricted (often limited to those sharing the same classroom), and privileged (limited to those with production facilities). Moreover, net communications provide access to and empower those with hearing, movement, or visual impairments. These communications affordances obviously can be used in a multitude of ways in formal education and teaching (see chapters 4, 12, and 14). The recent emergence of social software sites affords learners the opportunity to seek and share questions, understandings, and resources, thus creating learner-organized tutoring and support opportunities (chapter 6). Perhaps most importantly, this communications capacity creates
opportunities for many forms of collaborative informal and lifelong learning (Koper & Tattersall, 2004).

The second affordance we discussed in 2004 is that the Net creates a context that moves us from information and content scarcity to abundance. From early-learning object repositories to wide-scale distribution and production of Open Educational Resources from many networked sites, the Net provides learning content with many different display and presentation attributes. This content exists in many formats, and often uses multimedia to enhance its 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).

The third affordance we identified in 2004 has been less apparent, but still holds great promise for teaching and learning. This is the affordance of active and autonomous agents that can be set loose on the Net to gather, aggregate, synthesize, and filter the Net for content and communications that is relevant to individual and groups of learners and teachers. The educational semantic web still remains “just around the corner,” and there have been serious methodological (Doctorow, 2001) and epistemological (Kalfoglou, Schorlemmer, & Walton, 2004) challenges to its emergence. However, there is an increasing number of applications that utilize autonomous agents (Anderson, 2004a; Sloep et al., 2004) to induce and support learning. The most visible of these applications are the search-engine algorithms that we all use to find and retrieve Net-based content, products, and services. By noting which sites are selected most often and which have the most established traffic and links, search engines calculate short lists of options to select from among the often millions of matches that are found — and as often as not the “correct” site appears among those on the first result screen. Through agents actively monitoring the Net, the links, and the collective actions of users, algorithms produce an intelligent guess as to the searcher’s desired result — as well as a few targeted advertisements! Furthermore, agents monitoring these searches extract additional information that is used by marketers and social researchers to further understand our collective ideas, choices, and interests (Tancer, 2008),
as well as by researchers and educators who want to further understand learner behavior in Net-based learning environments (chapter 12). Net-based agents will doubtlessly continue to add value to all three of the visions for educational technology, including presentation, performance-tutoring, and epistemic engagement.

Nevertheless, being in awe of stunning technical affordances does little to direct or help us to understand teaching and learning. For this, I end the chapter with overviews of three more recent learning theories that evolved in the technology-enhanced learning networked area.

The Pedagogy of Nearness

The first of these network-centric learning theories relates to the capacity of learning to flow seamlessly between online and face-to-face contexts. Mejias (2005) has argued for a new “pedagogy of nearness” in which online interaction, collaboration, and learning are neither valued nor devalued as compared to interactions with those near at hand. We have all noticed the ease with which some of us move between online and offline living. And more recently we see evidence that Net-infused learning does not entail desertion of our physical spaces, but rather serves to facilitate, document, and deepen place-based communication and relationships (Ellison, Steinfield, & Lampe, 2007). In a network-infused environment, we are “on our way to a more sustainable relationship with the world when we learn to inscribe our online experiences into larger systems of action meant to bring the epistemologically far near to us, and make the physically near relevant again” (Mejias, 2005b).

Mejias also argues that it is not only the nearness of face-to-face interaction that presents unique opportunities for teaching and learning but rather “we need to acknowledge the kind of insights (about ourselves, about our world) that can be gained through online experiences that cannot be gained through unmediated perception” (Mejias, 2005). Although digital networks have not accomplished the death of distance, our sense of both time and distance has been altered in as yet little-understood ways by the cost-effective reduction of barriers to both. Mejias’ work points to the need for blended applications in which networks are used for teaching and learning when appropriate
and which offer particular access, time shifting, or pedagogical advantage. Moreover, learners and teachers must develop literacies to act effectively in both online and offline contexts and be able to shift rapidly between them.

**Heutagogy**

The second net-centric theory reviewed was developed in Australia and was named by its authors, Hase and Kenyon (2000), as *heutagogy* after the Greek for *self*. Heutagogy has roots in the literature on self-directed learning and renounces the teacher dependency associated with both pedagogy and andragogy. Heutagogy extends control to the learner and sees the learner as the major development and control agent in his or her own learning (Hase & Kenyon, 2007). 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 (2000) 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 to allow and support 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 heutagogy learning veers away from prescriptive content to an exploration of problems that are relevant to students’ lives (chapter 5). The teacher’s role becomes one of facilitator and guide as students use a very wide set of resources (both online and traditional) to resolve problems and to gain personal understanding and capacity. Heutagogy’s emphasis on self-direction and capacity of heutagogy focuses on the development of efficacy in utilizing the tools and information sources available on the Net.

**Connectivism**

The most recent network-centric theory was first developed by George Siemens, who coined the term *connectivism* and laid out a number of
principles that define connected learning. Siemens argues that “we derive our competence from forming connections” and that our “capacity to know more is more critical than what is currently known” (Siemens, 2005). The metaphor of the network whose nodes consist of learning resources, machines that both store and generate information, and people, dominates connectivist learning. Learning occurs as individuals discover and build connections between nodes. Learning environments are thus created and used by individuals as they access information, process, filter, recommend, and apply that information with the aide of machines, peers, and experts in their learning networks. In the process of learning, they expand their own learning networks by creating useful and personalized knowledge and connecting it to the ideas and artifacts of others in their networks. Being able to see, navigate, and create connections between nodes becomes 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 of a human being — in the databases, devices, tools, and communities within which a learner acts.

Additionally, connectivism sees the need for formal education to expand beyond classrooms and bounded learning management systems to embrace and to become involved with the informal. As Downes (2006) notes, “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.” Though often the topic of edublogger conversation, connectivism has yet to become widely accepted as the learning theory for the digital era as envisioned by Siemens and Downes. It has been criticized by Kerr (2007) for offering nothing new in learning theory that is not accounted for in earlier works (notably complexity theory and constructivism). Connectivism also seems to have trouble connecting to formal education. Kop and Hill (2008) note the lack of a substantive role for a teacher in connectivist theory and the requirements placed on the
learner (in common with heutagogy) to be capable of and motivated to engage in very self-directed learning. Finally, Verhagen (2006) argues that connectivism is more a theory of curriculum (specifying what the goal of education should be and the way students should learn in that curriculum) than a theory of learning.

Obviously a goal of connectivist learning is to create new connections, and the classroom, or any bounded formal education system, is a relatively small context in which to build these connections. Connectivist theorists are interested in both allowing and stimulating learners to create new learning connections. In the process, learners increase the pools of expertise and resources they can draw from and thus increase their own social capital, as they become valued resources for others. Our own modest contribution to this need for expanded interactions within formal education has been to differentiate three important but substantively different contexts in which connectivist learning is employed (Dron & Anderson, 2007).

The first of these learning contexts is the familiar group. Groups (often referred to as “classes” in formal education) are secure places where students aggregate (in classroom or online) and proceed through a series of independent and collaborative learning activities. Groups tend to be closed environments, have strong leadership from a teacher or group owner, and (in formal education) 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 actively engage with 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, group think, and teacher dependency (Downes, 2006).

Thus, in our courses we are developing a second form of aggregation based on networks. Networked learning activities that expand connectivity beyond the Learning Management System (LMS) to allow both registered students, alumni, and the general public to engage in creating networked learning opportunities (Anderson, 2005). Network
membership is much more fluid than that of groups, leadership is emergent rather than imposed, and networks easily expand and contract as learners find them of more or less use in solving particular problems. Networks are also less temporally bonded and may continue to exist long after formal study terminates.

The third aggregation we have referred to as “collectives.” Learning in collectives involves aggregating and synthesizing the myriad activities that go on over the Net and applying knowledge gained by these aggregations to particular problems. For example, searching very large aggregations of resources, such as found in Google, YouTube, or del.icio.us, and filtering them for perceived value or use allows us to selectively mine the activities of thousands or tens of thousands of individuals. These filterings can be socially magnified through collaborative resource tagging services such as citeulike.org and diig.com. Collective activities carry with them the potential for contagion and privacy invasion, but at the same time they allow us to benefit from the traces, tracks, recommendations, and activities of others, thereby creating paths which allow us to connect more easily to valued human and digital learning resources. We have expanded this discussion elsewhere to explore learning activities best suited for the “Aggregations of the Many” (Dron & Anderson, 2007).

Conclusion
This brief overview is intended to illustrate that understanding learning and learning designs that use emerging technologies can be enhanced by looking through the lens of both older and emerging educational and learning theories. 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 new affordances, seems to speed up and accentuate many of the ideas found in pre-Net learning theories.

However, as much as theories add value, they also need to evolve to account for the affordances as well as for any disruptive (Christensen, Horn, & Johnson, 2008) and unanticipated consequences (Taleb, 2007) of their use in any context. We are witnessing the birth and refinement
of learning theories that work under the assumption of the ubiquitous Net. Like Net culture itself, these theories borrow from and expand pre-Net ideas, while envisioning new ways that knowledge is created, shared, and adapted.

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