Chapter in:

Looking Toward the Future of Technology Enhanced Education: Ubiquitous Learning and the Digital Native

Topic: **Principles of Effective Learning Environment Design**

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Principles of Effective Learning Environment Design

Abstract

New thinking on the design and purpose of learning solutions is needed where the focus is not only on what to learn, but also the strategies and tools that enhance students' capacity to learn and construct knowledge. The vision underpinning this chapter is to extend the notion of advanced learning environments that support learners' to construct and apply knowledge to include the capacity to understand how and why they learn as individuals.

Whenever conceptual change occurs as a result of active cognitive processing, higher order thinking emerges, which is further enhanced through discursive interaction with other individuals and groups. A shift in the focus of learning from the passive accumulation of information and knowledge to learning as a life changing experience that is augmented by active, collaborative engagement in the learning process provides direction as to how the complex tasks of learning and creative knowledge construction can be supported in the design of advanced learning environments.

The purpose of this chapter is not to argue the need for 'virtual' learning environments – the literature abounds with positive endorsement for such applications. Instead, the strategies and factors that afford learners greater opportunities to engage in rewarding, productive learning experiences are examined with a view to laying down the groundwork and design principles to inform the development of a model for devising educationally effective, multi-modal (face-to-face and online) learning environments.

Keywords

learning environment design, knowledge construction, virtual learning, connectionist theory, emergent properties, information and communication technology, ecological design, metacognition, networked communication, knowledge communities, collaborative discourse, collaborative learning,

Introduction

Whilst many educational institutions throughout the world have introduced online learning as an option for delivering teaching content, little evidence exists of a predominance of innovative solutions that promote pedagogical diversity. Aside from a few notable exceptions, the design of most online learning environments is structured around the traditional instructional delivery model and has not taken full advantage of the empowering potential of information and communications technologies (ICT) (Dreher, 2006). Rarely are university students offered the tools to organise their learning activities to suit individual needs and circumstances; collaborative online problem solving activities and group projects seldom inspire rewarding learning experiences; and, seamless collaboration with the wider online community is not consistently encouraged.

At present, many university students use version '1.0' web-based learning management systems that deliver closed, centralised, server-oriented, and distribution-oriented virtual learning environments (VLE). The widespread adoption of VLEs by colleges and universities has led to the dominance of a handful of market leaders that promote the delivery of what is touted as new, advanced modes of learning. The majority however, have opted for little more than an online version of the traditional delivery model and as a consequence, online delivery systems that promote pedagogical diversity are the exception, not the rule. Few online learning systems provide learners with tools to organise themselves; most do not easily permit group learning or support group or problem-based learning;

many do not seamlessly integrate with the wider internet and in effect, create ‘learning ghettos’ (Liber, 2004, pp 137 – 38).

The current reality is that outside the campus intranet, people ‘meet’ each other in online chat rooms, operate Weblogs, engage in ‘virtual’ communities, answer questions on ‘support’ websites (bulletin boards and Wikis), and share resources using highly interactive and intuitive peer-to-peer systems. The Internet continually offers new tools to support such activities, but a discernible mismatch separates what is available on the Internet from what university learning delivery platforms permit. This version ‘2.0’ of the World Wide Web has rapidly evolved to incorporate social, distributed, open, peer-to-peer, and contributive elements that permit multiple layers of communication among people who share interests and resources to dynamically connect and exchange ideas using technologies such as short messaging services (sms), chat, weblogs, wikis, and email. Typically, few of these features are available in leading VLEs. Instead of learning how to create knowledge, learners are confined to receiving information using environments that are devoid of the richness and diversity inherent in face-to-face discourse and interaction.

During collaborative discourse, participants ‘build on’ the contributions of others. The outcome of such exchange is that each individual re-assesses and reflects on the knowledge they have gained and in the process reconstructs previously held concepts, notions, or ideas. Collaborative learning is achieved if conceptual change is explicitly affirmed and redirected during a sequence of discussions that are guided by the goal of transforming the shared thinking into new concepts and ideas, the supreme prize (ideally) being the emergence of new and creative knowledge. When learning is collaborative, concepts, notions, or ideas are refined or transformed during a collective exchange as transpires during synchronous ‘real-time’ discussions or over the course of asynchronous activities conducted through sms, email, or bulletin boards.

New design concepts and strategies are required that build on the social use of the web and extend this functionality into the realm of virtual (online networked) learning communities. Active engagement in communities of learning (whether physical or virtual) exposes the learner to the perspectives, ideas, practices, interests, and connections to other knowledge domains that may otherwise not be possible through independent study. In the design approach proposed in this chapter, the learner is encouraged to negotiate pathways (either preset or self-determined) through a multiplicity of contexts whilst simultaneously ‘monitored’ by community members who provide feedback on the concepts and knowledge generated during the learning process. The capacity for learning and knowledge construction is thus enhanced both individually and collectively.

Today’s technologies can assist students to collaborate whilst pursuing individual strategies and approaches to learning as opposed to following the same material as a group under the guidance of a teacher. Technology can also support lecturers to work together to develop and share resource materials and teaching strategies; and technology can be used to enable institutions to collaborate on providing better services to their students. In short, the design concepts and strategies outlined to this point require version 2.0 web functionality and thereby extend the experience to the realm of virtual communities of learning.

The Core Principles: Collaboration, Self-organisation, and Ecological Systems

From a teaching and learning perspective, the primary challenge confronting both lecturer and student is to master new and complex information structures, and to apply the available technologies and essential interpretive skills to participate in virtual learning environments. Within these environments, collaborations among individuals and networks of individuals (groups) are fundamental to the sustained generation of new ideas and to the refinement of accepted ideas through the efficient dissemination and application of knowledge across the networked community.

On the latter point, it should not be assumed that participation in a virtual world (or even the classroom) automatically results in a productive outcome – that is, learning and knowledge. Simply presenting large quantities of information and resources available online may in fact result in distraction and confusion. What is required is akin to that which occurs in nature: coherent bits of information presented so that they self-organise (cognitively) into emergent clusters of new connections in the form of ideas, innovation, and creativity. The difference however, is that the organisation of human thoughts is more complex than self-organisation in nature.

In the natural world, self-organisation is causal, whereas in individuals, cognitive organisation requires an internalised process of pattern recognition in order to form new connections amongst the perceived data and information. The key distinction is that nature is not innately organised, but appears (superficially) to display properties of self-organisation. That is, nature is inherently chaotic, out of which order naturally forms (Gleick, 1987, pp 259 - 262; Sheldrake, 1988, p 113; Rucker, 1988, pp 26 and 113; and Kosko, 1994, pp 21 - 3).

Cognitive self-organisation in learners occurs whenever patterns of connection or relational organisation are either identified or created and then communicated to others. The acts of dialogue, observation, questioning and research result in the retention of information, ideas, and concepts, which in turn gives rise to learning as new information is generated and combined to produce new understandings (Daniel, 1996, p 2; Brown & Thompson, 1997, p 75). The act of creativity is at one moment the process of internalising recognised order, and in the next, of passing the identified order onto the next person as a learned experience. It is in this sense that the (undiscovered) relationships that connect disparate ideas and the nuances of all knowledge domains can lead to the emergence of creative thinking and innovation. In a similar way, the human process of self-organisation also provides an effective means of evaluating (that is, community judged) the depth and quality of the knowledge and expertise that is constantly generated and distributed throughout the broader learning community.

The social element of active engagement in learning communities also poses significant challenges, in particular virtual environments where the relationship between collaboration and learning is crucial. As many experienced educators would know, there are many instances where learning naturally shifts into collaborative discourse involving continual interchange of ideas and views between individuals within a community and between communities, or among individuals and other communities. However, learners may also experience confusion and difficulties in such circumstances. Some communities may confine their focus to the knowledge and skills of a specific profession or others may span several disciplines united by a common purpose (operating for example, as a multi-disciplinary networked partnership). Alternatively, a networked (connected) learning community may be structured as a single organisation or span many organisations. Therefore, support systems and strategies for managing such diverse encounters must be readily available as the need arises. In light of the complexities noted so far, learning environments designed to meet the needs of both individuals and groups require an ecological design approach as derived from networked (natural) systems principles to:

- enable productive social interactions in the virtual world
- identify and provide for the needs of learning communities both in terms of the specific interests at the local level and the connections to broader community networks
- accommodate both individual and group preferences and behaviours
- manage the creation and transfer of knowledge within virtual learning communities, and,
- enable efficient sharing and protection of resources, ideas and the knowledge generated by individual learners and groups participating within and across networked communities.

An emphasis on ecological communities extends the individual's knowledge construction skills to embrace multi-level, interconnected, social learning systems that expose the learner to a broad array of perspectives, practices, interests, and the idiosyncrasies of divergent knowledge domains. The strategies for enhancing learner cognition through connected pathways using ecological or systems design principles are not the only area of relevance to this chapter. Expanding the 'connectedness' (or connectivist) metaphor further, of equal importance to ensuring successful learning is the level of expertise and depth of understanding provided by experts and organisations that participate within a community of learning. For example, consider the Web as comprising a vast number of 'authors' each of whom are members of separate interest groups, many of which embody a large cache of expertise accumulated in both written and tacit form. Given the vastness of the Web, it is relatively easy to locate a niche community with the required expertise or a special interest group with interests that coincide with that of the learner. Once identified, the diversity of input and comments provided by experts who may be situated anywhere throughout the world adds texture to the area of knowledge under examination and thus presents another example of how the Web can be used to enhance the learning process.

Consistent with the notions of connectedness and ecological systems, it is further argued that in order to enhance learning, not only will it be necessary to re-think the purpose of learning environments, but also to devise more advanced and adaptive learning strategies that connect people to people - not people to machines. With this goal in mind, this chapter observes several focal questions as a way of initiating debate on the nature and purpose of learning and associated learning environments in the coming decade. The questions that underpin the main themes of this chapter include:

- what is a creative learning ecology?
- how does learning emerge in ecological learning communities?
- what strategies are needed to enhance learning and creativity in a connected learning ecology?
- how to identify and provide automated support (human and technology assisted) for meeting the needs of networked learning ecologies?

In summary, this chapter examines how the learning experience can be enhanced by applying an alternative perspective on the purpose and design of learning environments where the focus is directed towards the design principles, methods, strategies, and tools that assist students to become creative thinkers and innovative constructors of knowledge. First however, it is important to understand that technology imposes both positive and negative influences on the learning process.

Technology is Transforming the Role of Education

The rapid acceptance of the Internet, the irrepressible revolution in information distribution, and the increasing sophistication of information and communication technologies (ICT), have converged (self-organised) to create a previously unknown dimension in human communications and expression that directly challenges long-held cultural and institutional boundaries. Moreover, the convergence between computers and communications has created 'virtual' communities and organisations in all fields of endeavour that in part are the result of the abolition of the barriers of time and distance. In the past, these barriers precluded collaboration on a wide range of tasks and activities. Because of these developments, it is now technologically feasible for students and teachers from all over the world to 'meet', collaborate, and exchange views.

In his examination of the current generational uses of information and communication technologies, Candy (2004, p 232) concludes that an unexpected yet fundamental reconceptualisation of the purpose of learning has emerged over recent years. The extent of this shift points to a marked transformation in the learning expectations of young people which is partly attributable to the view that they are the most innovative exploiters of the new mediums, and partly because they will become the next generation of self-directed adult learners. The Millennials (Generation Y or Net Generation, approximate birth years 1977 to 1997) for example, have grown up in a world in which computers, cell phones, and cable television are a normal part of everyday life. They are inundated with information from a multitude of sources, and are capable of using a wide variety of media and devices to communicate, learn, and to be entertained. The most favoured of these sources are those that permit relatively instantaneous, concurrent, communication with multiple people, regardless of geographic boundaries.

The Millennials are also a genuinely interactive generation (Mask, 2002, pp 3 – 4). Virtual chat is used by the current generation to communicate directly with their peers and chat archives attest to the frequent and topical use of the Internet in late night, peer-to-peer conversations that are conducted within the boundaries of their own cultural framework (Carmean and Haefner, 2002, p 5). Today's students not only constantly engage in interactive communications, they expect it. As a result, they are exposed to an unparalleled flow of customs and ideas that may in fact represent a significant step in the development of human cognitive processing.

The available evidence suggests that over the course of the coming decade, technology will exert a major role in breaking down the entrenched barriers instilled by industrial-centric thinking that are not only unsustainable, but will prove inadequate for resolving the educational demands of the twenty-first century. (Tiffin & Rajasingham, 1995, pp 1, 48, 57 and 73; Taylor, 2001, p 1; Taylor, 2002, p 4; Greater Expectations National Panel, 2002 p iii; Frand, 2000, pp 17 and 24; Wenger, 2005, p 10.).

Redefining the boundaries both within and outside the university sector will assure the future relevance of great universities. At each of the local, national, and international levels, it is likely there will be networked groups and organisations made possible through inter-institutional cooperation; a blurring of knowledge boundaries due to the interplay between highly advanced learning environments and instantaneous access to vast repositories of networked resources. As a result, today's educational institutions may one day become 'virtual' communities of learning. Then, as new forms of delivery are devised, the purpose of learning will be tested against the demands of society, the influence of new technologies, and the global economy (Candy, 2004, p 232; Marginson, 2000; Guile, 2003).

The Imperative for Universities to Prepare for Change

The full impact of recent technological developments on the way humans interact, how people learn, construct and use knowledge is at present not known. It is known however, that students can be competent in the use a nonlinear electronic form of text (hypertext) that permits multiple interactive authoring and demands high levels of visual literacy. No longer are learners restricted to the linear structure of print and consigned to the tedious task of passively absorbing knowledge. So far, educators have acquired little more than a brief insight into the enormous potential of technology as a productive aid in the learning process (Mott & Granata, 2006, pp 48 – 54).

If the implications of technology-directed change are ignored, especially in relation to learning, then the task of managing an exploding information and knowledge base will soon be insurmountable. As Hill and Hannafin (2001, p 1) observed, while the potential of technology for enhancing teaching and learning may be substantial, it may also be the case that educational practices will be inadequate for preparing graduates to work and learn in an information-centric world. It is also significant that education in general is still described using the language and metaphors of the industrial era, and school organisations continue to reflect the practices and beliefs of the industrial model. A failure to utilise the full power of information technology in most curricula is the result of a mismatch between traditional organisational values and the values ascribed to new technologies (Vrasidas & Glass, 2000, p 58).

In order to manage such unprecedented change, educational institutions should first identify the impact on teaching and learning that will result from the expanding presence of an information-dominated world and then enter into a transitional stage of actively re-examining the design and purpose of their education delivery systems. Otherwise, it is likely that within the coming decade, the skills and thinking abilities currently taught to students will not meet their future needs. To resist change will not benefit students once they graduate. Moreover, a reluctance to incorporate change may result in an education system that is not equipped to provide the thinking skills required in an information society. Only those educational institutions willing to take advantage of the opportunity to master and lead the processes of change will be prepared for the challenges of the future (McCune, 1991, p 3). However attractive such notions may seem at first, the history of introducing technology to teaching and learning provides a timely and valuable lesson. As Thackara (2005, p 158) rightly observes:

> Technology fixes for education are an old and discredited story. The delivery of precooked content, by whatever means, is not teaching. Radio, film, television, the videocassette recorder, fax machines, the personal computer, the Internet, and now the mobile phone: It was promised of each of these, in turn, that here was a wonder cure that would transform education for the better. And yet here we are, hundreds of years after the first books were printed, and teachers are still giving lectures, and students still line up to hear them. Why? They do this because the best learning involves embodiment – live experiences and conversation between people: Most people prefer talking to one another to talking to themselves.

Not all educational institutions are resisting the need to embrace change (Ward, 2000, p 26; Salmi, 2000; Gilbert, 2000 and 2003). There is a growing recognition of several worldwide phenomena: an information explosion of unprecedented magnitude; the rapid proliferation of new advanced technologies; significant changes in work practices; an increasingly fragile natural environment; the growing interdependence of societies; and concerns about changes in established values and institutional practices. As the restrictions of time and space become less relevant, new connections are being electronically forged and the concept of a 'global village' or 'networked community' is becoming a significant influence in learning design. This new reality must be acknowledged.

Just as the origins of the modern university arose from decisive changes that defined the boundaries of how knowledge and learning is derived and delivered, paradoxically these same boundaries are now almost obsolete as the influences of ICT transform that same obsolescence into a new and dynamic vision for the future of learning. If a time could be envisaged when technology is no longer apparent, then the important design issues will be (Thackara, 2005, pp 158 - 59):

- allow much more time for learning than allocated now
- redefine the guidelines that describe how learners, teachers and others relate to one another
- determine how best to design the support systems, platforms and institutions needed to make the first two to happen.

From Chaos to Creativity: Self-Organisation and Properties of Emergence

The Internet is not simply a vast network of connected computers. More accurately, it is a protocol for linking many separate computer networks. The actual number of connected computers and networks is impossible to determine. The number of potential links is even more impressive. This enormous complexity is managed by organising machines into a hierarchy of domains, all of which are linked through a system known as Internet Protocol (IP) addresses, a set of unique numbers that is allocated to every computer attached to the system. This numerical address identifies each machine and the various gateways that allow access to the Internet. With the development of information management and file transfer services, the Internet exhibits a capacity for self-organisation and properties of emergence, two clear indicators of complex systems.

The principles of systems theory with its underpinnings of interconnected systems, subsystems and interrelationships among systems illustrate how even the most complex of systems are subject to universal principles of randomness, complexity, chaos, emergent properties, and self-organisation.

Such properties are evident in the organisation and structure of information distributed throughout the World Wide Web, or even in human behaviour (including the way we think and learn). The Internet is an example of complexity in practice, displaying many instances of emergent properties (an indicative factor of adaptive complex systems) and self-organisational principles (the natural tendency for order to emerge out of chaos).

A systems theory perspective provides a framework from which to examine and characterise a learning environment, its components, and all its sub-parts. By integrating systems concepts and principles into the design process and by determining how to apply such factors, new ways of thinking, experiencing, exploring, understanding, and describing a learning environment become apparent. The design of learning environments based on a systems perspective should account for a range of factors (Banathy, 1988a, 1991, 1996):

- properties of wholeness and the characteristics that emerge at various systems levels as a result of interaction and synthesis.
- identifying the relationships, interactions, and mutual interdependencies of systems.
- the dynamics of the interactions, relationships, and patterns of connectedness among the components of systems and the changes that manifest over time.
- interpreting and tracking interconnectedness and interdependencies in complex information systems.
- identifying obscure relationships within information systems using complex analysis techniques to derive new insights and meanings.
- managing the difficulties of deriving meaning and the loss of meaning from a surfeit of information.

The application of a systems perspective to learning design assists to determine how the cognitive processes of knowing, thinking, and reasoning can be exploited to facilitate inquiry and generate knowledge (Banathy & Jenlink, 2004, p 49). As signalled by the preceding factors and principles, the identification of relationships within information using enhanced interaction methods provide direction to empower learners to organise, reflect, analyse, and synthesise information to construct new knowledge. What is also alluded to here is the concept of emergent properties.

The term 'properties of emergence' refers to the notion that meaningful order can emerge of its own accord out of complex systems comprised of many interacting parts (Buchanan, 2002, p 198). To put it more simply, emergence occurs in systems where a few simple rules govern the interaction of the component parts. To establish the pre-conditions that give rise to creativity and innovation, several principles of emergent properties assist to design networked learning environments (paraphrased from Lewin, 2001, pp 202 - 3):

1. the source of emergence is the interaction among learners who mutually influence one another. Relationships characterised by mutuality among people, groups and organisations are enabled and encouraged through the provision of access to shared resources and facilities.
2. small changes lead to large effects. Cultivate change through small experiments, problem-solving exercises, and task analysis, while reinforcing the potential for exploring a broad landscape of possibilities without making any judgement as to correctness or wrongness.
3. emergence is certain, but there is no certainty as to what it will arise. Establish conditions conducive to initiating constructive emergence rather than attempting to plan a detailed strategic goal. In other words, evolve outcomes, not design them.
4. a greater diversity of learners engaged in a learning community leads to richer emergent patterns. People of different cultures, expertise, age, personalities, and gender who contribute and interact individually or in teams increase the potential for enhanced creativity.

One notable example of emergent properties originated from the need to source and co-ordinate information for a specific purpose from a large number of networked databases. As a result, individuals and organisations have recognised the need to compile reference indexes specific to their area of interest. In some instances this action has generated the need for information gathering resources out of which has emerged a new whole that has quite literally became more than the sum of the parts. There are now ‘virtual’ sites that arose not just from one source, but instead through a systematic process of linking information services provided by hundreds or even thousands of websites around the world. These sites do not exist in a physical form, they are generated by the Internet in what is often termed ‘cyberspace’.

Virtual libraries provide an example of where huge database-managed tables of content are co-ordinated to provide immediate access to servers located anywhere in the world. We are also witness to many attempts to create ‘information networks’, ‘virtual communities’, and other co-operative projects. Many researchers for example, now submit their raw data to public databases to allow other interested researchers to access and interpret their results, or to carry out entirely new research. Thus, by combining data from many different sources, it is possible to derive a richer, more diverse knowledge base than if the data were to remain in the hands of individuals.

Other instances of emergent properties exist in technological solutions such as distributed computing where different machines are assigned the task of solving specialised components of much larger and sophisticated problems. From each of these specialised sources it is possible to draw together up-to-date data and compile accurate information about a subject of interest or concern (Bossomaier & Green, 1998, pp 159 - 69). What is now evident is that the technology of the Internet has created an information storage, retrieval, and processing system that display properties characteristic of dynamic systems theory: a multidimensional (non-linear), multi-level, interconnected and interrelated (networked) web of data, information, and knowledge. In essence, the Internet provides an intriguing example of self-organising complexity and connectivity as occurs in practice, which in turn points to the key attributes that influence learning environment design as proposed in this chapter.

Chaotic, Networked Learning Communities

Networked learning communities comprise three key elements: content, coherence, communication. From another perspective, a successful networked learning environment comprises simple rules, a universe of possibilities, and the capacity to adapt (Lewin, 2001, p 216). A self-organising, creative learning community leading to the emergence of new 'thinking' models is dependent upon the establishment of an ecological environment in which the structure adapts and evolves through the dynamic formation of novel, complex relationships and connections. By adopting a chaotic, network approach, both in relation to design and in the means of delivery, paradoxically an ineffective, non-productive community (a stable structure) can be restructured to produce a diversity of perspectives. Such environments are uninspiring and a deterrent to learning.

In this scenario, new sources of contention, dissonance, argument, and innovation are introduced, which undermine the stability imposed over time by a culture of low interaction and ineffective idea generation. Genuine creativity and innovation requires a balance between the natural human tendencies for stability and the dynamic, chaotic participants and elements that challenge the status quo. In this way, change is facilitated and new thinking and new ideas emerge. This balance can be likened to the 'edge of chaos' where spontaneous processes of self-organisation occur and new patterns of 'behaviour' emerge as acts of creativity and innovation. Such complex, adaptive environments thus accommodate every individual schema in many different ways and so increase the likelihood that all learners will experience effective learning, more often.

The acquisition of higher order thinking skills and the meaningful conversion of information into knowledge are not isolated processes as many factors contribute to the establishment of learning environments in which the requisite skills for a knowledge-focussed future can be cultivated. The level of learning effectiveness is also due to (chaotic) group dynamics forming an interactive synergy in which the whole becomes more than the sum of its parts. Given the complexity of the task at hand, how can educators, begin to teach thinking skills to their students? The short answer is to apply a networked ecological model to learning design.

Self-Organising, Ecological Learning Environments

An ecology is defined an open, complex, adaptive system comprised of many dynamically interdependent elements (Brown, 2002, p 13). In nature, all species exist as integral components of an interconnected network of ecosystems and sub-ecosystems displaying systemic properties at all levels (Lewin, 2001). Businesses and corporations also operate in complex networks of interactions, first by forming a community of interest at the local scale, then expanding into wider communities at the national scale, and eventually, broader global communities at the international scale. The rigidly structured, static, linear thinking of the industrial era has evolved into a highly adaptive, dynamic, non-linear, multi-levelled, interconnected network of people, resources, and interests. Unpredictability and chaos operate in an atmosphere of information sharing and knowledge production in which creativity and innovation can and often occurs at a rapid pace. These same principles naturally apply to learning environments where learning is viewed as an open system or ecology of people, groups, resources, activities, supporting tools, and infrastructure. Participants involved in an ecological learning environment share their knowledge and expertise, form groups, and establish projects, each according to their individual interests and personal motivations for contributing resources, sharing ideas, and engaging in communal discourse.

An ecological learning environment assists learners to seek greater value from their learning experiences. The fundamental components are people, places, and ideas connected through a combination of deliberate design and random (chaotic) chance to inspire creative thinking and innovation. Such interactions cultivate awareness and expectations in learners engaged in environments in which human dialogue and activities afford greater opportunities to generate new thinking and ideas. Learning naturally ensues when people interact with emergent ideas and concepts. However, learning is not the only outcome.

Ecological learning design also has the potential to redefine the purpose and goals of education. For this to occur requires a willingness to challenge the assumptions enshrined in our educational ideologies and to examine the purpose and aims of the social and organisational structures that support them. In other words, the nature of power, control, authority, responsibility, and entitlement in learning needs to be transformed into a highly interactive, interconnected, self-organising networked ecosystem of individual learners, teachers, groups, and organisations. As Campos (2004, p 7) explains:

> The ecological constructivist perspective suggests that the social environment and the individuals are part of a symbolic ecosystem which is the networked cognitive communication. Configurations of meanings (meanings upon logical structures) are shared and evolve in collaboration across time.

Two factors that make the concept of ecological learning so powerful is diversity and adaptability. Consider for example, the learning ecology that has formed around the World Wide Web. First, consider that the web is much more than a network of computers, it is a transformative medium that facilitates multiple intelligences (abstract, textual, visual, musical, social, and kinaesthetic), and individual learning styles (Candy, 2004, pp 185 and 305). That is, the Web introduces the potential to match the medium to the specific needs of learners. In short, the Web displays characteristics of an interconnected, ecological learning environment described by Brown (2002) as:

- a collection of interdependent and fluid (virtual) communities of interest
- cross pollinating ideas and knowledge with one another

- constantly evolving and adapting to change and new ideas
- dynamic and self-organising

The Internet also provides an example of how connections can result in new meanings and knowledge. The central premise is that the connections established around unusual ‘nodes’ of information and activities can support and intensify existing activities. The amplification of learning, knowledge and understanding derived through the conscious extension of a personal network is the epitome of connectivism in that it provides insight into the learning skills and activities that empower learners to create new knowledge. The networked connections are constantly changing (dynamic), responding to interests, experiences, and new understandings, and continually adapted and expanded as more is learned and the volume of accumulated knowledge increases. In essence, a connectivist approach to designing a learning environment presents a model of learning that acknowledges the act of learning involves much more than an individualistic, internalised process.

In light of the foregoing factors (there are many other factors not raised here), it is argued that education in general has been slow to recognise the impact of the Internet and the consequent environmental changes that have transformed what it means to learn. Thus, the untapped value of the Internet for learning is in its capacity to change both the nature and purpose of learning through the power of connectedness. Again, we are reminded that whenever new technologies are employed, the ways people learn inevitably change.

Content, Context and Connections

In some ways, developing effective teaching content for the online environment goes against the hallmarks of good technical or expository writing taken for granted by many educational designers and curricula writers. The addition of new content does not always connect naturally or logically to existing learning materials. The inherent meaning of the content may change according to need or context application and therefore, its relevance to the expected learning outcomes. If it is assumed that content is fixed and only the connections change then we move to a connectionist theory of learning and enter into the long standing debate between Connectionists and Classicists (Stanford University, 1997, p 1). Fodor and Pylyshyn (1988), Fodor and McLaughlin (1990), and Fodor (1997) for example, often dominated in this debate.

On the classical account, strings of symbols represent information in much the same way data is represented in computer memory or on pieces of paper. The connectionist view on the other hand, claims that information is represented non-symbolically by patterns of connections or relationships between networked units. The classical account presents an objectivist (or atomistic) approach to learning design whereas the connectivist position introduces a constructivist, systems theory perspective. The focus of systems thinking is not aimed at applying a building block model, but to the principles of organisation where an object or event is examined in relation to a larger system or whole. Structuring conceptual understanding using a systems approach is known as contextual thinking (Lipman, 1988, p 3).

The concept of connectivism encompasses the integration of the key principles that apply to the theories of chaos, networked systems, complexity, and self-organisation. It is driven by the understanding that decisions are made in response to changing circumstances followed by the assimilation of newly acquired information into the learner’s existing cognitive framework. As individuals engage in learning, they are continually exposed to new information. In processing this information, the ability to draw distinctions between important and unimportant information is vital, as is the ability to recognise when new information is out of context and conflicts with existing understandings that are drawn from past decisions and experiences (Siemens, 2004).
By applying connectionist theory principles, learning occurs in instances where individuals encounter unclear or ambiguous activities and projects (either planned or unplanned) that may not be fully

resourced. The focus of learning is directed toward discerning the patterns of connected relationships that reside amongst what at first appear to be disparate information sources. In this circumstance, the ability to make connections that inspire learning assumes priority over the learner's experience and understanding. The depth of learning and knowledge gained in the process is directly dependent upon the learner's ability to discern connections between ideas and concepts identified amongst a wide diversity of information and perspectives and their capacity to determine the relevance and accuracy of the acquired knowledge (Siemens, 2006, p 6). We thus begin to identify the design principles that could advantage the construction of effective learning environments.

Enablers of Meaningful Learning

If students are to experience meaningful learning in an era of information overload, three convergent factors are essential (Healy, 1991, pp 52 - 3). That is, meaningful learning occurs at the point where developmental readiness, curiosity, and new subject matter converge to create previously unrecognised learning experiences. However, the task of bringing all three factors together to produce creative thinking and learning is not always a straightforward proposition. The successful transition from formal education to coping with the demands of a fast changing future remains largely contingent upon ensuring students are equipped with the 'traditional' skills of critical thinking, rational analysis, problem-solving, research, communication and writing. Equally important, is the need for the skills developed through teamwork, group presentation, negotiation and conflict resolution, the provision and acceptance of feedback, active listening, cross-cultural communication, and finally, time and project management (James, McInnes & Devlin, 2002, p 48). Again, there is an emphasis on the educational significance and value of social networks and collaborative learning.

To complicate matters further, today's students also need to learn much more than the 'know what' (explicit knowledge). Moreover, it is important they experience and understand the 'know how' (tacit knowledge) through personal and active involvement in applying what they have learned. At the interplay between the tacit and the explicit lies deep expertise where the learner is required not just to assimilate the explicit knowledge of a given subject area, but also apply that knowledge by engaging in the practices of the related community of interest (Brown, 2002, p 6).

The Internet is not only an enabler of 'virtual' social networks and learning networks, it also has the capacity (using purpose built tools and systems) to prompt learners to structure, integrate, and interconnect new ideas with pre-existing knowledge and prior experiences facilitated by tools that enable them to rearrange, synthesise and restructure information. This means in effect, that ICT provides a useful aid for teaching the complex tasks of thinking, problem solving, and learning (Candy, 2004, p 230). In the design principles to be synthesised later in this chapter, it is the learner's active identification and creation of relationships amongst data and information that becomes the focus of learning. This is where the inherent connectivity and interactivity of the Web reveals a unique strength in the long history of failed educational technologies.

Emergent Learning: Connected Networks of Learning

Social networks operate on the relatively simple principle that people, groups, systems, nodes, entities can be connected to create an integrated whole. Changes that occur within any of the components that make up the network generate a ripple effect throughout the entire system. Within an ecological learning environment, learning is focussed on the creation and strategic use of connections and relationships to form new ideas and concepts. Burbules and Callister (1996, p 7) provide a more precise account of what these notions infer by explaining that 'learning' and 'understanding' operate by making connections. They point out that we do not learn information as discrete, isolated facts, but instead integrate new information with prior knowledge. Our best learning they argue, occurs when new information and additional resources are readily connected with multiple nodes of association.

Nodes can be information, ideas, individuals, and communities for example, that become more relevant as the learner is exposed to opportunities for recognising new connections, which in turn lead to cross-pollination of ideas and concepts across learning communities. Thus, a social learning network is a structure within which a coordinated set of resources and activities provide opportunities for learning that empower the learner to create and evolve a range of experiences among people, places, and information. A potentially useful advantage of this design approach is that access to connected information and related media could further prompt students to conceptualise and formulate a non-linear or multidimensional exploration of the presented teaching content (Harris, 2000, pp 36 - 7). In other words, the learner is actively supported to engage in shaping the learning environment to support his or her own motivation for learning. In essence, generating knowledge is what learners do with information resources as they define needs, generate hypotheses, and refine their understanding.

Where individual versus group knowledge is concerned, it is important to recognise that any change in concepts, notions, and ideas derived through networked discourse and argumentation that has become more or less established (stable) during individual or collaborative learning does not automatically indicate evidence of knowledge building (Campos, 2004, p 10). Whereas the resulting outcome may be in the form of knowledge that arises from conceptual changes that have stabilised through group consensus, manifestly unique knowledge that could not be derived by any one individual is the collective result of many interconnected minds.

It is natural to assume that knowledge resides in the minds of individuals, but when tacit knowledge is factored in especially as related to practice, it is quickly realised there is much more to learn than what is already known and understood. Complications arise when considering the broader epistemological topology as a whole in that both tacit and explicit knowledge apply not just to the individual, but also to the social network or 'community of practice'. Much of what is referred to as 'knowing' is made more authentic through active participation in the world and with other people where the focus is directed toward solving practical problems. More specifically, a great deal of an individual's 'knowing' or 'know-how' derives from active participation within a network, much of which is socially constructed, especially in work and social settings. The reasoning just presented reinforces the position that not all knowledge is derived from individuals.

Moreover, the capacity of technologies to facilitate information and knowledge sharing and to seek clarification of the understandings of individuals is a major factor in building on acquired understandings to consolidate deep expertise (Candy, 2004, p 231). Such cognitive activities are increasingly being performed in 'virtual' networked contexts where the co-creation of knowledge is achieved through learning communities. The key concept underpinning such online activity is that through active collaboration on the production, creation, improvement and innovation of knowledge, a community can accomplish much more than the sum of the individual contributions. Campos (2004, p 3), adds further insight to these views:

> Knowledge communities that develop within a networked cognitive communication process follow a path in which formal individual structures blend with collectively shared content. Knowledge building represents a collaborative process in which conceptual change and innovation are apparent. Therefore, both conceptual change and innovation are indicators of collaborative learning.

Conceptual change is an intentional and reflective cognitive process leading to higher order thinking, which is the result of the verbal and physical interactions that naturally occur among individuals and groups (Campos, 2004, p 10). In other words, new knowledge emerges when an individual or a group of individuals engages in some form of discourse and interaction with one or more additional participants within an identifiable community of practice. When it is collaborative, concepts, notions and ideas are refined or transformed in a collective exchange as may occur in synchronous 'real-time' discussions or through involvement in asynchronous activities such as the exchange of ideas through a bulletin board. If the shared aim of a community of learners is to leverage knowledge building, then an understanding of how knowledge is distributed across a broader community of learning is offered by Brown (2002, p 7) who explains that during collaborative discourse, participants "build on" the contributions of others. The outcome of this exchange is that participants re-assess and reflect on knowledge and in the process, reconstruct and refine previously held concepts, notions, or ideas. Collaborative learning is achieved if conceptual change is explicitly affirmed and redirected during the sequence of discussions with a view to transforming the shared thinking in new concepts and ideas.

Connections, Conceptual Change, and Knowledge Construction

As emphasised in the early part of this chapter, providing access to information without the benefit of equipping students with the skills to convert information into knowledge will prove inadequate for future learning needs. Learners need to reflect on new material, discuss their tentative understandings with others, actively search for additional information in ways that may further illuminate or strengthen their understanding and ultimately build conceptual connections to their existing cognitive framework (Brown & Thompson, 1997, p 75). Megarry (1989, p 50) emphasises the importance of understanding the knowledge building process:

> Knowledge is not merely a collection of facts. Although we may be able to memorise isolated undigested facts for short while at least, meaningful learning demands that we internalise the information: we break it down, digest it and locate it in our pre-existing, highly complex web of interconnected knowledge and ideas, building fresh links and restructuring old ones.

As previously noted, concepts may be viewed as nodes in an interconnected or networked system. Representing knowledge as an integrated network of concepts and ideas as opposed to a linear, structured sequence of facts or information affords students the opportunity to discover the relationships and explore the connections in their preferred way. Students are permitted to reconstruct the network (or part of it) so that it aligns more closely with their prior cognitive experiences. While on occasion, there may be a need to impose a more sequential or hierarchical structure to comply with the required learning outcomes, some allowance can be given to providing flexibility in terms of individual learning styles and preferences.

Moreover, a networked structure of concepts permits students to conduct critical interrogations in order to form new conceptual understandings as requisite concepts are mastered. It is technically feasible for example, to provide a networked structure of information and concepts in which predefined sections are connected within a document and/or interconnect across many separate documents. An interesting prospect stems from the possibility that connected information and related media could prompt students to conceptualise and formulate a non-linear or multidimensional exploration of the presented teaching content (Harris, 2000, pp 36 - 7). To illustrate the 'greater than the whole' properties that can emerge from connected, interrelated networks, consider the following account of the connectionist intelligence of bees as described by Bloom (1995, pp 140 - 1):

> It is possible for a community of bees to solve problems that could not be tackled by a single bee. An experiment was undertaken where sugar water was placed at the exit of a hive, which over time was moved a few inches, then a few feet, then a few feet more. Each time the bowl was moved, the distance was increased by a precise increment. Initially, the bees followed the movements of the dish but after a few days, the bees would fly from the hive and cluster on a spot where the dish had not been placed – the site where the insects anticipated exactly where the bowl would be placed next. In each instance, their calculations were precisely on target. Even though the brain of a bee is insubstantial – a slender thread of neural fibre barely capable of any process we would regard as intelligence, the bees had worked as a mass brain.

Bloom explains that the strength of a networked intelligence is not dependent on the limited capacities of any one of its many nodes, but is the product of a connected intelligence – the problem solving ability of the network itself. A single bee did not solve the problem of where the bowl would be placed next, but resulted from the interconnected mass of all the bees' brains. A social network solves problems by applying the same principles that underpin the Internet. The connections participants find most useful are strengthened, whereas those connections that prove unproductive are ignored.

It is useful to view the acts of creativity and knowledge construction as cognitive activities in which the abstract combination of previously unrelated mental structures or ideas result in the formation of a new emergent whole. Anyone who has experienced that moment where a new idea arises without apparent prior connection would agree that the resultant outcome is often much more than the mere sum of a collection of unconnected thoughts. However, not only is the effect of the sum of the parts important, but of comparable significance is the notion of the creative process as an expression of the interrelationships that connect the various abstract components. The formation of each new synthesis leads to the emergence of new patterns of relationships with each more complex than the previous, and each extending to higher and higher cognitive levels of a mental hierarchy.

Koestler's view is that contrary to popular beliefs, scientific discoveries do not occur by producing something out of nothing. Instead, researchers combine, relate, and integrate known but previously separate ideas, facts, and associative contexts. The researcher aims to synthesise prior knowledge in a way that adds a new level to the existing knowledge hierarchy. For some, the synthesis of previously unrelated knowledge may result in what is commonly referred to as the 'aha' effect where apparently disparate bits of information suddenly click into place. At this point, we realise new knowledge, and in the process, reach toward higher levels of cognitive understanding (Koestler, 1978, pp 131 - 33).

Consistent with an ecological design approach, the principal factors to note in designing effective learning environments are summarised from the work of Schuur (2003, pp 3 - 7):

- opportunities for ordering and classifying the most important information and knowledge should be offered and made accessible using technologies and mental schemas
- community networks are crucial. Given that a network consists of nodes and connections, learning should focus on strengthening the competences of the individual and on developing connections between individuals.
- although content is important, the focus of design should also be on the development of processes in learning delivery and on managing the complexities of the system
- new learning paradigms should be defined and adopted where learning systems are not restricted to existing learning philosophies and become relevant to a networked society
- learning environments should fulfil the needs of the user. Often a simple resource can be more effective than a well-composed, complete, and complex learning environment.
- evaluation of learning environments must be a continuous iterative process, and
- evaluation of learning environments should focus more on the criteria of the user, than on design, functionality, or cost benefit.

Given the potential for enabling a holistic approach to educational design, the implications for ecological learning systems are profound. Beyond allowing students to proceed through a document by taking prescribed pathways in a linear, regulated pace (the once-heralded attributes of computer-aided instruction), students can instead focus their investigations on questions informed by their own unique interests and experiences. They are empowered to work through and organise materials in ways that make sense to them, developing and comprehending their own heuristics. As new understandings emerge, they discuss their findings with their tutor and/or their fellow peers. This flexible, 'connectivist' approach to inquiry and discussion has many advantages, not the least of which is a capacity to accommodate diverse personal or cultural learning needs. In order to manage complex levels of autonomy and faculty, learners must be experienced in the explicit use of tutorials, guides, indexes, and reading materials designed that provide a basic grasp of what the textual source contains along with the models or heuristics that can be learned and adapted as each student is gradually encouraged to become an autonomous learner.

A Synthesis of Principles for Structuring a Learning Environment Design Model

Part One: Learning Environments as a Catalyst for Learning and Metacognition

The liberating power of ICT extends from its capacity to redefine the learning environment in a manner that allows individual potential to be maximised (Gipson, 1996, p 19). However, technology alone cannot do this. Unless technology is intentionally incorporated with reformed educational practice that acknowledges the primacy of the learner rather than the centrality of the lecturer/teacher, then its use will be limited. This shift in thinking permits the lecturer to become a facilitator of the student's learning as opposed to the repository and provider of knowledge. Moreover, unrestricted access to information and learning materials through technology provides an opportunity for teachers and lecturers to develop and devise learning experiences tuned to individual needs. Most significantly, it affords learners the opportunity to experience both independent and group learning. Thus, the power of technology lies in its capacity to enable individualised learning whilst encouraging participation in collaborative learning environments, a community of learners where learning is the intention, not an incidental outcome. Support for these views is evident in the work of Leidner and Jarvenpaa (1995, p 266) who write:

> The effectiveness of information technology in contributing to learning will be a function of how well the technology supports a particular model of learning and the appropriateness of the model to a particular learning approach.

The design of educationally effective learning environments requires the functionally of current delivery systems to be extended to include the enhancement of metacognitive thinking skills acquired through direct 'intelligent' interaction between individual learners and software systems devised for this purpose. For online learners to become skilled in deriving new meanings and understandings, then it follows that software support systems that interact with the investigative/learning process and provide immediate feedback are needed. A parallel requirement is to ensure such tools are readily incorporated into existing learning delivery systems and interoperate with all electronic content and natural language input.

It is feasible for example, to design software support systems that allow learners to make informed decisions about how their learning goals are met by guiding their interactions with 'intelligently' selected and dynamically assembled teaching resources. There are several ways this could be achieved. Using software agents or concept analysis technologies (Dreher, 2006; Dreher & Williams, 2006), key concepts provided through learner input (questions, answers, responses, queries) can be identified and analysed to generate automatic responses such as feedback on progress or additional questions. Learners could also be permitted to request the content display to be dynamically modified to suit their immediate needs by selecting from a range of computer-initiated options generated in response to automated background analyses of their typed input and the selections made during a learning activity. For example, learning resources could be dynamically assembled to generate customised displays based on progress, areas of difficulty, or the need for revision.

In one scenario, learners could make decisions (with varying degrees of guidance) about both content (what to learn) and strategy (how to learn it). They can then employ adaptive, computer-managed, 'intelligent' learning tools to identify and highlight the connections contained within the given information and thus refine their understanding and knowledge. A number of effective strategies can be applied to generate varying degrees of emergent (learning) properties: alert the student to the need for revision and present appropriate alternative material; require the student to repeat a set learning sequence using new materials; dynamically generate quizzes, assignments, or exercises to determine the student's comprehension levels and immediate learning needs; and evaluate students' comprehension levels to provide just-in-time feedback and if required, formal assessment.

The new imperative for today's educationalists is to stay abreast of new technological developments and aspire to excellence in the research and application of ICT to education. This vision can be realised in number of ways (in no set order of importance):

- provide ubiquitous, reliable access to digitised materials and information (learning objects) so that every user – whether learner, researcher, teacher or administrator – is provided access to state-of-the-art technologies that support and enhance their workflow and study activities
- further enhance information retrieval and processing, and multi-mode learning delivery processes by incorporating intelligent machine-to-machine and human to machine dialogue systems, thus freeing the user to apply and benefit from the use of information in more efficient ways
- improve student learning though the provision of autonomous, interactive learning experiences that are supported by dynamically assembled, fully customised learning environments where the focus is on meeting the preferences and needs of each individual
- broaden student access to high quality learning materials and services that facilitate greater choice of access regardless of time, location, and device
- gain greater insight and knowledge on how emerging technologies may underpin innovative teaching, learning, research, and administrative practices
- devise 'intelligent', next-generation' technology enhanced learning and research tools (enabling technologies).

The core principles that inform Part One of a model for designing effective learning environments are thus synthesised to include:

- *encourage and support students to negotiate learning pathways through a multiplicity of contexts and domains by applying ecological and connectionist design strategies to dynamically assemble clusters of teaching content and information (also useful for evaluation purposes)*
- *devise and apply intelligent feedback and cognitive support systems that interactively empower learner cognition and respond immediately to learner input through the dynamic assembly of content that is relevant to the specific learning needs of the individual*
- *incorporate 'on-demand' tools for facilitating and managing collaborative encounters whenever the need arises.*

Part Two: Strategies and design factors that afford increased learning opportunities

Whenever individuals and sub-groups focus on the creation and strategic use of connections and relationships to form new ideas and concepts, any changes that occur within known components have the potential to inspire learning and knowledge generation across the entire system. The likelihood that a new concept will be made evident to other individuals within the network is dependent upon how well it is linked to supporting information and other resources. Thus, a networked community can be described as a decentralised structure within which coordinated sets of resources and activities assist participants to create and evolve a range of experiences among people, places, and information. In other words, the members who make up the network are afforded an opportunity to engage in shaping the discussions and interactions that directly support his or her incentive for involvement.

Networked learning communities operate on the relatively simple principle that individuals, groups, information, resources, and ideas are interrelated in a myriad of ways to create a highly productive and innovative whole. As each individual and group is exposed to the flow of information that occurs throughout the network, the relevance and depth of understanding of the available resources and related activities expands and leads to increased opportunities for identification and connection of ideas and concepts that emerge from the interactions and discourse that occur throughout a learning community.

To be successful however, learning activities (whether face-to-face or online) require meaningfulness and collaboration. However, the dynamics of networked learning environments differ fundamentally from the traditional classroom and distance education models in that their design should also encompass ecological and connectivist principles whilst displaying properties characteristic of adaptive, interactive, evolving systems (chaotic). In order to provide for the social, biological, and environmental aspects of human experiences that are critical to establishing effective learning, educational environment design should be composed of three key components:

- a means of organising learner input and experience
- a mechanism for applying that experience into context, and
- a means of empowering learners to create knowledge and to share the experiences of other individuals or groups.

Online games provide unique insights into learning environment design as they faithfully illustrate the potential of a networked learning community and the ecological, chaotic principles that assist to realise that potential. Albeit informal, learning in a game context occurs in a highly social, collaborative way. Teams and groups are constantly formed and reformed to ensure the needs and desires of the entire community are always met. A community of peers and advisors is readily available to assist both new and experienced players as needed and to undertake research and development to ensure continual improvement to the game and the available resource base. All players are actively involved in many aspects of the game community and although not all contribute equally, innovation is distributed in a parallel, decentralised process resulting in a bottom-up, self-organising collaborative system. Games environments therefore, are self-organising and self-sustaining displaying properties of emergence in a many creative ways. For higher learning institutions, the advantage of online games communities is that the same social ecology principles that encourage networked collaboration and interaction in real-world communities of practice can be applied as a proven model for online learning environment design.

Pivec and Dziabenko (2004) conclude that for the purposes of learning, the new forms of interactive content developed for electronic games hold considerable promise. They emphasise that already the game-based learning model has been successfully adapted to formal education, in particular, in military, medicine, and training applications. They argue that whenever students engage in learning environments modelled on proven game theory principles, they learn to understand and combine different points of view in a wide variety of unexpected ways: understanding individual/corporate interests versus the interests of teams and societies; discerning their own points of view whilst remaining aware of the perspectives and opinions of others; applying not just singular factors, but also integrate multiple aspects to resolving problems; and knowing how to turn confrontation into cooperation. There are many aspects of electronic game design that benefit the learning process. For example, learners can:

- be encouraged to combine knowledge from different subject/discipline areas
- choose from a number of given solutions or make decisions at critical decision points
- test how the outcome of the game changes based on their decisions and actions, and
- contact other team members to discuss and negotiate subsequent steps, thus improving social skills.

In citing the work of other researchers, Pivec and Dziabenko (2004, p 15) highlight the increasing demand for greater interactivity to be built into learning materials. In their view, there is a clear need to support and facilitate the learning process by offering a variety of different knowledge presentations and to create opportunities to apply that knowledge within the virtual world. To achieve this goal, they advocate the need for complex levels of interactivity to stimulate learner engagement, and to apply “different interactivity concepts such as object, linear, construct or hyperlinked interactivity, non-immersive contextual interactivity and immersive virtual interactivity”.

The provision of advanced learning environments (physical and virtual) that cultivate sustainable virtual learning communities presents an effective strategy for facilitating mutual learning and information exchange among teachers, practitioners (experts), academics, administrators, and researchers. Moreover, the networked learning community model as described in this chapter provides a fertile platform from which to theorise the principles that support the introduction of new strategies to enhance learning capability. The value of such a foundation is most evident in its potential to explain how to exploit the depth of learning that can be derived from the interplay of individual and group activities. Where social change is concerned, the question to resolve is how to engage individuals and groups in communal discourse and mutually co-operative activities in which experts and organisations define, capture, and facilitate the transfer of deep learning capability, creative knowledge construction, and specialist expertise to other individuals and groups.

The concepts of learning communities and social networks have the capacity to transform online learning design and the way research, debate and work is conducted in universities. It also introduces an opportunity to inform the transition from a centralised, institution-based education system that is dependent on a top-down structure and rigid standards to a decentralised, bottom-up grassroots system for generating creative thinking and resource sharing based on informal, ad hoc standards. The essential factors to observe are that the design and structure of a networked learning environment should not be limited to technological application and interface design for the human participants. Nor should it be confined to the provision of curricula and learning materials.

The core principles that inform Part Two of a model for designing effective learning environments are thus synthesised to include:

- *devise adaptive / interactive strategies that connect people to people and information, not people to machines*
- *apply a bottom-up design approach to empower and motivate learners to assume responsibility for managing and participating in the learning environment*
- *facilitate active engagement in the learning process using strategies aimed at fostering both independent and collaborative learning*
- *encourage experts and organisations to engage in collaborative knowledge production and facilitation of understanding – in effect, a connected network of mentors / interest / practice.*

Conclusion: The Challenge before Us

The task of bridging the transition from ‘traditional’ learning to individualised, human or electronically facilitated learning is fraught with difficulties. As implied, success in meeting the future needs of learners requires radically new teaching methods and strategies. Any attempt to accommodate the skills and preferences of current generation computer ‘literate’ students (Millennials) will inevitably compel education designers to think entirely ‘outside the box’ and consider design strategies that are in line with students’ expectations and demands. Such strategies might feasibly include the provision of:

- user defined and dynamically generated teaching material that is relative to the current context
- ‘intelligent’ search and cognition support tools capable of interpreting meaningful keywords and interacting with learners
- the ability for learners to annotate and record ideas at will and to receive constructive responses
- automatic display of learning and assessment activities, and immediate provision of feedback tailored to students’ performance and learning needs

- traditional print-based libraries to become an integral component of a vast network of digitised information resources.

Thus, assuming such innovations are viable, the nature and function of the learning environment is poised on the verge of a dramatic transformation, in particular with regard to the application of distributed computing and communications systems, advanced learning systems, sophisticated adaptive (ecological) design strategies, and universal access to high quality learning resources irrespective of device, location, and time.

Proficiency in the application of higher order cognitive competencies to the creative construction of knowledge extends well beyond the transmission of prescribed knowledge and the application of traditional problem-solving skills. This in turn raises the many latent and complex problems of how to assist learners to structure knowledge and to identify the key relationships and properties that connect predefined knowledge to unfamiliar teaching content while taking into account contextual relevance, innate cultural biases, and the need to produce innovative, creative solutions. Resolving such complex issues requires learners to model the conceptual structure of a targeted knowledge domain. Such cognitive models can be supported through the provision of tailored navigational strategies using 'intelligent' software systems to manage and enhance their knowledge construction skills through the strategic exploitation of digitised teaching resources and the dynamic selection and contextualisation of teaching materials.

A major challenge facing educationalists is not just to design and deliver innovative learning solutions, but also to devise learning design methodologies that employ emerging technologies to support the refinement of knowledge creation skills such as analysis, problem-solving, conceptual thinking, and metacognition (which is dependent on and thus further complicated by tacit, experiential knowledge). Over the coming decade, all these skills will be highly valued by individuals, organisations, and society in general. With these outcomes in mind, the ideal learning environment should assist learners to derive answers to the broad level 'meta-questions' of: how do I know what I need to learn?; how do I get there?; how am I progressing?; are my goals still relevant?; what are the best learning models for me?; and, what are the effects of social change, culture, and market needs on my personal learning goals?

Given the tenor of the preceding views, learning in the immediate future should demonstrate a clear pedagogical and technological capacity to interweave all known aspects of the learning process within a loosely structured (flexible) environment where the focus is on the needs and preferences of the individual. In other words, addressing the quality and effectiveness of learning are not the only factors to consider. Future learning environments, regardless of the delivery mode, should facilitate support for the divergent needs of current and past generations, from pre-school through to senior citizens. These needs apply to the distinctive attributes of; technology use and skills; personal influences, needs and aspirations; values, perceptions and attitudes; and, current and future concerns. Emphasis should also be given to identifying and allowing for variations in learner behaviours, inter-personal communication skills, preferred learning strategies, and intelligence type relative to all generations, interests, and modes of learning. In essence, the individualisation of learning requires an evolving research programme of design, experimentation and development augmented by qualitatively and quantitatively distinct modes of support and resources.

Ultimately, the goal of designing effective learning environments is to support the lifelong learning needs and personal development of all individuals through the provision of dynamically facilitated and/or self-directed environments, characterised by flexible, ubiquitous, and/or mobile delivery at any time and to any place. A systemic focus on flexible, individual learning redirects the focus of research towards the creation of new methods of learning while recognising the need for learners to develop knowledge skills that demand entirely new perspectives on the purpose of learning. For example, 'just-in-time', 'incremental', and 'on-the-fly' learning provide three access methods that are well suited to the preceding design approaches and offer the advantage of being readily transferable to many environments (thus raising the possibility of providing professional development to companies, governments, and organisations).

Whilst formal education is useful for transferring specific skills and competencies for the purpose of gaining qualifications, the evidence is mounting that it is failing to encourage the higher order analysis, problem solving and knowledge construction skills (metacognitive thinking) required for the twenty-first century. As currently practised, education is inherently counterproductive to creative thinking.

Education not only has the capacity to stifle creativity and innovation. Unmotivated teachers, irrelevant curriculum, substandard learning environments, and uncomfortable conditions all contribute to unsatisfactory learning outcomes. Despite such limitations, many of us would recall that special teacher who was able to connect with our unique learning needs and styles in ways that changed our personal learning experience from a tedious, unrewarding chore to something that was intrinsically fulfilling and life changing. With the 'right' teacher, in the 'right' learning environment, using the 'right' resources, individual learners can be encouraged, motivated, and inspired to be highly creative and innovative.

Once identified, the 'right' combination can be incorporated to construct dynamic, ‘intelligently interactive’ learning environments that respond as and when required by the learner. Only then (I believe) will it be possible to inculcate the cognitive support tools and thinking strategies that will enable learners to adopt a creative mindset. Whilst it may be countered that creativity can never be taught, at the very least ‘creative thinkers' can be better equipped with the cognitive tools that assist to derive elegant solutions to complex problems. This chapter is intended to encourage such direction.

The current line of reasoning represents the core of my philosophy on learning design. The right educational approach holds the potential to add considerable learning value to the individual regardless of whether it is applied to the K-12, high school, college or the university sector. The value I refer to is greater than the sum total of all known and measurable aspects of the learning process in that it inspires creativity regardless of age, interest, profession, and educational level.

Thus, a more inclusive approach to articulating what is meant by ‘learning’ is crucial to ensuring successful participation in a world that is increasingly focussed on innovative knowledge. Today’s young people exercise their creative imagination in ways 'undreamt' of a few ago. They also want (and demand) continuous education and ready access to 'always-on' information and knowledge. These expectations can only be satisfied through advanced educational practices that are guided by revolutionary design models. Equally critical is continued research to determine the needs, preferences, and propensities of disaffected ethnic groups, disabled people, the mature aged, and senior citizens.

Taken as a whole, it is conceivable that education as we have known it over the past century is poised on the verge of entering into new realms of possibilities that will transform accepted views on the role and purpose of learning. The emergent power of the web and related technologies makes it both desirable and viable to not just access and manage far more information than previously thought possible, but also to ensure learning effectiveness will remain the primary goal. Again, the reader is reminded that regardless of the promised potential, we should not lose sight of the fact that ready access to information does not always equate to being educated, in particular when employing asynchronous and computer-mediated ‘distance’ communication modes. As noted several times, it is not enough to deliver information and assume learning will result. Moreover, the technological solutions proposed in the preceding pages are intended to support the learner’s cognitive processes and not in any way do the work for them. This qualification raises a timely warning to consider the question of how we can ensure technology supports exploration and learning.

In practice, the strategies required for constructing effective learning environments are highly complex and diverse requiring an ecological, systems-based design approach. Then, as connectivist principles are applied, learners can be empowered and supported to participate in learning communities where an 'edge of chaos' strategy inspires all participants to be innovative thinkers and creative constructors of knowledge.

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