

## Immersive Learning Environments as Complex Dynamic Systems

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In this paper, it is argued that education, especially in the online learning setting, should be viewed as a complex, dynamic endeavor. Design and evaluation grounded in systems thinking principles of relationships and connectedness, as well as complexity theory concepts such as self-organization and emergence, prove valuable tools for understanding what happens in education and helping to improve both theory and practice in online learning. Immersive environments provide rich opportunity for exploring these ideas, and they can help researchers and practitioners gain a rich understanding of education through complexity theory.

Given the level and complexity of challenges facing the educational enterprise, viewing challenges and potential solutions through a systems thinking lens provides opportunities to investigate the potential of local innovations to affect change at a systemic level. As Meadows (2008) states:

As our world continues to change rapidly and become more complex, systems thinking will help us manage, adapt, and see the wide range of choices we have before us. It is a way of thinking that gives us the freedom to identify root causes of problems and see new opportunities. (p. 2)

As educational institutions struggle for coherence in order to meet students' needs in the 21<sup>st</sup> century with an ever-changing technological marketplace, being able to identify the interrelationships and see how various components have the potential to impact the whole enterprise becomes critically important. Author of *The Fifth Discipline* Peter Senge (1990) defines system thinking as:

... a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static "snapshots." It is a set of general principles—distilled over the course of the twentieth century, spanning fields as diverse as the physical and social sciences, engineering and management. . . and systems thinking is a sensibility – for the subtle interconnectedness that gives living systems their unique character. (p. 68-69)

He (1997) describes the system of education as one based on reductionism, competition and individual learning, and he cites the disconnect between our educational system and the current workforce as one that is derived from the fact that complex skills such as collaborative learning and problem solving are not taught within the current school systems or the online learning systems which help comprise them.

Better understanding systems thinking as it applies to education, technology, and the role of complexity,

specifically the notions of self-organization and emergence as mechanisms for facilitating learning, is necessary. It is the goal of this paper, therefore, to outline one university's approach to meeting the needs of adult learners within a virtual world, which can be seen as a complex, dynamic system. The paper will provide the theoretical rationale, as well as practical pedagogical and technological examples of how engaging learners through such a system can provide opportunities for more organic and emergent learning that is well-aligned with the needs of the complex, rapidly changing 21<sup>st</sup> century workplace.

As Cilliers (2005) notes, educational systems generally exhibit characteristics of those that are closed and controlled. Kennedy and Kennedy (2010) describe many of the assumptions of mainstream schooling: that knowledge is discrete and quantifiable, that learning proceeds by building upon unquestioned assumptions, that cooperation is necessary but a secondary dimension of classroom discourse, that the authority of the teacher is a sacred part of pedagogy, and that individual intelligence is the only relevant intelligence. They write:

All of these assumptions tend to support the social and historical maintenance of a closed or control system, and as such, may be characterized as undemocratic to the extent that they inhibit the ideal speech situation, and ignore the potential of the autopoietic process for optimal individual and group development. (p. 13)

These assumptions are evidenced in online learning environments as well, as designers call upon objectivist models such as Dick and Carey (1996) and Gagne, Briggs and Wager (1988) – requiring the setting or identification of prior knowledge, goals and/or learning outcomes, specific performance objectives, assessment strategies, and evaluation procedures (Moallem, 2001). These objectivist models typically translate to environments that predominantly distribute content, and do not provide opportunities for the levels and types of interactivity and engagement that are characteristic of more open and dynamic systems. While these models

Table 1  
*Education Viewed as Closed v. Open System*

As Closed System	As Complex, Open, Dynamic System
Behaviorist/Objectivist	Connectivist/Constructivist
Focus on individual	Focus on community
Knowledge as discrete and quantifiable	Knowledge constructed in support of common goals
Authority of instructor	Instructor as guide and facilitator; distributed control
Knowledge transmitted from teacher to student	Knowledge generated through interaction and collaboration; self-organization
Prescribed learning activities	Negotiated and personalized learning activities
Focus on content acquisition	Focus on learning outcomes and reflection

have formed the basis for the design and development of many systems of learning, it can be argued that given the current generation of technologies, design models that are more complex and responsive to deeper levels of interaction are necessary.

### Traditional Learning Systems

Instructional technologies designed for course management (CMSs) and learning management (LMSs) are used widely throughout higher education: they are, arguably, the most prevalent tools for online education at this level. Courses that are delivered through these systems typically emulate traditional models of face-to-face instruction. Bronack, Riedl, and Tashner (2006) discuss the many similarities: among the characteristics identified, they note that these courses and systems are content delivery driven, driven by assumptions of need and usefulness, not conducive to interactions with peers or mentors, and not characterized by the building of community. Lane (2009) expands on the notion by arguing that this is a factor of the very design of the systems widely used for online learning:

Course management systems each contain their own inherent pedagogy, and for most systems these pedagogies are traditional in nature. As with all technologies, the design of the product is a result of its perceived use. Today's enterprise-scale systems were created to manage traditional teaching tasks as if they were business processes. They were originally designed to focus on instructor efficiency for administrative functions such as grade posting, test creation, and enrollment management. Pedagogical considerations were thus either not considered, or were considered to be embodied in such managerial tasks.

The author goes on to note that, while these systems reflect nineteenth-century behaviorist pedagogies, the systems themselves are not completely to blame: 'novice' instructors with little to no training in online

pedagogy rely on the tools available to them. Many of the barriers to large-scale systemic improvement, therefore, become evident within the technologies that have been designed and developed to move traditional instruction to an online environment.

Weller (2009) further continues the discussion of Learning Management Systems (LMSs) in this way:

In elearning terms, current LMSs can be seen as the embodiment in code of the physical structures of learning. In Lanier's phrase they are further sedimentation as to how education should be conducted. This is acceptable if we believe that the existing educational model is the best there can be, but there are many issues in education which the current model struggles to address. (p. 182)

The author goes on to note the specific issues which seem to have not yet been addressed with online learning systems: limited curricula, personalization, changing demands, and informal learning. With growing numbers of students interested in online education, it is clear that solutions to these issues must be pursued.

### Complexity and Dynamic Learning Communities

Wilson and Ryder (n.d.) challenge the traditional models of instructional design and delivery of online learning and call for more situated approaches. They present the concept of dynamic learning communities, with attributes such as flexibility, distributed control, and high levels of interaction. Wilson and Cole (1996), who expand on Scardamalia and Bereiter's (1994) concept of first-order and second-order environments, labeling them instead static and dynamic learning communities, look for schools to become dynamic knowledge-building communities. Scardamalia and Bereiter (1994) themselves state that "schools need to be restructured as communities in which the construction of knowledge is supported as a collective goal, and the role of educational technology should be to replace classroom discourse

patterns with those having more immediate and natural extensions to knowledge-building communities outside school walls” (p. 265). Therefore, it is important that educators be able to identify, develop and facilitate complex, dynamic systems that represent new models of learning and can provide the knowledge-building practices that connect to authentic contexts in order to work toward complex and dynamic systems rather than closed (Table 1).

### **The Possibilities of Open, Dynamic and Complex Approaches**

In stark contrast to online learning systems that are products of a different era, in need of transformation, and in which innovation and learning are seemingly stifled by tools, lack of instructor support, and systemic barriers, a recently popularized and award-winning TED Talk entitled “Build a School in the Cloud” ([http://www.ted.com/talks/sugata\\_mitra\\_build\\_a\\_school\\_in\\_the\\_cloud](http://www.ted.com/talks/sugata_mitra_build_a_school_in_the_cloud)), presented by educational researcher Sugata Mitra, describes a project that was implemented outside of the bounds of any formal system of education.

The “Hole in the Wall” experiment involved installing a computer literally in a hole in a wall in a New Delhi slum and leaving it for children to explore and teach themselves. The study (Mitra, 2012) showed that students could teach themselves to navigate the internet regardless of location, language, and level of schooling. Mitra’s team placed 100 computers in 22 locations and estimated that approximately 40,000 children learned to use the computers on their own. According to Mitra (2012), “the Hole in the Wall study showed conclusively that groups of children can teach themselves to use a computer and navigate the Internet, irrespective of who or where they are, what language they speak and whether they’ve attended school or not” (Kindle Locations, 348-349).

While the “Hole in the Wall” project (Mitra, 2012) proved to be effective in teaching computer literacy skills, the context and setting of the project stand in stark opposition to most traditional educational institutions that are characterized by more seemingly closed, hierarchical, and rigid systems. Others who have problematized various aspects of the “Hole in the Wall” experiment, but support the pedagogical innovation aspect of the project, recognize the variety of challenges with integrating such types of learning into more formal systems of education (Arora, 2010).

Mitra (2012) attributes the results of this experiment to self-organization and emergence, and he posits that in order to understand learning we must further understand these processes. Specifically, he states: “I think the nature of learning is hidden in the new science of self-organization and emergence. To understand learning, we must understand how self-

organization happens and what leads to this mysterious process called ‘emergence.’” (Kindle Locations, 507-509).

When considering the role of complexity in education, Morrison (2008) notes:

Complexity theory poses a major question: What do the following mean for the philosophy of education: emergence and self-organization; connectedness; order without control; diversity and redundancy; unpredictability and non-linearity; co-evolution; communication and feedback; open, complex adaptive systems; and distributed control? (p. 19).

These questions provide us with a framework from which to consider the contrast between the barriers to innovation presented by closed systems and the mainstream technologies used to facilitate online learning, as well as the opportunities presented by initiatives such as the “Hole in the Wall” experiment. It then becomes necessary to consider how to leverage technologies to better facilitate deep learning and innovation. Complexity theory, which “concerns itself with environments, organisations, or systems that are complex in the sense that very large numbers of constituent elements or agents are connected to and interacting with each other in many different ways” (Mason, 2008, Kindle Locations 154-155), focuses on systems and structures that allow for self-organization, which in turn encourage the emergence of new concepts, properties, and behaviors.

Sawyer (2003) equates new conceptual structures with ant colonies by stating that emergence occurs through the interaction of simpler elements. In other words, just as ants self-organize to form new structures, so too can learners come together to create meaning. In an educational context, Davis and Sumara (2006), in their description of qualities of complex learning systems, acknowledge that by its very nature, complexity cannot be reduced to a variety of independent aspects that are dependent on each other in a very complex and dynamic manner, but do, however, identify self-organization, the bottom-up formation of collectives, and decentralized networks as characteristics of complex systems that facilitate emergence. As such, in order to begin to consider complex systems in educational contexts, it is necessary to view the interactivity between different parts of the systems, paying close attention to the structure of relationships and networks within. Newell (2008) notes that both teachers and students are complex adaptive systems in their own rights, but that dynamic local interactions make possible emergent behaviors that signal learning transcending that of individuals.

Therefore, a complex educational system may be defined as a “recursive, open system characterized by

emerging entities, the evolution of new capacities, and by developmental growth” (St. Julien, 2005, 101). Developing new models of complex, dynamic systems of learning by providing the mechanisms by which emergent understanding and conceptual development can occur is an important consideration for systems of education. Jörg (2009), in a discussion of the ways in which viewing education as a dynamic, non-linear complex reality may enable us to build a new science of learning and education, writes:

It is the very dynamics of sense-making in whole human beings through meaning-making in communicative human interaction that makes learning and development inherently complex, but also promising. The concept of learners should therefore be formulated as self-regulating, evolving learning systems, who evolve in their linking of systems by the activities of problem-based and problem-posed situations, and learn in and through communicative human interaction within learning-full reciprocal relationships (p. 13).

There is still much work to be done to design, develop, and evaluate learning systems and processes that are based in notions of complexity – self-organization and emergence that can facilitate emergent conceptual development and knowledge building.

### Self-Organization and Emergence

When considering the various facets of complex, dynamic learning environments that are situated within constructivist frameworks of interactivity and learner agency, the notions of self-organization and emergence arise as constructs that are components of such theories of learning. As Mason (2008) states, “[I]t is in the dynamic interactions and adaptive orientation of a system that new phenomena, new properties and behaviours, emerge” (Kindle Locations, 174-175). Therefore, careful consideration of the constructs of self-organization and emergence can assist with further understanding ideas and initiatives that lead to creating innovative and effective learning environments.

Morrison (2008), who defines self-organizing systems as being autocatalytic and autopoietic, notes that self-organizing systems contain features of adaptability, open systems, learning, feedback, communications, and emergence. Self-organization itself, which has also been referred to as ‘bootstrapping’ (Jörg, 2009; Stanley, 2008) is generally considered to be a process in which systems bring themselves into existence with minimal direction.

Self-organization, which Davis and Sumara consider to be emergent, and credit as being the most important and most difficult aspect to appreciate, occurs when

“agents that need not have much in common—much less be oriented by a common goal – can join into collectives that seem to have a clear purpose” (2006, 81). The interaction of agents within an open, dynamic system, therefore, becomes a critical feature of complex systems as they can potentially self-organize in order to achieve certain goals. As Cilliers (2005) states as he lists twelve different characteristics of complexity theory, “complex systems display behavior that results from the *interaction* between components and not from characteristics inherent to the components themselves. This interaction is sometimes called emergence” (p. 257).

The result of the self-organization of agents within a complex, dynamic system therefore becomes that of emergent behaviors or structures. More specifically, the definition of emergence, according to Wikipedia (“Emergence,” n.d.) is that it “is conceived as a process whereby larger entities, patterns, and regularities arise through interactions among smaller or simpler entities that themselves do not exhibit such properties” (para. 1). To further contextualize and connect the notions of self-organization and emergence within the complexity theory framework, Stanley (2008) states:

Emergence, therefore, is driven by the self-organizing nature of a system far-from-equilibrium. It is in this manner that the notions of emergence and self-organization are linked. Thus, in the context of human beings, the self-organizing nature of local interactions gives rise to globally emergent, coherent patterns (p. 146).

Within the educational context, therefore, the concepts of self-organization and emergence become critically important as we consider the potential of technologies and pedagogies that can create emergent conceptual structures. For instance, in Scardamalia and Bereiter’s work on knowledge building (2006), they write that acquiring complex new concepts is a function of self-organization and emergence, equating this type of emergence to connectionist models of learning and ultimately dynamic systems of learning. They state that “the practical import of this discussion is that instructional designers need to think more seriously about ideas as real things that can interact with one another to produce more and complex ideas” (p. 104).

Additionally, from a larger-scale educational systems perspective, Davis and Sumara (2006), who liken the system of formal education to the modern factory in a teacher as worker and learner as incomplete product metaphor, look to complexity theory to enable a transformative process within the system that would more adequately align education to the needs of the adult world. They, too, rely on notions of emergence and interactive structures such as conversations as a way to facilitate the possibility of the occurrence of rich interpretive moments.

Beyond the “Hole in the Wall” experiment, we can see these notions of complex, constructivist, dynamic learning systems specifically related to notions of self-organization and emergence operationalized within online learning environments that are focused on community and connectivism/constructivism. For instance, Williams, Karousou, and Mackness, (2011), who distinguish between prescriptive learning systems and emergent learning networks, define emergent learning as:

Learning which arises out of the interaction between a number of people and resources, in which the learners organize and determine both the process and to some extent the learning destinations, both of which are unpredictable. The interaction is in many senses self-organized, but it nevertheless requires some constraint and structure. It may include virtual or physical networks, or both (p. 2).

Kennedy and Kennedy (2010) also form an emergent learning network through the Community of Inquiry (CI) framework. They discuss the role of self-organization and emergence from this perspective as they describe it as being a process of group inquiry that is a continuously emergent process. The main goal of their CI framework is one in which members build on each other’s ideas in a dialectical fashion in order to build a collective argument. Feedback, primarily from the facilitator, is a part of this dialogic and dynamic system and is an important aspect as it is seen as “a complex and dynamic combination of positive and negative instances, both of which drive the growth of the system, and contribute directly to its self-organization” (p. 6).

Therefore, as we see instances of complex, dynamic systems that are being applied within educational settings, investigating the potential for these systems to be applied to online learning environments becomes a critical next step.

### **Dynamic Learning with Immersive Technologies**

One genre of innovative technologies that contains attributes and functions that can be leveraged to create complex, dynamic systems of learning has been labeled ‘immersive’ technologies. In basic terms, these are technological tools which allow users some type of sensory immersion in their use. In their description of the Immersive Education Laboratory (iEL), Gardner and Elliott (2014) cite the definition of immersive education provided by the Immersive Education Initiative (<http://immersiveeducation.org>) as giving:

Participants a sense of ‘being there’ even when attending a class or training session in person isn’t possible, practical, or desirable, which in turn

provides educators and students with the ability to connect and communicate in a way that greatly enhances the learning experience (p. 2).

Common examples include tools which are known to provide a sense of immersion, or “being there,” are those that enable a sense of embodiment by use of avatars, such as virtual worlds and massively multi-player online role-playing games (MMORPGS). Other types of technologies considered immersive include augmented reality (AR) and emerging tools for user experience of virtual reality such as the Oculus Rift. Dalgarno and Lee (2010) note that immersion relies upon the technical capabilities of a technology to render sensory stimuli, and they argue that the fidelity of the representation, along with the types of interactivity available within the environment, lead to a high degree of immersion.

Schrader (2008) provides another useful lens for considering what defines an immersive environment, noting the difference between learning “about” technology to learning ‘with’ technology to learning “from” technology to learning “in” technology. The author writes:

It would follow that because the net generation’s cognitive engagement is so heavily intertwined with virtual spaces and content, the two are inseparable; their actions with the technology and cognitions are truly seamless. Another way to describe this immersion, integration, and depth of use is to suggest that users function, learn, and interact within the technology (p. 466).

An important consideration of the user experience in immersive environments is the way in which the individual can construct and represent an identity. In a discussion of virtual worlds, Dickey (2002) discusses three factors which help shape the user experience: presence, representation of self, and embodiment. This representation of self, or identity, is an important consideration: Wenger (1998) points out that having a sense of identity is crucial in learning organizations. Dalgarno and Lee (2010) suggest that an important aspect of a 3D environment is the way in which users construct identities through embodied actions and social interactions, but they note that this construction and portrayal of identity are consequences of representational fidelity and learner interactions which are facilitated by the environment. This idea of embodiment is important when considering virtual and immersive spaces, as Cheney and Bronack (2011) note:

The ability to sense the digital presence of others in environments such as virtual worlds, serious games, and simulations re-introduces the concept

of social facilitation into our online endeavors in ways that we have relied upon in traditional spaces, but have been difficult or impossible to utilize in web based ones (p. 80).

The discussion of learner interactions, and the ways in which immersive environments enable and enrich them, is tied to the ideas of presence and co-presence. Simply put, presence is the sense of “being there,” and co-presence that of “being there with others.” Dalgarno and Lee (2010) suggest that immersion leads to a sense of presence: that the technical affordances of these environments lead to psychological experience. When together in well-designed virtual spaces, students can interact with their peers, instructors, and the environment in ways that promote shared building of knowledge.

This notion of presence—being there with others—is one that has been prominent in literature on virtual and immersive technologies. The CI design of Kennedy and Kennedy (2010) mentioned above was developed based on the Communities of Inquiry (COI) framework, which was first introduced in 1999 (Garrison, Anderson, & Archer), and is perhaps the best-known theoretical framework for the exploration of technology-mediated communities. The COI framework explores three distinctive types of presence in online environments: social, cognitive, and teaching. Social presence is the ability of participants to communicate and develop relationships within a community; cognitive presence is the way in which learners construct meaning through discourse and reflection; teaching presence is design and facilitation of social and cognitive processes.

These three categories function together to enable communication, collaboration, relationship-building, and ultimately learning by all members of an environment.

This type of collaborative learning involves three constructs: learner sharing, learner interdependence, and active involvement of learners in activities (Yang, Wang, Shen, & Han, 2007). In other words, just interacting is not enough to produce a rich online learning experience:

Some have argued that in higher education, it is valuable and even necessary to create a community of inquiry where interaction and reflection are sustained; where ideas can be explored and critiqued; and where the process of critical inquiry can be scaffolded and modeled. Interaction in such an environment goes beyond social interaction and the simple exchange of information. A community of inquiry must include various combinations of interaction among content, teachers, and students. (Garrison & Cleveland-Innes, 2005, p. 134)

It is in going beyond mere interaction, of learners coming together in immersive environments to collaborate and create meaning, that it becomes apparent that immersive environments are indeed open and dynamic systems: those that focus on community, distributed control, and personal and mutual knowledge construction. As learners come together in constructivist communities of practice, the stage is set for self-organization and emergent behaviors.

### **AETZone: A Model of an Immersive and Complex Learning Environment**

AETZone is a virtual world that has been used for graduate classes in education at Appalachian State University for more than ten years. At the time of its beginning, the University had adopted an LMS, which faculty members felt was passive, isolating, utilitarian, and lacking in opportunities for social connections to be made with other students or faculty. Students had little sense that others were present when logged into the LMS, a new set of tools that afforded an approach better aligned with a social constructivist philosophy was needed (McClannon, Sanders, Cheney, Bolt, & Terry, 2013).

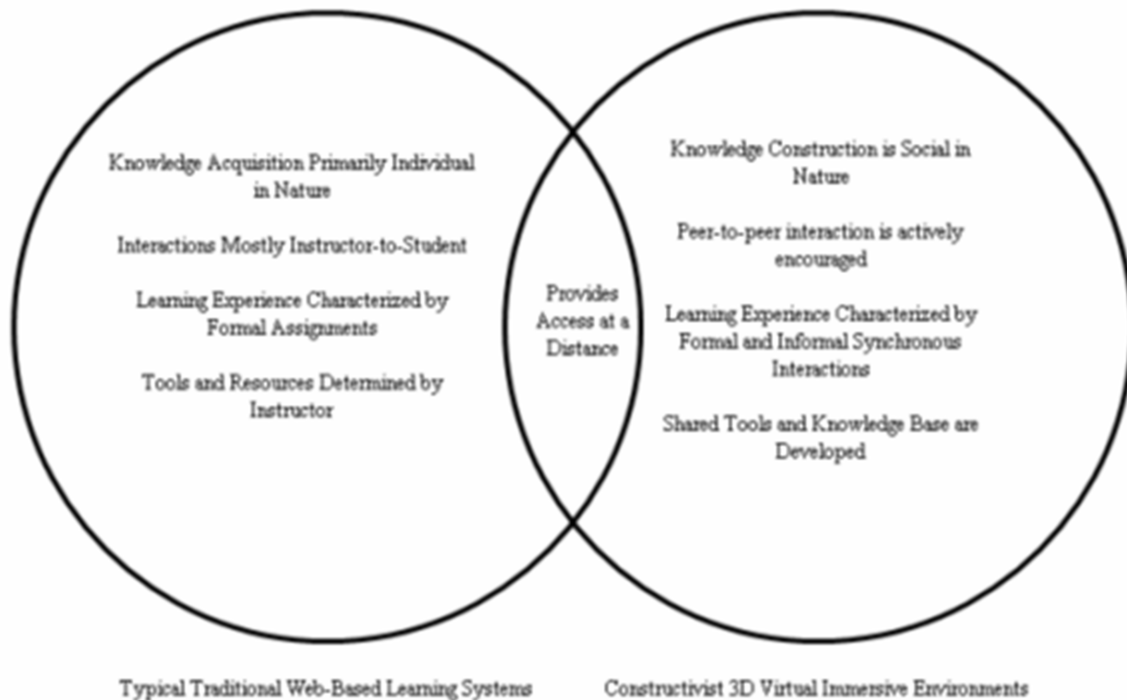
As such, the creators of AETZone designed the system with social constructivist theory at the center, working to create an environment in which interaction and collaboration are key considerations. Jonassen (1997) argues that technologies should be used to keep students active, constructive, collaborative, intentional, complex, contextual, conversational, and reflective. Wilson and Ryder (n.d.) add the term “dynamic” to this list of characteristics of a learning community to emphasize a group characterized by the “distribution of control, commitment to generation and sharing of new knowledge, flexible and negotiated learning activities, autonomous community members, high levels of interaction, and shared goals and projects.” It is the ongoing goal of faculty in AET Zone to ensure that technologies are effectively utilized to create such learning experiences for our students.

The social constructivist approach of AETZone is in stark contrast to that of traditional online learning systems. Cheney et al., (2010) provide a comparison of the two (Figure 1).

Discussing the design of AET Zone, faculty noted that the environment is unique in that it is designed to meet the needs of learners engaged in self-directed meaningful activity within a community of practice. This environment is characterized by significant components of space, movement, physical presence and co-presence, conversational tools with small and large group shared workspaces, and metaphors and artifacts that assist collaboration and learning online in new and different ways (Sanders et al., 2007).

Figure 1

*Traditional online learning systems v. constructivist 3d virtual immersive environments*



An example of how this looks in practice is described by Becnel and O'Shea (2013). They outline a course in which Library Science students, working online in their own virtual public libraries, engaged in an extended epistemic game that required the participants to work as if they were practicing professionals in charge of libraries. Participants in activities like this one are given unique library spaces within AET Zone, which they can build and modify as they see fit. Working in teams, students created (and later modified) budgets, dealt with staffing and community relations issues, and completed other tasks related to library administration. AET Zone allowed for these tasks to be customized for each group, and surprises occurred along the way. Weekly challenges ranged from irate customers to storm damage to the libraries. Group members had to organize and adjust for both the custom tasks and the "bumps in the road," and they had freedom to deal with these issues in ways most meaningful to them. The interaction in courses, like this one in AET Zone, is guided by participants, with faculty acting as moderators, and students—and in some cases, general contractors—who help "build" the virtual spaces based on student budgets and priorities.

### Presence Pedagogy

Drawing upon these ideas and others, the developers of AETZone developed a framework for

both design and evaluation of virtual environments known as Presence Pedagogy (P2) (Bronack et al., 2008). In this article, describing typical activity in this environment (Figure 2), the authors write:

Students work and interact with others present in the world, often across the traditional boundaries of class, course, or program area. Students respond to feedback and advice offered by faculty and peers present in the world when they are. Students are not limited only to their own course instructors, but instead are free to interact with and learn from instructors and peers from other courses and across multiple program areas. Students utilize tools and resources ever-present in the world in the context of authentic, hands-on activities, and projects. The multiple manifestations of presence enabled by this combination of content, context, and activity are the critical attributes for engagement among students in a social constructivist learning environment. Embedded within an immersive virtual world, they combine to create a new approach to teaching and learning that, in many ways, is significantly different from those on which educators traditionally rely and those which students typically expect (p. 59).

The idea of Presence Pedagogy was based on many of these attributes: conversations not bound by specific

Figure 2  
*Community of learners in AETZone.*



courses meeting at a specific time; and student interactions with one another, instructors, and the environment itself. Learning activities are structured to be approached in groups, with maximum flexibility in the ways in which students investigate and present knowledge gained.

The core tenets of P2 are the shared values surrounding how educators and learners ask questions and correct misperceptions, stimulate background knowledge and expertise, capitalize on the presence of others, facilitate interactions and encourage community, support distributed cognition, share tools and resources, encourage exploration and discovery, delineate context and goals to act upon, foster reflective practice, and utilize technology to achieve and disseminate results (Bronack et al., 2008, p. 61-2). In a system such as AETZone, designed and organized around these principles, it can be demonstrated that immersive environments provide a clear pathway to complex, dynamic interactions. Some of the ways in which these principles manifest are included in Table 2.

It becomes evident that an environment such as AETZone, designed around constructivist ideas of presence, situated learning, and communities of practice, is one which exhibits many characteristics of complex, dynamic systems.

Recent data confirms that these notions of presence and community are significant in AETZone. Ongoing research utilizing the COI (Communities of Inquiry)

and SCI -2 (Sense of Community Index) have questioned both of these constructs from students' points of view. Findings from McClannon et al., (2013) confirmed that:

- Teaching Presence was a significant predictor of students' sense of community based on the COI scale; Teaching Presence was the strongest predictive variable.
- Level of immersion in the environment was a significant factor in students' sense of community based on the SCI-2; in fact, students in fully online cohorts were more positive in their perception than those in hybrid/blended cohorts. Reinforcement and Members Success Needs Met were the significant predictive variables;
- Time Spent in the virtual environment was a significant factor on the SCI-2. Reinforcement was, again, the significant predictive variable. It was also significant using the COI instrument – again, Teaching Presence was the predictor. The Direct Instruction variable also explained differences between students.

One of the most interesting things about these results was that they stem from a system which is designed to be complex: in which traditional direct



Table 2  
*Characteristics of Presence Pedagogy and Complex, Dynamic Systems*

Complex, Dynamic Systems (Morrison, 2008)	Presence Pedagogy (Bronack et al., 2008)	Examples from Practice: AET Zone (Some examples from Bronack et al., 2008)
Self-Organization	Capitalizing on the Presence of Others	<ul style="list-style-type: none"> <li>• Removal of the present hierarchy of expertise</li> <li>• Naming convention to identify instructors ('experts') who are available to all students no matter which program or course</li> </ul>
	Facilitating Interactions and Encouraging Community	<ul style="list-style-type: none"> <li>• Design which encourages participants to gather in shared spaces, enabling serendipitous interaction</li> <li>• Multiple spaces and tools for interaction and formation of community (large group forums, small group chat spaces, offices and workrooms)</li> </ul>
Adaptability	Encouraging Exploration and Discovery	<ul style="list-style-type: none"> <li>• Exploration and use of shared in-world tools, resources, and knowledge base.</li> <li>• Exploration and sharing of professional resources – constant user contribution</li> </ul>
Open Systems	Sharing Tools and Resources	<ul style="list-style-type: none"> <li>• In-world library manned by distance education library staff</li> <li>• Generative world that is constantly modified - all members are 'admins', free to add or change content and resources at any time based on their needs</li> <li>• Real-world projects shared with colleagues and peers</li> </ul>
	Utilizing Technology to Achieve and Distribute Results	<ul style="list-style-type: none"> <li>• Utilization of virtual world and associated Web 2.0 tools for communication and collaboration</li> <li>• Gallery crawls: learners post products and provide feedback on work of others</li> </ul>
Learning	Stimulating Background Knowledge and Expertise	<ul style="list-style-type: none"> <li>• Providing spaces and designing activities in which students can share personal and professional experience</li> <li>• Case studies and role plays drawing from real-life scenarios</li> </ul>
	Delineating Context and Goals to Act Upon	<ul style="list-style-type: none"> <li>• Participation in and negotiation of learning goals by all participants</li> </ul>
Feedback	Fostering Reflective Practice	<ul style="list-style-type: none"> <li>• Learner reflections embedded in each course</li> </ul>
Communications	Asking Questions and Correcting Misconceptions	<ul style="list-style-type: none"> <li>• Iterative process of cueing, guiding and questioning rather than telling</li> <li>• Asynchronous interactions utilizing Web 2.0 tools (Facebook, Skype)</li> </ul>
Emergence	Supporting Distributed Cognition	<ul style="list-style-type: none"> <li>• Creation of situations where learners' performance results from emergent, collaborative networks</li> </ul>

instruction rarely occurs, and most classes only meet in synchronous full groups a handful of times in a given semester. Though instructors plan courses and learning activities, they design to encourage individuals and groups to work together to create relevant products.

Nevertheless, students reported across a number of measures that interaction with faculty was an important part of their sense of belonging to a learning community. This constructivist, immersive environment, in line with complex, dynamic systems as

demonstrated above, is a powerful tool, when combined with appropriate pedagogy, to inspire learning.

**Research In and On Immersive Environments**

There is a growing trend in the research to move away from traditional methodology when considering immersive learning environments. Cheney and Bronack (2011), in their discussion of research affordances of virtual worlds, draw the following comparison between research in the physical and virtual worlds (Table 3). This leads to a plethora of possibilities: instructors as participant/observers, learners’ reflections on and reporting of in-world experiences and interactions, virtual ethnography and interviews, and design-based research.

Design-based research, instead of following traditional research models which dismantle complex systems to evaluate how each component works, seeks to put all components of a system together to see how the system functions over time. Dai (2012) states, “[W]e need a new methodology that is apt to handle the complexities and responsive [sic] to emergent possibilities and constraints involved in designing such a learning environment” (p. 12). The process, then, attempts to investigate the whole system and includes contextual, instructional, and cognitive variables. Dai further describes the unique properties of design research in educational settings as being one that deals with open systems, involves designing actions and processes for human beings (as opposed to object-based or agent-based subjects), and consequently deals with “soft” instructional designs with degrees of freedom that involve enactment through human actions and interactions. Wang and Hannafin (2005) describe design-based research as exhibiting the following characteristics: pragmatic; grounded; interactive, iterative, and flexible; integrative; and contextual. These characteristics echo many of those indicative of complex systems. In sum, and according to Greeno and Middle School Math Project Group (1998), design research is well suited for investigating complex teaching and learning because it situates itself at a level of

complexity commensurate with real-life teaching and learning conditions.

Design based research, with its focus on contextual issues, cognition, interactivity, and improvement of theory and practice, can provide significant benefit to the examination of immersive worlds as complex dynamic systems. Research by investigators of AETZone will continue to take this approach when examining the complexities inherent to the environment. Future projects include:

- Further exploration of formation of community and sense of presence uses repeated measure of the COI and SCI-2 indexes
- Examination of ways in which self-organization and emergence manifest in AETZone, including focus groups and analysis of written student reflections on their work in the environment.
- Continued design and re-development of the virtual world spaces and structures in order to best facilitate concepts inherent in complex, constructivist learning environments.

**Conclusion**

The project of education is among the most complex of human enterprises, arising in the nexus of individual interest, social need, disciplinary diversity, cultural self-perpetuation, and humanity’s efforts to situate itself in the more-than-human world. Oriented by this realization, the insights offered by hard complexity research do more than inform education; they transform education (Davis & Sumara, 2010, p. 856-857).

It is obvious that attempts in recent years to understand and improve education in the United States have been based in a closed system approach: specific learning

Table 3  
*Research Affordances of Physical and Virtual Environments*

	Physical	Virtual
Unit of analysis	Person-in-environment	Avatar-in-world
Environment for investigation	Experimental control	Constructed realism
Observational context	Experiment	Experience
Genesis of theory	<i>a priori</i>	<i>in fabula</i>
Population sample	Convenient	Created
Replication	Difficult; costly	Facile; free
Identity of investigator	Fixed	Fluid

outcomes measured by multiple choice and the emergence of 'big data' as indicator of educational progress. This trend is rapidly moving from K-12 to higher education, as nationwide, quantitative measures of things like the quality of teacher education programs make national news. This is certainly true of online education, as widely accepted systems such as CMSs and LMSs lend themselves readily to a behaviorist approach to the collection of data on student learning. As Jones and Brader-Araje (2002) note, after years of implementation, behaviorism fell short of producing the anticipated positive effects within the complex context of classrooms. These rigid, structured systems for designing learning experiences and examining data deny the inherent chaotic, complex, human qualities of educational systems, leaving an important process-oriented part of the picture unexamined.

It is within this context that it is apparent that a systems thinking approach to exploring educational systems adds a great deal of value. Senge (2006) states that systems thinking is "concerned with a shift of mind from seeing parts to seeing wholes, from seeing people as helpless reactors to seeing them as active participants in shaping their reality, from reacting to the present to creating the future" (p. 69). Therefore, providing online learning environments in which students can become actively engaged, embodied, and present carries great potential to facilitate learning that can be transformative.

This true transformation of education has not yet occurred despite a decades-old emphasis on strict quantitative measures. As early as 1991, Jonassen argued that evaluation should be driven by context, should assess experiential constructions (process v. product), include multiple perspectives, be multimodal, and require socially constructed meaning. It is not until education is viewed through these lenses of complexity, community, self-organization, and emergence that a true transformation of education can begin. Immersive environments provide a rich opportunity to begin this process.

Therefore, as we consider the possibility of full-scale transformation and systemic change, we are reminded by Mason (2008):

Complexity theory suggests . . . that what it might take to change a school's inertial momentum from an ethos of failure is massive and sustained intervention at every possible level until the phenomenon of learning excellence emerges from this new set of interactions among these new factors, and sustains itself autocatalytically (Kindle Locations, 178-180).

As such, we are reminded of the need to continue to design, develop and evaluate innovations such as the

AETZone that can, at its level, do much to inform, and ultimately transform, education.

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