Distance education is defined not so much by the geographical distance that the label implies as by the technologies, both soft and hard, that are used to reduce that distance. Along with the technologies come processes that relate to their use, pedagogies that are made to fit with those tools and processes, and a demographic that is defined in some large part by its ability to access the information and communication technologies (ICTs) used in the process. When considering change and innovation in distance education, our focus will, inevitably, be on those technologies, their implementation, invention, meaning, diffusion, and acceptance.

This chapter addresses the following main questions:

- What changes and innovations have occurred in distance education?
- How does such change come about? What are its drivers, what are the obstacles to change?
- How should change be managed in a distance environment?

Change in distance education comes about due to a range of factors, none of which may be seen in isolation, all of which combine and interact to form a complex set of conditions. These include, non-exclusively:

- the opportunities afforded by new technologies, including pedagogies
• the constraints of available technologies, including pedagogies
• path dependencies caused by earlier decisions
• the desires and expectations of learners
• the constraints of learners, notably geographical isolation, the need to live and work somewhere else while learning, the need to access learning opportunities not available at their own location
• constraints due to external contextual factors such as competitors, government legislation, funding models, and relationships with prior learning
• changes in theoretical models of learning
• trends, fashions, and attitudes to learning and to technology

Some of these aspects are common to all education. For the sake of economy, by and large we will only focus on those that are notably different in distance education. There are many theories of innovation and many theories of change that account for diversity, creativity, adoption, and design. To avoid a massive creep in scope, in this chapter we deliberately limit our focus to those that are distinctive to distance education.

MAJOR THEORY

Generations of Distance Education

If we are to understand change as it relates to distance education, then it is important to clearly identify those aspects of distance education that are susceptible to forces of change and that are distinctive in distance education. To do this, it seems logical to look at the history of distance education and what kinds of change have occurred. Traditionally, the history of distance education has been divided according to the kinds of ICT it employs, which, given that the field is largely defined by ICTs, makes some sense. Bates (Bates, 2005) for example, follows Kaufman and Nipper in identifying three generations: single-mode (such as print or radio), mixed mode with tuition (an industrial model typified by CD-ROMs, high production values, and telephone tutors) and social modes (typified by forums and learning management systems). Similarly, Gunawardena and McIsaac trace its history in terms of ICTs, from early print models, radio, television and networked technologies to the present day (Gunawardena & McIsaac, 2004). Anderson and Dron take a somewhat different tack by considering
generations in terms of dominant pedagogies of the period (Anderson & Dron, 2011). This perspective helps to maintain a focus on the distinctive features that make those technologies educational rather than simple information and communication tools, and thus distinguishes them from other uses of similar tools outside an educational context.

The first generation of distance pedagogies uses the behaviourist/cognitivist model. This model includes cognitive-constructivist approaches such as those of Piaget as well as behaviourist and cognitivist approaches such as those of Skinner, Bruner, and Gagne. The model is based on a learner-centric view in which the focus is on how individuals learn. The second generation is the social constructivist model, following such theorists as Dewey and Vygotsky. This model is informed by the notion that knowledge is socially constructed and emphasizes the importance of others in developing and refining understanding. The third generation is the connectivist model. In this model, knowledge is in the network, both human and non-human, and learning lies in wayfinding and making sense of the network. There is an emerging fourth generation that Dron and Anderson suggest should be described as holist, which recognises that, learning and teaching are deformed by context and that no pedagogy has primacy. It is important to note, however, that pedagogies are no less technologies than the ICTs with which they are combined to form a specific learning technology. Given, therefore, that distance education is essentially about technology, if we are to understand what it is and how change occurs within it, we need to explore the meaning of technology.

Technologies

Almost every aspect of distance education is enacted and defined through technology, from organizational processes to communication tools, from production methods to pedagogies. To understand technology and how it changes is thus by far the most important foundation for understanding change in distance education.

Unfortunately, technology is a slippery and evolving concept. Its modern usage emerged in the early part of the 19th century (Kelly, 2010) but has often been seen as an elusive abstraction (Nye, 2006) that has led some to abandon it altogether and replace it with something more precisely defined, such as technics (Mumford, 1934) or technique (Ellul, 1970). Technologies predate scientific methods by at least tens of millennia (Kelly, 2010; Taylor,
2010; Zhouying, 2004) but are often associated with science. Guangbi’s useful distinction, quoted in Zhouying (2004), is that science is theoretical knowledge that is concerned with discovery and cognition, while technology is operable knowledge that is concerned with invention and practice. Much science is made possible only because of technology and much technology is made possible only because of science (Rosen, 2010). There are numerous alternative definitions of technology. Bessant and Francis (2005) call technologies the “ways that people get complicated things done” (p.97). Nye (2006) sees technologies as a combination of tools and purpose; Papert (1987) suggests that technologies are tools with a context. For Kelly, technology is “a force: a vital spirit that throws us forward or pushes against us. Not a thing but a verb” (2010, p. 56). S. Johnson (2010) describes technologies in terms of the jobs they do for us. The highly persuasive definition that we will use here comes from Arthur (2009) who argues that technologies are the “orchestration of phenomena to some purpose” (p. 51). This makes sense of Franklin’s discussion of the technologies of prayer (Franklin, 1999) and Dron’s identification of pedagogies as educational technologies (Dron, 2012). Phenomena may be natural or artificial, physical, mental, or abstract—from the effects of rubbing carbon on paper to the interaction of different aspects of legislation, from understanding how people learn to the quantum behaviour of subatomic particles.

Technological Evolution and Change

Technologies evolve and change in fairly predictable patterns. McLuhan’s suggestion that humans might be the “sex organs of the machine world” (1964, p. 56) hints at a teleological view of a technological ecology. Technologies appear to involve a dynamic of their own that is not designed from the top down nor intended by their creators. By treating what he calls the technium as a richly intertwined ecology in which patterns of evolutionary change emerge with similar retrospective inevitability as those in nature, Kelly shows that our technological ecosystems are evolving in a manner that approaches natural systems in complexity (Kelly, 2010). This does not mean that technological and natural evolution are identical. Technologies are designed. This means that they are subject to fewer constraints than natural systems; new types can emerge without local constraint and almost ex nihilo: designed systems do not need to move through intermediate working forms (Page, 2011). None the less, there is a
trajectory to technological evolution that is strongly determined by history. Ideas and developments occur in relation to what came before, building on and nearly always incorporating earlier forms. Johnson (2010) makes use of Kauffman’s construct of the adjacent possible (Kauffman, 2000) to explain how, as complex ecosystems develop, they open up new possibilities that were not formerly available, thereby leading to creative opportunities for further possibilities to emerge.

Kauffman formalizes the concept to show how, whether in natural or designed systems, it inevitably leads to an efflorescence of forms. Arthur builds on this to demonstrate that technology evolves not through genetically mediated reproduction with variation but with variation arising through assembly and recombination (Arthur, 2009). As more technologies are available to combine and recombine, so they experience accelerating rates of evolution, and increasing diversity (Page, 2011). This constant expansion of the adjacent possible helps to explain how patterns of growth in numbers and ranges of technologies used in all education, not just that at a distance, have exploded over recent decades after hundreds or perhaps thousands of years of slow change (Bates, 2005).

**Hard and Soft Technologies**

In order to understand how innovation can occur in technologies, it is necessary to understand the ways that technologies may be changed. Technologies are not equally malleable. They can be softer (implying greater malleability) or harder (implying less flexibility). While there are many competing and overlapping definitions of what this means (e.g., McDonough & Kahn, 1997; Norman, 1993; Zhouying, 2004) we take the view in this chapter that, building on Arthur’s definition of technology, softness comes when humans actively enact the orchestration of phenomena to some use (Arthur, 2009). By contrast, hardness occurs when the orchestration is built into the technologies. This means that softer technologies require more effort, are less consistent, and are mostly slower to produce results than harder technologies, but they offer greater flexibility and opportunities for creativity, innovation, and change. The minimal definition of a learning technology is that it must incorporate, as part of its orchestration, pedagogy or pedagogies, whether implicit or explicit. Simply put, learning technologies must do something to enable people to learn, which implies that they employ some method for bringing about learning. Pedagogies, on the whole, are
rather soft technologies, adapted, contextualized, and reified by teachers in response to beliefs, activities, and feedback about phenomena that are orchestrated to achieve learning.

When technologies, be they hard or soft, are assembled with others by addition they make the original softer. Generally speaking, when hard technologies are assembled to replace those that already exist, technologies become harder. For example, if a learning management system is too restrictive in requiring a particular form or date for submission, then it may be softened (made more flexible) by asking students to submit work via e-mail instead. Conversely, if e-mail submission proves inefficient or unreliable, the process may be replaced with a more automated system employing a learning management system.

What makes a technology softer or harder is the degree to which humans are compelled to, may, or should make creative choices. For example, licence conditions that prevent end-users from adapting software for their own needs are a hard technology that is enacted in law rather than software or hardware, making most proprietary learning technologies harder in at least one respect than their open-source equivalents. Conversely, a computer, because it is the universal tool, medium, and environment, is among the softest of technologies ever created. However, the degree of hardness/softness of a technology is partially determined by the end users and their competencies. A computer may be a very soft technology for a competent programmer, but a very hard one for the operator of a sales terminal. It is important to note that, though they are using the same machine, the assembly is quite different in each case, utilizing different phenomena for different purposes: the tool that is labelled “computer” can thus be infinitely many technologies. This is also true of even humble tools like the screwdriver, which is a quite different technology when it is used to stir paint than when it is used to turn screws, demonstrating the technology often orchestrates different phenomena for different purposes. Because it has many uses (Kauffman, 2008), a screwdriver is thus a part of many very soft technologies.

The more we embed processes and techniques in our tools, be they pedagogies or machine tools, the fewer choices are left to humans. The price we pay for the efficiencies and capabilities offered by hardening our technologies is therefore the loss of capacity to make changes, but the price we pay for softening our technologies is in effort, speed, and potential for error. A central theme in the evolution of distance learning is thus a tension between creativity and efficiency. It is usually easier to adopt a soft technology in the
short term, but more difficult to sustain it in the longer term. For example, open source software may be more flexible, but the skills and effort needed to maintain it could make it a costlier and far more complex alternative than an off-the-shelf product. A course based on soft and malleable dialogue is quicker to design than one based on cognitivist–behaviourist principles, but takes much more effort to sustain and to scale. A learning management system that makes some pedagogical decisions on behalf of the teacher may be easier to use, but constrains the range of pedagogies that may be employed. Hard technologies are resistant to change and embody the status quo. Soft technologies enable creativity and change: where change occurs in distance education it is thus because, to the creator of a technology, it was soft. The harder the technology, the more resistant it will be to change.

**Technological Acceptance and Use**

It is not enough for technologies to change in order for change to occur in distance education. Those technologies need to be used, integrated, and absorbed into the educational system. Rogers's innovation diffusion theory (Rogers, 1995) has been highly influential as a means of describing how new technologies are taken up within a group or society. The pattern of acceptance by innovators, early adopters, early majority, late majority, and laggards has entered into popular vocabulary as a means of identifying or asserting identity in an individual's relationships with technology.

As well as describing the ways that technologies are taken up within a community, Rogers identified a characteristic S-curve for adoption that was influenced by five main factors: relative advantage, compatibility, trialability, observability, and complexity. While the S-curve is broadly accepted as a fair empirical description of the ways that identifiable groups of people approach innovative technologies, there is considerably less agreement about the factors relating to technologies that influence their success or failure. Rogers's factors were based more on inductive reasoning than empirical observation. Several competing models that provide a more solid foundation for exploring the ways that technologies diffuse through a society or community have been developed, the most popular of which is the technology acceptance model (TAM), based on the theory of reasoned action (Davis, 1989). The essence of the TAM model is that the success or failure of a new instance of (information) technology is determined by interplay between its perceived usefulness and its perceived ease of use. While it
offers a compelling model, TAM has been criticized in recent years as providing an idealized and empirically naïve view that provides little predictive power and only some help with managing the process when applied in the real world (Bagozzi, 2007).

The uptake of technology is not simply a matter of whether people choose to use a technology but whether that technology actually has any real value. TAM has been developed and refined by Venkatesh and others to incorporate more of these factors, leading to the Unified Theory of Acceptance and Use of Technology (UTAUT), which has become widely used over the past decade (Venkatesh, Morris, Davis, & Davis, 2003). UTAUT attempts to place more emphasis on empirical findings as a means of prediction as well as to provide a broad description of how technologies are accepted by a given population. UTAUT extends the two main constructs of TAM to include social influences and other facilitating conditions. Overlaid on these, various authors have added a host of other factors including gender, age, experience, voluntariness, playfulness, self-efficacy, and much more. As Bagozzi (2007) observes, the combination of many (at least 8) independent variables for predicting behaviour and at least 41 independent variables for predicting intention makes the model seem very cumbersome, to say the least, as well as highly culturally determined.

The Task-Technology Fit (TTF) model provides an alternative concerned primarily with the performance of a technology. It is a common-sense idea that, simply put, implies that one will achieve good performance when a technology provides features and support that fit the task (Goodhue & Thompson, 1995). Goodhue and Thompson’s version of the TTF model includes a range of factors that lead to utilization, to create the Technology to Performance Chain (TPC) model. This considers task characteristics, individual user characteristics, technology characteristics, and an assortment of precursors such as beliefs, habits, norms, and facilitating conditions that, together with TTF, can be used to predict or explain performance impacts. Of course, any technology acceptance model has to work within a distance education setting to be of use. For this, it is useful to apply a domain-specific quality model. The most successful of these in recent years is the SLOAN-C five-pillar model (Moore, 2005) which considers five dimensions of quality: learning effectiveness, scale (cost-effectiveness and commitment), access, faculty satisfaction, and student satisfaction. While subject to many interpretations, the breadth of the five pillars provides a useful framework for evaluation of innovation.
Disruptive Technologies

Perrow offers a model of technology divided into the routine and the non-routine, with the latter finding their application in unanalyzable, problem-solving areas, with many exceptions to rules (Perrow, 1986). In the behaviourist/cognitivist years, the technological assemblies that constituted distance education were notably fixed in the area of the routine: to create learning sequences was to follow a series of formalized steps, typified by Gagne’s nine events of instruction (Gagne, 1985). To support such developments, models such as ADDIE and Dick and Carey’s systematic design methods (Dick & Cary, 1990) attempted to turn loose, craft-based methods into reliable and repeatable mechanical design methods. It is notable that, as distance education has become more social and grounded in the construction of knowledge; the technologies that support it have become softer, more yielding and more open to uncertainty in form and function. This tension between soft and hard technologies has been and remains an ongoing feature of distance education over the past decades. Softness opens up opportunities for change and increasing creativity, in which teacher-invented technologies are overlaid on top of the electronic and organizational tools. This makes fertile ground for the non-routine or disruptive technologies.

Christensen distinguishes between routine and non-routine kinds of technologies, differentiating between those that sustain and those that disrupt, for which Christensen coined the term disruptive technologies (1997). As the ever-increasing changes wrought, as the adjacent possible expand, some technologies have the capacity to change the way we behave or work, whether they are at the high end of discontinuous revolution or the low end of improving efficiency. There are significant differences in how we adopt each kind of technology. Arthur notes that most technologies grow by a process of assembly, and radical discontinuities are as rare, for much the same reasons, as Kuhnian scientific revolutions (Arthur, 2009). One reason for this is that disruptive technologies are innovations that at first may result in worse product performance than what came previously (Christensen, 2008). It is an almost universal feature of truly innovative technologies that they tend to be less able when they first make an appearance than the technologies that they replace. For example, propeller-driven aircraft outperformed jet engines for around two decades before jet engines developed to a point where they were clearly superior to their forebears (Arthur, 2009).
This initial worsening can act as a brake on initial uptake, especially for hard technologies that lack innate flexibility, and may be part of the reason that, though there are many inventions, only a few take root.

**Systems Theories**

An alternative way of understanding technology diffusion in distance education relates to systems theory, in which the various components of an educational technology system are examined in relation to one another and their broader context. Systems theories create dynamic models in which actors are viewed in terms of their connections with others, a principle followed to its logical conclusion in actor-network-theory, where the human and the non-human are all treated as *actants* in an interconnected and co-dependent network (Latour, 2005). Thanks to their deep connectedness with almost all systems in society, from government to commerce, as well as path dependencies that stretch back into medieval times, educational systems are unusually impervious to change, a feature that masks the effects of disruption at first (Christensen, Horn, & Johnson, 2008). This is echoed by Blin and Munro (2008) who, looking at technological change through the lens of activity theory, make the important observation that technologies are a part of an overall socio-technical system and that their success or failure is highly dependent on how they integrate with the existing processes and technical forms within an institution as well as in a broader context. Importantly, they often fail to fit. Dron (2012) similarly suggests that there is no innate primacy in the roles of technologies (including pedagogies) within an educational system but that all must work together as part of the technological assembly. Something radically new is unlikely to fit as easily as something that is an incremental evolution of old technologies.

This is an unequal assembly in which some parts are more equal than others. As Brand (1997) observes, slower moving, larger scale agents play a more important role in determining the shape of a system than smaller, faster changing technologies. This means that the path dependencies of history that have led to large-scale structures, such as universities, schools, classrooms, libraries, and so on, will tend to force smaller innovations and changes into a mould that may be a poor fit, and thus such technologies may fail to gain a significant foothold or be mutated so that their usefulness is considerably diminished.
A complete systems view suggests that to make big changes the changes should therefore be made across the system, concentrating on the larger slow-moving parts. Such changes are, thankfully, rare, or we would spend our lives running to stay in the same place like the Red Queen in *Alice Through the Looking Glass*. That said, disruptive technologies could be the lever for such a change. Christensen describes how innovative change spreads in a technological system, typically through small footholds that work their way through the system once established in niches (Christensen, 2008). It is notable that the spread of distance technologies to face-to-face institutions, where the LMS is virtually ubiquitous and increasingly large parts of programs are available in distance formats, shows very much this pattern. Dron (2002) explains how, in distance education, open universities provided relatively secluded spaces that were fertile breeding grounds for innovation; these spaces were able to develop fairly fully before spreading to the broader ecosystem. This is a distinctly Darwinian evolutionary pattern. Like the species of finch evolving on different Galapagos Islands, parcellation enables a higher rate of evolution that may then spread to the broader population as links and isthmuses form. This is not limited to changes across the educational system. For such changes to spread in a similar way within an organization, an organizational hierarchy that is either relatively flat or that distributes significant autonomy to the branches of the hierarchy can provide the levels of parcellation needed for innovations to gain a foothold. Allowing many flowers to bloom requires new varieties to be at least partially sheltered from each other at first, so that those that might be weaker in their initial stages of development have a chance to reach maturity.

**OPEN QUESTIONS**

**Behaviourist/Cognitivist Solutions and Open Questions**

The behaviourist/cognitivist approach to distance education has traditionally led to a slow process of change to or within a course. For those following a pattern of large-scale industrialization, as suggested by Peters (1994), huge amounts of effort and time are delivered up-front in the production of learning resources, designs, and materials, with reduced costs emerging only when courses and learning materials are re-used over a period of, typically, years (Bates, 2005). This makes them extremely unresponsive to
changes occurring around them: topical courses are difficult to produce, and it is hard to adapt a course to any social context much less for an individual. They are archetypally hard technologies, especially when presented as monolithic packages.

One response to these problems has been attempts to employ reusable learning objects (RLOs). The theoretical advantage of RLOs lies in the ability to reuse and recombine objects to create new learning resources with relatively little effort. This allows creative flexibility because of the softening effects of aggregation. RLOs were popular among their creators in the 1990s and early 2000s but, in most contexts, failed to gain much foothold. A variety of reasons for this failure have been proposed (McGreal, 2004; Polsani, 2003) and they may all play a role. A proliferation of incompatible and committee-driven standards, issues around ownership, licensing and copyright, a failure to define appropriate granularities for RLOs, inflexibility in options or tools to modify, assemble and customize objects, a focus that failed to take into account the ways that people actually construct courses, and weaknesses in a conceptual model that claimed benefits derived from object-oriented software design but only delivered minimal benefits of poorly fitting Lego bricks might have played a role (Dron, 2007).

However, where it is possible to enforce more rigid adherence to standards and methods, such as in large private education companies and military organizations, RLOs have had a good deal of success. In recent years, a more flexible approach has been employed that rechristens RLOs as open educational resources (OERs), a more generic term that embraces the ambiguities inherent in the original concept (Friesen, 2009). What makes OERs distinctive is not their technical implementation so much as the fact that they are open and softer, so may be freely adapted and changed, rather than simply assembled in limited ways, as was the case with RLOs. They benefit both from the innate softening power of assembly as well as the capacity to be changed, modified, and adapted at a fine level of granularity. OERs present a far more powerful approach to reuse than RLOs, which re-establishes context, adaptability, and ownership for those seeking to use them. Economic models for sustainability of such resources remain an issue, but in practical terms, the availability of countless millions of high-quality OERs from reputable sources, including many of the world’s top universities, makes this a moot point. Unfortunately, as such content becomes more prevalent, it becomes increasingly difficult to find the most effective and relevant OERs.
Collaborative filtering provides a potential solution as it has proven to be a highly effective means of recommending books (Amazon), videos (YouTube) and other resources, while Google’s PageRank, an adaptive algorithm, makes it perhaps the most successful example of online learning on the planet today. However, recommendations based on explicit or implicit preferences are of far more limited value in an educational context, where needs are highly discontinuous, where current needs seldom predict future requirements, and where there are many dimensions of value apart from simple preference (Drachsler, Hummel, & Koper, 2007; Dron, Mitchell, Siviter, & Boyne, 2000). Some attempts have been made to marry semantic web ontologies to recommendations (e.g., Karampiperis & Sampson, 2004), but these are complex to produce and maintain, and the ontologies are nearly always driven by rigid subject taxonomies rather than pedagogical value that shifts to suit learner and contextual differences. Few if any effective solutions yet exist that adapt well to context or that provide a pedagogically driven map that can supply a program of learning rather than just resource recommendations. There are also risks of unnecessary hardening if recommendations become too strong and the development of sub-optimal fitness (Page, 2011) and filter bubbles—an echo chamber effect in which novelty and diversity is suppressed (Pariser, 2011).

One solution to the problem of adaptation and diversity is the use of adaptive hypermedia (AH), in which a single set of resources can be adapted to many different user needs (Brusilovsky, 2001). While this continues to flourish as an area of research, few benefits have seeped into the mainstream, at least partly because AH is difficult to produce. This is not just because of having to model potential paths but also because the provision of more material is more work, which makes production even slower than in the traditional non-adaptive model. Also, there are limited authoring tools (Cristea & Verschoor, 2004) and learner models are often quite primitive and inflexible, but it is difficult to improve flexibility without also increasing difficulties or at least complexity for learners (Kay, 2006). Some success has been achieved in looser forms of adaptation, especially those employing social methods, and some attempts have been made at establishing standards for inter-operability of user and content models, but the fact that adaptivity means that there must be more content also means that cost and complexity of AH remains high. Whether or not such methods result in learning improvements, their cost effectiveness remains open to question. Some forms of AH, especially those
that present a filtered view rather than emphasizing or de-emphasizing content, also run the risk of hardening.

Social-Constructivist Solutions and Open Questions

Social models of learning are effective and, in principle, soft and flexible, requiring relatively few resources to create and relatively little time to make changes and implement innovations. However, in keeping with the maxim that soft is “hard,” they are very expensive to run and they scale very badly (Annand, 2007; Bates, 2005). For small cohorts, flexibility is easy to achieve and innovations can be implemented quickly and easily. For large cohorts, the only plausible method of teaching is to split students into small groups, often led by cheaper trainee or student facilitators, whose expertise and experience may lead to variable standards and quality. This in turn raises issues of quality control and management, which means that costs are not only high in terms of tutoring time but also in management. Unless standards are allowed to drift, this introduces a harder layer of management technology, which means that many of the benefits of softness and flexibility for change are lost.

Few effective generalizable solutions to this quandary have been proposed, though there are methods that can work in limited cases. Pedagogical techniques such as peer teaching, for example, offer some reduction in the need for tutoring time and can increase the number of students that may be accommodated by a single academic facilitator (Goodlad & Hirst, 1989). This is a very soft technology that generally requires skill and creativity to implement effectively, although intelligent crowd-powered ICTs can help to guide the process (Gutiérrez, Pardo, & Kloos, 2006; Vassileva, 2004) and there are great pedagogical benefits from teachback (having students demonstrate their knowledge by simulating or actually teaching someone else) (Pask & Lewis, 1972).

Connectivist Solutions and Open Questions

One of the most compelling arguments for the use of connectivist approaches in distance learning is their innate capacity for and valorization of change. The major foundations of connectivism include the principles that currency is critical for all connectivist learning, that learning is a knowledge creation process, and the learning happens in many different ways
Innovation and Change

and rests in a diversity of opinions (Siemens, 2005). This makes connectivist approaches innately extremely soft. The methods and technologies used in a connectivist approach to learning and teaching thus embrace change at a fundamental level and provide fertile ground for diversity and innovation. Connectivist approaches are seldom bound to any but the broadest of intended learning outcomes, seldom involve the need for large amounts of planning or structure, and seldom require the use of specific tools. This does not make the management of change in a connectivist model unproblematic. In fact, the chaos that ensues swings notably away from a Stalinist regime of excessive control to one where it is commonplace for there to be insufficient control, a chaotic Red Queen regime in which learners are left lost in social space, running to stay in the same spot, and moving through sub-optimal paths. Once again, we see that soft technologies are hard to use.

The enormous drop-out rate from such courses is, partly, the consequence of such problems, though other factors such as lack of need for commitment, lack of accreditation, and lack of formal support have also contributed to challenges of early connectivist learning experiments. This is a fast-evolving and developing problem space where solutions ranging from simple organizational procedures to complex mashup, analytic, and visualization tools vie to provide solutions that are, as yet, poorly developed, and the balance between soft flexibility and hard structure remains problematic.

IMPLICATIONS FOR PRACTICE

The braiding of technologies that defines and characterizes distance education presents both threats and opportunities. As technologies evolve, they open up new adjacent possibilities, but they do so in an environment of constraint full of ossified paths and histories that cannot easily be rewritten. In this section we look at approaches to facilitating innovation and assembling systems for distance education that are flexible and reliable.

Conditions and Cultures for Innovation

If it is assumed that change is a good (or at least a necessary) thing, then it is important that an organization designs the processes and procedures
In an organizational context, this is about building processes and organizational forms that provide space for innovation to occur. Organizational approaches include the use of a variant on Skunk Works (a term derived from Lockheed Martin’s separate entity for innovation, who own the trademark in most countries), time to play (such as Google’s famous day-a-week on innovative projects that interest their workers), and policies that valorize diversity and experimentation. Florida (2005) has found that the most creative and innovative cities thrive because of tolerance of and cultivation of diversity, and very similar principles apply within organizations (Seely Brown & Duguid, 2000).

Importantly, such initiatives should not be separated from the rest of the organization, nor should they separate those who are innovating from those who perform more mundane work. Brown has found that organizations that take people out of their working context in order to foster innovation do indeed encourage people to innovate, but their innovations do not seep into and spread through the organization unless such a process is embedded in the workplace (Brown, 2009). There is a fine balance between providing the space and time to innovate and the need to integrate: It is easy for demands of everyday work to reduce the capacity to innovate, but separation of people from their context in time and/or space reduces the chances that innovative thinking will spread through the organization. The same digital technologies that have come to dominate distance learning, especially those that are inherently social, can, of course, help to fill this gap by enabling communities to overlap and blend (Dron, Anderson, & Siemens, 2011).

### Conditions and Cultures for Adoption

Hew and Brush (2006) identify a range of barriers to adoption of technologies: resources, institution, subject culture, attitudes/beliefs, knowledge/skills, and assessment. The grocery-type list seems a little arbitrary and full of overlaps but is useful as an instrument for discovering areas of difficulty. The researchers found that the overwhelming number of reported barriers (in this case for K–12 teachers but the principle is transferable) related to resources and knowledge/skills. If change is to be enabled and passed through the system, it is vital that sufficient resources, including time, tools, and opportunities to learn are provided.

Classic divisions within academia and commerce, where hierarchical levels of organization effectively separate disciplines and administrative
areas, are a poor means for innovation to occur and disseminate (Becher & Trowler, 2001). Hierarchies make it difficult for connections between branches of the tree to be made and encourage a monoculture where diversity is throttled (S. Johnson, 2012). An institution that is built on hierarchical lines is a harder technology than one that is more distributed. Innovation and change tend to happen at the edges between communities when people are able to shift between systems, communities, and disciplines (Wenger, 1998). It is also important in any system to ensure that the organizational technologies are not too hard: as Brand observes of buildings, “high-road” magazine architecture tends to be beautiful but inflexible, failing to adapt to changing needs and circumstances.

The most effective designs for change are those that may most easily be extended and modified (Brand, 1997). This primarily means building systems from smaller pieces by assembly, following Arthur’s observation that technologies evolve through a process of assembly (2009). An ecological approach can help evolve diversity and thus innovation (Brown, 2009). In ecological terms, parcellation plays a central role in accelerating evolution, but must be tempered by a mechanism for innovation to pass out of small islands and isolated spaces into the larger savannahs and spaces (Calvin, 1997). The message is clear, there should be fuzzy, permeable, and changeable borders between isolated organizational spaces, where innovation can emerge and seep through the organization, without the bottlenecks and filtering of artificially imposed hierarchical layers (Seely Brown & Duguid, 2000).

**Approaches to Design for Change**

Soft technologies enable and usually demand creativity, adaptation, and change, while hard technologies actively militate against it with regard to the phenomena that such technologies orchestrate. Constraints can form a stable base from which creativity might stem, but only if they do not replace the creative process. If those constraints are the result of hardening and replacing, say, pedagogies then they prevent innovation.

Given that distance education is defined by technologies, if we are seeking to enable change our technologies should be at least somewhat soft with regard to pedagogies, or at least capable of being softened. This creates a complex tension because the price to be paid is usually in terms of ease of use, efficiency, freedom from error, and speed. There is at least a partial
solution to this dilemma. Arthur’s (2009) insight that technology evolves through a process of assembly provides the key to building distance education systems that are adaptable and evolvable.

Physical assembly has historically required a high degree of skill but, now that the majority of distance learning involves digital platforms and virtual technologies, the means to assemble rich learning spaces for distance education is now affordable, available, and within reach. When it was necessary to understand complex tools such as programming languages to create dynamic content and interactive designs for learning, making changes was a technically complex process. Building from pre-assembled components makes it simple, though does demand that teachers and learning designers need proficiency or the means to become proficient or call on the proficiency of others. The principle of making change through assembly applies to both content and the processes needed to create the technologies of distance education. Assembly of components allows softer technologies to be built out of smaller, harder technologies and, where it is necessary to make adjustments, narrows the range of adjustments that need to be made to smaller, more easily managed components.

In general, the softer a system is to begin with, the easier it will be to change. Because humans are the orchestrators of phenomena, they are part of the technology and can therefore influence it to become whatever they wish simply by deciding to do things differently, notwithstanding the affordances and limitation of change inherent in the surrounding technologies with which it is assembled. However, the effort needed by both teachers and students in softer systems can make it uneconomical and unnecessarily difficult for both parties, so it is often useful to replace softer processes with harder technology pieces. To give an extreme example, the softest pedagogy for a course might be to simply tell students the topic to be covered and to tell them to go and find out for themselves. This might be seen as a very flexible approach, but for most learners it would be far too soft and would leave many feeling unsupported and confused. Increasing the hardness by adding more structure to the process, based on knowledge of cultural standards, prerequisite knowledge, and how people learn, would make it easier for most students. However, beyond a certain point, the reduced flexibility and reduced opportunities for change and adaptation as increasingly hard elements replaced the softer processes would be counter-productive for those who need more personal control.
Content Re-Use Process

In the cognitivist/behaviourist model of distance education, the use of OERs as part of the learning technology assembly can make an industrial approach far more adaptable and agile, reducing the time from planning to implementation of courses from years to weeks, and enabling the fairly rapid adaptation of courses that are already running. It can also allow for the development of different paths that may be more suited to different learners, a process that was, in the past, unfeasibly expensive for all but the largest scale of course implementation. This means that older cascading waterfall design methodologies that take a step-wise project management approach of the sort championed by Dick and Carey or embedded in the ADDIE process need to be modified, accelerated, or abandoned to enable faster development cycles, easier learner and teacher customization, and richer feedback loops. There are lessons to be drawn here from the software development world using methodologies such as Scrum or Extreme Programming (XP) (Johnson, 2006).

For those adopting a social–constructivist model, OERs can provide vital resources to help scaffold a problem-based approach, providing raw materials to be used in the co-construction of knowledge. OERs, in the loosest sense, are also a necessary basis for connectivist models of learning: They offer important nodes to be connected in the knowledge that exists out in the network.

Whatever pedagogies underpin the use of external content, difficulties remain in finding OERs that are appropriate and adaptable to specific needs and the Not-Invented-Here syndrome, though lessened by the capacity to adapt some resources (Laurillard, Swift, & Darby, 1993).

Learning Environment Design Process

Beyond OERs, the use of components is also crucial to the creation of technically mediated processes that may be easily changed so that, for example, technologies for communication, sharing, discovery, connection, and organization may be used and customized by those who are relatively unskilled in the use of these technologies. To support cognitivist/behaviourist and social–constructivist models, variations on the LMS have become the normal supporting technology. Unfortunately, they have proven to be hard technologies, brittle and inflexible, creating a strong set
of path dependencies and proprietary lock-in, even when implemented through open source tools (Lane, 2009).

Much of the value of the LMS is that it reduces choices for the designer of learning spaces, offering a pre-built structure where the system designers have already made smaller decisions. However, this makes it significantly complex to make changes that are not easily accommodated by the system. There are various levels of technology support based on assembly of components that can overcome this problem, again softening through the process of assembly. At its simplest, a plugin-based architecture, enabling the development of learning environments that are customised to their context, can provide a flexible and easily extended basis for learning at a distance. Moodle (flexible through plugin modules) or Blackboard (flexible through plugin Building Blocks) are popular examples of this genre, each offering a monolithic core that can be modified or extended with extra blocks of code created by IT departments, the community, or commercial providers.

A more flexible framework, OKI, was initially designed as an ambitious attempt to provide a system built almost entirely around plugin-like components but it was over-complex and its flagship product, Sakai, largely ossified this framework into what is essentially just another LMS like its more monolithic competitors. The problem with plugin-based approaches is that they tend to be run at an organizational level, with plugins determined and installed centrally. The larger the organization, the higher the hierarchical top-down level at which this happens, which means that the most well-meaning centralized IT departments are bound by the need to cater for everyone to produce something that is, inevitably, a compromise for some, if not all, who wish to use it. They are soft for the system administrators but can remain hard for those who use them to create learning experiences. The more that component-based assembly can be devolved to the creators of learning spaces, the greater the opportunities for innovation and change because it makes the technologies as used by those individuals softer.

At the opposite extreme to the managed spaces of institutional and commercial learning environments, for those following a connectivist approach there are countless sites and systems that may be found and/or configured to suit almost any conceivable learning need. Larger social sites offer a wide range of means for individuals to assemble a variety of technologies in a single space, in a manner that is not dissimilar to the process of adding plugins but that, crucially, is under the control of the teacher or learning
designer rather than the administrators of ICTs. Facebook and OpenSocial apps, or widget-based interfaces such as those used by Wookie, or social application assembly kits such as those provided by Ning allow teachers and learners to construct very highly customized learning technologies.

For those following a connectivist model, the emphasis on sense-making, filtering, and assembly means that any and all technologies for sharing, communication, and connection are valid means of acquiring knowledge. To a large extent, control over not just the content and process but also the technological means of managing that process is what makes it a connectivist approach in the first place. The big downside of the total freedom implied by a connectivist approach is the skill needed and the relatively unstructured and unguided dispersal of knowledge across the network. With virtually limitless choices, making any intelligent choices becomes difficult and thus reduces rather than increases control (Schwartz, 2004). As Baynton (1992) suggests, control is not just about having choice but also having the power to make those choices, which means knowing enough to distinguish between them. A number of solutions can make this easier, most of which involve some form of further assembly: in essence, to make systems from larger pieces. Lightweight APIs (application programming interfaces) as well as interchange formats such as RSS make it possible to link most modern social systems more or less richly in the form of mashups. This is especially useful when combined with templates, whereby designers do not need to build systems from scratch but may use partially assembled systems as a starting point.

Bearing in mind that change is a learning process, templates provide the scaffolding to help less experienced learners to become competent and effective experts. Unlike the guided process of the LMS, templates that are constructed from components do not present an insuperable barrier for those who need something not provided by the system. Component-based designs may always be softened by adding new technologies to augment the old, or hardened by replacing flexible, softer components with less flexible, harder components.

There is one notable dark side to an assembly approach to enabling change in learning environments: managing many small pieces that are required to interoperate can be significantly harder for ICT managers than managing a monolith, where a single team of creators helps to assure consistency and interoperability between the pieces. There are no simple
answers to this problem apart from careful adherence to standards (as they emerge) for interfaces, coding, and design.

Approaches to Selecting Learning Technologies

While a combination of objects and templates that can be assembled is effective for building distance education systems with flexibility for change, it is also necessary to be able to select the right pieces in the first place. Tony Bates (2005) has devised the ACTIONS model for selecting technologies for use in a distance education context, which includes, in approximate order of importance:

- **Access.** No technology will have any value unless learners may access it. This is not quite as simple as whether, say, a device is available, but also how it is available; a shared computer in a house, for example, is less valuable to learners than one to which they have exclusive use.
- **Cost.** It is at least as much to do with cost-effectiveness as actual price of delivery.
- **Teaching and learning.** How good is the support provided for intended or implicit pedagogies and methods? While the technology should minimally provide the necessary medium for the intended practices, some will be a better fit than others.
- **Interactivity and user friendliness.** Does it enable learners to interact with content, teachers, and one another?
- **Organizational issues.** What are the requirements and barriers within an organization? For Bates, this covers a multitude of contextual and system factors.
- **Novelty.** How new is it?
- **Speed.** How quickly can it be used to create and change courses?

While access is probably the first thing to consider in most cases in distance education contexts, the order of significance of the other factors will vary. The author has participated in many developments where speed is far more significant than the other factors and drives the choice of technology, for example, but has never come across a situation where novelty is more important than any other factor on the list. Although one suspects that the order of the factors is more to do with creating a snappy acronym,
and Bates plays down the huge range of interdependencies between them, his ACTIONS model offers a viable framework for technology selection and specification that can greatly increase the potential for successful change.

Consideration of all of these factors does not assure successful uptake. For this it is necessary to turn to models of technology acceptance and task–technology fit but, as we have seen, these are best seen as guides for reflective practice than formulae for success. It is also notable that Bates’s model underplays the dependencies between novel technologies and those that are already available, relegating the problem to a minor aspect of organizational issues. This is not just important but, one could argue, it is paramount. If, as we have seen throughout this chapter, technologies are assemblies, then it is crucial that they should work well together. This is not only true of the electronic elements, where things like standards and APIs can help, but in the pedagogies and organizational systems of which it will be a part. To give a trivial but telling example, a technology in which the word course is hard-coded to mean what North Americans recognise as a certain kind of learning unit will fit poorly with an educational system such as that found in the UK where such units are more commonly described as modules, or papers in New Zealand, and where course has a quite different meaning, more akin to that of program in North America.

Following from this, an important aspect of managing change is not just selecting but in deselecting technologies. Path dependencies, locked-in databases of content and interaction, and the inevitable intertwining of technologies into other technologies and systems means that this is often significantly more difficult than selecting them in the first place. Few have the luxury of reinventing systems from the ground up and the costs of moving from something as deeply entwined as, say, a learning management system, are extremely high, almost always leading to resistance and resentment. Once again, being able to assemble technologies from small components in the first place can mitigate many of these problems, allowing components to be replaced with relatively little disruption to the whole system.

CONCLUSION

The rapid and radical changes in teaching and learning technologies during the past decade show little or no sign of abating in the future. Disruptive non-routine technologies change the rules again and then again. Increasing
affordability and sophistication of extraordinarily useful and convenient machines—such as 3D printers—means that the ability to easily assemble technologies for learning will soon no longer be limited to virtual objects. The merging of physical and virtual spaces through ubiquitous computing, where devices are embedded in our surroundings in ever-greater densities, from shirt buttons to furniture, from intelligent cloth to smart dust, will open vistas of opportunity and threat. Augmented reality, where virtual information is overlaid on real spaces so that we can know more about our surroundings when we need to know it, will open up adjacent possibles that we can only begin to guess at and change the things we need to know and how we need to know them. These, and others like them, will be and are becoming truly disruptive technologies that will radically alter the ways that we can enable learning and that will, no doubt, lead to new and enhanced pedagogies that are not yet conceivable. This is not because we cannot imagine the tools and their affordances (we can), nor that the pedagogies that will emerge will be completely new to the world (they won’t), but because we cannot reliably infer the effects that they will have in a large system, nor the roles they will play when they work together, nor the adjacent possibles that will emerge through those assemblies.

The shared characteristics of these emerging systems are their capabilities for assembly and integration at a depth of sophistication that we have never seen before. This means that they will be remarkably soft, malleable and open to creative uses. If such changes are not to overwhelm us or to channel us in directions we do not wish to go, we need models and conceptual tools to deal with them and their interactions, of which we have hinted in this chapter.

However, we also need to be mindful that change is, for the most part, not a wave so much as a diverse rippling tide that fills in gaps very unevenly. Resistance to change is only a small factor when compared with the massive economic, cultural, and social inequalities that exist worldwide, where there are innumerable places that the Internet has barely touched, places it is controlled with vigour, places where clean water, let alone electricity, has yet to arrive, places where cultural mores, exploitive elites, and religious prohibitions actively resist change. Learning technologies, be they pedagogies, programs, or pedestals, are codetermined by their surrounding ethics, socio-economic circumstance, legislation, belief systems, histories, and desires. They are not, and have never been, neutral agents. As well as being
value laden in their inception and acceptance, they are co-determinants of what we do, what we are and how we behave (Feenberg & Callon, 2010). We shape our buildings and afterwards our buildings shape us (Churchill, 1943). We shape our tools and then our tools shape us (McLuhan, 1994, p.xxi). While change will surely come, it will be uneven and take many forms. The great softness of the new opportunities for assembly might make such tools bend easily to fit the larger whole, perhaps (at least at first) even reinforcing rather than disrupting educational norms and rituals.

What binds all aspects of change is the process of learning. To learn is to change and the changes wrought by and wrought in distance education are, by and large, virtually all manifestations of learning: a process of growth that incorporates earlier knowledge and builds upon it to create new knowledge. To learn is also to learn to learn, and learning to learn is thus, more often than not, to change how we go about changing. If we can learn new ways of changing, then we can begin a rich evolutionary process where the rules of evolution themselves evolve (Kelly, 1994), thus enabling more change and continuous evolution towards a peak of fitness that forever moves as we approach it. This process of change and learning defines all of our educational systems, albeit sometimes it seems as if the change happens in almost geological timescales. It is therefore quite important to understand it, not as a simple process of cause and effect but as a richly dynamic, interconnected, and human system in which we are at once the actors and the acted-upon, simultaneously subject and object, caught in a never-ending dance where no one knows the steps but from which a marvellous order emerges.

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