A Design Theory for Vigilant Online Learning Systems

M. Keith Wright, Ph.D.
Associate Professor of Information Systems
University of Houston–Downtown
Houston, Texas

ABSTRACT

There is now a preponderance of evidence suggesting that the types of online course management software (OCMS) used in purely online undergraduate college courses, do not meet the needs of younger immature students. These students often lack the learning skills necessary to succeed in such courses, nor do the popular OCMS include the vigilance mechanisms to guide such students to successful course completion in the absence of face-to-face human instruction. This paper explores the literature relevant to design theory, learning theory, decision support, and vigilance, to develop a design theory as a guide to software developers and academics studying how to design future systems for the immature student in accordance with the latest research.

INTRODUCTION

Online courses are usually thought of as one form of distance education. They typically involve the use of the world-wide-web and online course management software (OCMS) such as Blackboard or Moodle. However, for many years now, evidence has shown that typical OCMS have fallen short of their educational potential (See Demirkan & Goul, 2010; Kim &Bonk. al, 2006, Ioannou & Hannafin, 2008, Chua, 2008). In spite of this, the emerging cyber-space culture, as well as the accelerating demand for college degrees, made online courses a global pop-culture phenomenon in the early 21st century (Pappano, 2012; Rosenthal, 2013). By 2002, over three-quarters of all U.S. colleges and universities offered at least one online course (Molenda & Bichelmeyer, 2005). As of 2006, a third of all college students (more than seven million) were enrolled in online courses (Jaggars, 2006); and there were more than 90,000 online college courses. By 2010, 89% of public, four-year colleges offered at least one course online. (AACSB, 2010).

The summer of 2011 saw the first widely known MOOC (Massive Open Online Course) which was taught by Sebastian Thruna, the famous Stanford professor (Pappano, 2012; Rosenthal, 2013). He and a colleague created a free online course, which featured their filmed lectures on artificial intelligence. Roughly 160,000 students from around the world enrolled. The popularity of that course touched off a wave of investment in MOOCs. To date, venture capitalists have poured more than $100 million into MOOC companies like Coursera and Udacity. In 2013, the University of Pennsylvania along with other elite schools, such as Stanford, Princeton, and the University of Michigan, partnered with Coursera, an educational technology startup. As of 2012, 2.6 % of higher education institutions had a MOOC, and another 9.4% reported MOOCs in the planning stages. The majority of institutions (55.4%) report they are undecided about MOOCs, while under one-third (32.7%) report they have no such plans (Seaman, 2013).

Starting in 2013, MOOCs came under fire in the popular press. A Baltimore Sun article reported that many MOOCs were poorly developed, and were merely,

"turning good teachers into mediocre filmmakers... Where the incoherence and mindlessness enter the picture is the current thinking among university officials and digital-minded faculty that delivering a degree or college-level courses to anyone with an Internet connection will revolutionize U.S. higher education institutions." (Grimmelmann, J. 2013, p.1).

Perhaps because of bad press, the growth rate of purely online courses began to decline in 2013. The 2013 annual College Board survey showed the annual enrollment growth rate of online courses to be only 9.3 %, the lowest in ten years (Seaman, 2013).

There is now much empirical evidence that purely online courses are not well suited for the average undergraduate online college student. For example, a University of Pennsylvania study, which examined the behavior of a million Coursera MOOC students from June 2012 to June 2013, found that only 4 % completed the classes, and that these students were disproportionally wealthy and well-educated (Perna et al, 2013). Furthermore, there is evidence that younger students just out of high school or community colleges are most at risk, in part because they lack effective learning skills. For example, the 2013 College Board survey found that the proportion of academic leaders citing the need for more "discipline" on the part of online students increased from 80% in 2007 to 89%. (Seaman, 2013). In that study the majority of university chief academic officers reported that online undergraduate courses have a lower retention rate than do classroom courses. Many of those online students spend their first two years in community colleges, where according to a 2013 New York Times article, they are significantly more likely to fall behind, fail or withdraw than are classroom students (Rosenthal, 2013). Such students were found less likely to earn degrees or transfer to four-year colleges. Among the reasons cited were that students, looking for shortcuts, were attracted to online asynchronous courses, because of their lack of time-management and language skills (Rosenthal, 2013).

Today's typical online course management systems (OCMS), including Moogle, Blackboard, Coursera, Udacity, etc. are a poor fit for the needs of younger immature students. These students, whose undergraduate online college courses typically operate without day-to-day human instruction, simply log on to the OCMS, get their assignments, and try to complete and submit them, while isolated intellectually from classmates and course authors. These OCMS, were designed based primarily on how the system developers and administrators wanted to use the systems, rather than on what ordinary students need or want (Ioannou & Hannafin (2008)). As a result, these OCMS are simply rudimentary information systems, rather than vigilant learning systems: they do not well incorporate what is known about learning theory, expert systems, decision support, and vigilant information systems. To hasten the future development of the more vigilant OCMS that will be needed as we move into an age when many if not most college students will not be able to afford face-to-face college instruction, this paper presents a design theory of vigilant online learning systems (VOLS).

The paper is organized as follows. First, it reviews the literature surrounding design theory. A design theory is a composite theory derived from the underlying kernel theories (Walls, et. al. 1992). The remainder of this paper develops a VOLS design theory by reviewing its kernel theories, and generates hypotheses derived from these kernel theories. These include learning theory, expert systems theory, decision support theory, and the theory of vigilant information systems. To help clarify the ideas presented in this paper, it concludes by presenting one individual VOLS design derived from the design theory presented.

DESIGN THEORY

An information system design theory is a prescriptive composite theory that integrates theories from the natural sciences, social sciences, and mathematics (Walls et al, 1992; Dubin 1978; Simon (1981). It says how a design can be accomplished both feasibly and effectively. Furthermore, design theories are predictive social science theories, which, according to Dubin (1978), have the seven components shown in table 1.

Table 1
Examples of the Properties of a Predictive Theory of VOLS Development (Dubin, 1978)

	Properties	Examples
1	Units	students, teachers, course designers, administrators
2	Law of Interaction	Increased system vigilance leads to increase learning.
3	System Boundary	online course management system in a university
4	System State	the design accomplished according to principals of vigilant information systems
5	Proposition	Increased system vigilance leads to increased student learning.
6	Empirical indicators	results of summative assessments of student learning binary indicator of whether or not the system was designed in accordance with the principles of vigilant information systems design
7	Testable Hypothesis	The mean student performance on summative tests of learning is significantly higher for the group using a vigilant online learning system than for the group using a traditional online course management system.

First, design theories have units whose interactions are the subject of interest. Second, design theories have propositions, and the laws of interaction among units, which are a subset of the propositions. Design theories have boundaries within which the theory is expected to hold. They have system states, which affect how the units interact. They also have empirical indicators related to the terms in the propositions. Finally, design theories have testable research hypotheses incorporating empirical indicators.

As well as satisfying the characteristics of any theory, a design theory has several additional characterisstics. For example, Simon describes an information system design theory (ISDT) as, "a body of "intellectually tough, analytic, formalizable, partly empirical, and teachable doctrine about the design process" (Simon, 1982, pp 132.) Furthermore, an ISDT differs from a natural science theory in that a design theory involves goals achievement. For example, a natural science explanatory law is of the form "Y causes X". On the other hand, an analogous design theory law is of the form –"If you want to achieve goal X, then make Y happen" (Walls et al, 1992). Thus, a design theory prescribes what properties the design product should have, as well as the process of how the product should be built. Furthermore, Simon contended that design theories are composite theories, which integrate kernel theories from natural science, social science and mathematics. This integration is accomplished by the theory's prescriptions, which state how to perform a design and why to do it that way (Dubin, 1978).

In the tradition of Nagel (1961), design theories should be subject to empirical refutation. Accordingly, an assertion that possession of a particular set of attributes will enable a design product to meet its goals, can be verified only by building and testing the product. Furthermore, a hypothesis that a certain design process will result in a design product that meets its goals can be verified only by using that method to build the design product and testing to see if it satisfies its goals(Walls 92, pp. 41.)

Therefore, we see from examining the theory building ideas set forth by Dubin, Simon, Nagel, and Walls; any information systems design theory (ISDT) has two aspects—the design product and the design process. A design process is "to so plan and proportion the parts of a machine or structure such that all requirements will be satisfied" (Walls et al 1992, pp. 41). Further, the design product and the design process each produce a set of empirically testable hypotheses, which can be tested only after the object of the design product is built. However, the design process component of vigilant online learning system (VOLS) design theory,is beyond the scope of our paper.

Walls et.al. (1992) proposed the components of an information systems design theory (ISDT) as a set of meta-requirements, and a set of meta-designs. Meta-requirements are written statements of the requirements for an entire class of designs – hence the prefix, "meta". The meta-de-

Table 2
Example of Components of an IS Design Theory (ISDT)

Design Product	1	**Meta-requirements products**	Written description of the *class* (hence the prefix ("meta")) of goals to which the theory applies. (e.g. data base systems should remove update anomalies)
	2	**Meta-design products**	Describes a *class* of design products hypothesized to meet the meta requirements. (e.g. normalized tables)
	3	**Kernel theories**	Theories from natural or social sciences governing design requirements. (e.g. relational calculus)
	4	**Testable design product hypotheses**	Used to test whether the meta-design products satisfy the meta-requirements. (e.g. theorems of relational calculus)
Design Process	1	**Design process method**	A description of the procedure for design product construction. (The normal progression method: First, produce tables in first normal form, then second, third. etc.)
	2	**Kernel theories**	Theories from natural or social sciences governing the design process itself. (May be different from those associated with the design product.)
	3	**Testable design process hypotheses**	Used to verify whether the design process method results in a product consistent with the meta-design. (E.g., the normal progression method produces seven tables in third normal form.)

signs describe a class of design products hypothesized to meet the meta-requirements. Thus, meta-designs are general written descriptions of the data structures and algorithm types for that same class of designs. The third component of an ISDT is a set of kernel theories from natural or social sciences which govern the design products and the design processes. Table 2 summarizes the information design theory (ISDT) components set forth in Walls et.al (1992).

*Walls et al (1992) gives an example from relational database theory (Codd 1970) as the most fully developed ISDT.

LEARNING THEORY

Kernel theory pertinent to vigilant online learning system design theory (VOLSDT) can be divided into two broad areas--learning theory and decision support system (DSS) theory. Although there are many published papers on DSS software, there have been fewer in the area of vigilant computerized learning software. However, there are now computerized measurements of learning style. The roots of learning style research go back almost eighty years, in the three similar streams of Lewin, Dewey, and Piaget. The Lewin school believes that learning is best understood and facilitated as an integrated process that begins with immediate experience followed by collecting observations about that experience (Lewin,(Kolb, 1984)). The learner then analyzes the data to form conclusions which provide feedback from which learners use to modify their behavior and choose new experiences. Lewin and his followers believed that much individual and organizational ineffectiveness could be traced ultimately to a lack of adequate feedback processes. "This ineffectiveness results from an imbalance between observation and action, either from a tendency for individuals and organizations to emphasize decision and action at the expense of information gathering, or from a tendency to become bogged down by data collection and analysis". (Lewin (Kolb, 1984. pp 22)).

On the other hand, Dewey's model of learning is similar to the Lewin's, although Dewey makes more explicit the developmental nature of learning implied in Lewin's conception of it as a feedback process. Dewey described how learning transforms the impulses, feelings, and desires of concrete experience into higher order purposeful action (Lewin (Kolb, 1984)). Dewey believed in the emphasis on learning as a dialectic process integrating experience, concepts, observations, and action.

Piaget drew upon the work of Lewin and Dewy, as well as his own exhaustive study of child behavior, to create a learning model mirroring his conception of the process of scientific discovery (Piaget (Flavell, 1966). Piaget described mental maturization as it moves from the concrete phenomenal view of the world in infancy, to the adult's abstract constructionist view. For Piaget the key to learning lies in the mutual interaction of two processes, the accommodation of old concepts to new experience, and the assimilation of new experience into old concepts (Piaget (Flavell, 1966)). Cognitive growth from concrete to abstract and from active to reflective is based on continual transition between assimilation and accommodation, occurring in successive stages, each of which incorporates experience into a new, higher level of cognitive functioning.

Piaget is credited for what is now called the Constructivist Learning Approach. Constructivism encourages the student to create his or her own personal mental models, and encourages hands-on problem solving. Constructivism suggests that instruction should be accommodating of prior student experience, and that students should be encouraged to analyze, synthesize, and derive information (Piaget (Flavell, 1966)). It encourages frequent feedback and other teaching methods that enable self-directed learning. Constructivism draws upon two key learning paradigms in education: the cognitive and the situative. The cognitive approach simulates the way in which humans think and apply knowledge. Some psychologists believe that this approach is a requirement for high-quality online learning systems (Simmering & Posey, 2009). Cognitive learning approaches include scaffolding, fading, coaching, and meta-cognitive support. Scaffolding provides support to novice learners when concepts and skills are being introduced. Fading is the gradual removal of scaffolding as the learner becomes increasingly competent. Meta-cognitive support is information given to learners to improve awareness of their ability to understand, control, and manipulate how they learn (Peiris and Gallupe, 2012). The situative paradigm takes a social perspective--where help and guidance from peers and instructors are considered most important to learning. (See Ahmad & Lajoie, 2001; Greeno & Hall, 1997; Hall & Greeno, 2008; Alavi, 1994). Thus, there is reason to assert that a VOLS should provide multiple communication channels for different learning sources, including peers, instructors, subject matter experts and practitioners.

Further, constructionism implies that a VOLS, should continually explore students' prior experiences and assumptions, and then help them search for learning objects (IEEE, 2008; OEDb; 2007,) that will help connect new concepts to that experience. Effective classroom instructors do this as a matter of course. For example, experienced classroom computer science instructors know they may confuse students if they introduce object-oriented programming as a style of programming that uses inheritance and polymorphism. A vigilant instructor however

can easily determine a student's current cognitive frame of reference (CFOR) by asking about their prior experience. For example, if the student knows nothing of polymorphism and inheritance, the vigilant instructor searches for a more appropriate analogy. If the student has some programming background, then the vigilant instructor may choose to introduce object-oriented programming simply as a style of programming that can result in programs that are easier for the maintenance programmer to read, understand, and modify. We propose that a vigilant online learning system (VOLS) facilitate student learning in the same manner—by following a student's CFOR at each stage in the learning process.

By the end of the 20th century, researchers had synthesized and expanded the original works of Lewin, Dewey, and Piaget to what is now known as experiential learning theory (ELT) (Kolb, 1984). ELT hypothesizes that learners increase their knowledge in one or more of the four stages shown in table 3. Over the years, these four stages have come to be known as Kolb's learning cycle (Kolb, 1984). It was ELT that spawned Bloom's taxonomy of learning objectives (Bloom 1956), which divides educational objectives into three domains: cognitive, affective, and psychomotor. Within the domains, learning at the higher levels is dependent on having attained prerequisite knowledge and skills at lower levels. The goal of Bloom's taxonomy was to motivate educators to focus on all three domains.

Kolb (1984) proposed that individuals have a dominant learning style, which can be thought of as preferences for combinations of the various modes of experiential learning shown in table 3. Kolb argued that, although most of us have a dominant yet mostly unconscious learning style; to a certain extent, we can choose which style to use at any given time—resolving cognitive tension by suppressing one style while focusing on the other. There are now assessments of learning style; the most noted being the learning style inventory (Kolb, 84). This instrument has been used to identify four learning styles, Diverging, Assimilating, Converging and Accommodating.

We argue that a VOLS should support mechanisms to elicit the student's dominant learning style, make him aware of it, and support his or her conscious choice of learning objects matching the preferred real-time learning style. Consider the following examples of how a VOLS could leverage a student's learning style.

Suppose the student is faced with the following case related to the ethics of computer programming:

Assume you are a programmer on your last few days of a time-and-materials contract with your client. You have been asked to repair a major defect in one of the system modules you developed. Further, suppose that you have discovered the following possible repair options:

Option-1 will require little of your time, but the repair will last only until the next scheduled complete system restart, a month after you are to begin work for another more lucrative client.

Option-2 will require almost all your remaining current contract time, but the repair will be permanent.

However, you feel that your resulting lack of spare time will prevent you from taking on any new small assignments on your current contract, and may create the opinion amongst your peers that your technical skills are lacking.

Which option should you choose and why?

If the student prefers a diverging style, his dominant learning abilities are concrete experimentation (CE) and reflective observation (RO). He is best at viewing concrete situations from many different points of view. He performs well in situations that call for generation of ideas, perhaps in a brainstorming session. In formal learning sit-

TABLE 3
EXPERIENTIAL LEARNING THEORY THE LEARNING CYCLE, KOLB (1984).

		Ability
1	(CE) *Concrete experience* engagement	The learner involves themselves fully, openly, and without bias in new experiences.
2	(RO) *Reflective observation*	The learner reflects on and observes their experiences from many perspectives.
3	(AC) *Abstract conceptualization*	The learner create concepts that integrate their observations into logically sound theories.
4	(AE) *Active experimentation*	The learner tests their theories by making decisions and solving problems.

uations, people with the diverging style prefer to work in groups, listening with an open mind to different points of view and receiving personalized feedback. A VOLS, upon discovering that a student prefers the diverging learning style, could facilitate the student's search for material supporting different points of view associated with the above type of ethical dilemma. Alternatively, the VOLS could provide the opinions of classmates, and /or project managers, maintenance programmers, project secretaries, end users, etc. – either virtual or real.

A student with a converging style has "abstract conceptualization (AC) and active experimentation (AE) as dominant learning abilities. He is best at finding practical uses for ideas and theories. These students have the ability to make decisions based on finding solutions to successions of problems, based on a question-answer dialog. Individuals with such a learning style prefer to deal with technical tasks and problems rather than with social and/or interpersonal issues. In formal learning situations, this student prefers to experiment with new ideas, simulations, laboratory assignments, and practical applications. In this case, the VOLS could assist the student by first allowing him to observe the possible effects of the computer flaw over time, and then providing the tools necessary to perform simulations of possible computer program repairs.

Finally, an individual with an accommodating style has concrete experiences (CE) and active experimentation (AE) as dominant learning abilities. These types of students learn primarily from hands-on experience. They act often on feelings rather than on logical analysis. In solving problems, they rely more on people for information than on their own technical analysis. In formal learning situations, people with the accommodating learning style prefer to work with others to get assignments done, to set goals, to do field work, and to test out different approaches to completing a project. A VOLS might assist this type of student by facilitating group collaboration on a project in a divide-and-conquer approach.

Recent research has indicated that, that for a complete learning experience, students should go through all four stages of the learning cycle. This approach has the advantage of ensuring that at least one stage will match a person's learning style preferences. Konak et al (2014) provided empirical research to support this claim, as well as specific constructs to operationalize the four stages. Their experiment involved students in an introductory cryptography class. The concrete experience activity was a set of step-by-step instructions demonstrating asymmetric encryption. The activity instructions were written so that students could complete the task with no previous cryptography experience. The Reflective observation activity included peer discussion and reflective questioning. After completing the concrete activity, students were asked to analyze the components of a digital certificate, and then to discuss questions such as why they have to export their private encryption keys. That research found that student-student interaction achieved a higher level of reflective observation. For example, instead of asking students to analyze their own digital certificate individually, better results were obtained when students were asked to compare their certificates with their teammates'. For the abstract conceptualization activity, students were asked to create a diagram of the asymmetric encryption activities they performed, and then to participate in an instructor led discussion about what they performed in the earlier exercise about symmetric encryption. Then they were asked to list the advantages and disadvantages of asymmetric encryption algorithms. For the active experimentation activity, they used two strategies. The first was to give students a new task, similar to that in the concrete experience stage, but without step-by-step instructions. For example, students were asked to send encrypted messages to students other than teammates. The second strategy was to combine a few related topics in the same activity such that the later topics built on the former ones.

The research found that students whose activities were based on Kolb's experiential learning cycle (ELC), perceived higher levels of interest and competency compared to the control group, whose activities were based on no theoretical learning model. Students given opportunities for conceptualization, experimentation, and reflection with other students performed better than students working alone and following systematic written instructions. Findings also indicated that the amount of group work was positively correlated with feelings of learning competency, and that group work facilitates the implementation of the reflection and conceptualization stages. The findings suggest that student learning outcomes can be enhanced by incorporating all stages of Kolb's Experiential Learning Cycle.

There has been other valuable empirical research suggesting how to improve online learning systems (OLS). For example, Carliner (2004) proposed that they should enable a learner to use the Internet to access learning materials; and to interact with the content, instructor, and other learners to construct personal meaning. For other similar research, see also Wang, 2007, Paulsen, 2003, Stephenson, 2001 and Peiris & Gallup (2012).

In review, the literature around learning theory contributes valuable meta-products to a vigilant online learning systems design theory (VOLSDT). Examples of these are shown in tables 4 and 5. Table 4 lists the proposed meta-requirements. Table 5 lists the proposed meta-designs, which are the data structures and algorithm types necessary to implement the meta-requirements. Table 6 lists examples of the testable hypotheses derivable from these design products.

. Table 4
Elements of a Design Theory of Vigilant Online Learning Systems Meta-requirements products Derived from Experiential Learning Theory

MR1	The system should provide the ability to detect student learning style.
MR2	The system should make student aware of this dominant learning style.
MR3	The system should support the conscious student choice of pedagogical material matching his dominant learning style.
MR4	System should facilitate the presentation of ordered sequences of the four activities in Kolb's learning style.
MR5	The system should facilitate collaborative learning with other students, professors, field experts, internet communities of interest, etc.
MR6	The systems should support scaffolding, fading, and coaching.
MR7	The system should periodically survey students to determine their up to date cognitive frames of reference.

Table 5
Elements of a Design Theory of Vigilant Online Learning Systems Meta-design products Derived from Experiential learning theory

MD1	index to web learning objects tagged according to learning style compatibility
MD2	Web crawler to search, index, and tag learning objects according to learning style compatibility
MD3	API to Kolb's learning style inventory
MD4	Knowledge management API
MD5	API to groupware for collaborative learning

VIGILANCE THEORY

To take full advantage of is known about the process of human learning, we contend that a VOLSDT should integrate a theory of vigilance. To this author's knowledge, what little is known about vigilance in information systems design is found primarily in the decision support systems literature (Sprague & Carlson, 1982; Klein & Methlie, 1995; Walls et al, 1992). In that literature, the concept of cognitive frames of reference is emphaaized. To our knowledge, the term cognitive frame of reference was first used in the decision support literature by Shrivastava and Mitroff (1983). However many variants of this term have appeared in the literatures of psychology, philosophy, linguistics, organization theory, strategic decision-making, political science, artificial intelligence and expert systems. For example, schemas were discussed in Bartlet (1932), internal images were studied by Boulding (1956), paradigms (Kuhn, 1970), frames (Minsky, 1975), socially defined frames (Goffman, 1974), cognitive maps (Axelrod, 1976), scripts (Schank and Abclson, 1977), assumptions (Mason and Mitroff, 1981), frames of reference

Table 6
Elements of a Design Theory of Vigilant Online Learning Systems Examples of Testable Design Product Hypotheses Derived from Experiential Learning Theory

H1	It is feasible to design system to accommodate detection of student learning style. etc.
H2	Students using a system that makes them aware of their dominant learning style will perform better on summative assessments than students using a system that does not make students aware of their learning style.
H3	Students using a system offering them the opportunity to perform activities using learning objects tailored for all four phases of Kolb's learning cycle will perform better on summative assessments than students using a system that does not offer them such activities.
H4	Students using a system supporting asynchronous collaborative learning will perform better on summative assessments than students using a system that does not facilitate asynchronous collaborative learning.
H5	Students using a system with scaffolding and fading will perform better on summative assessments than students using a systems without scaffolding and fading.
H6	Course authors using a system that associates students, learning style, and assessment performance will be more satisfied than course authors using a system not supporting this feature (because they will be able to better target their learning content to the course audience).

(Shrivastava and Mitroff, 1983) and templates (Pondy, 1984; Peiris and Gallupe, 2012).

An interesting study by El Sawy & Pauchant (1988) provides empirical research that operationalizes cognitive frames of references in the context of executive decision making, especially issues tracking and environmental scanning. That paper discusses environmental scanning as a form of organizational learning that involves changes in the cognitive frames of reference (CFOR) of groups of decision makers. The research contended that, in organizations, the issues tracking effort "involves the shift of decision makers' CFOR generated through the perception of new information or the occurrence of new learning and ideas". El Sawy & Pauchant (1988, pp. 457).

Piaget, as discussed earlier, identified two basic modes of learning, assimilation and accommodation (Piaget(Flavell, 1966) where assimilation occurs when new information is assimilated into old frames of reference, and accommodation is when old frames are modified if new data do not fit the old frames. Similarly, Norman identifies a three part learning process: accretion, when new knowledge is added to existing frames; structuring, the formation of new frames; and tuning which is the ongoing maintenance of existing frames that are better matched to the real-time task. Similarly, Boland (Pondy, 1984) argues that reasoning occurs through the interweaving of data with multiple frames of reference in a process of frame shifting. They argue that the cognitive tension engendered by dissonant competing frames underlie the dynamics of frame shifting. Piaget (Flavell, 1966) describes a dialectic of assimilation and accommodation based on mutual adjustment between cognitive structures and knowledge. Norman's "tuning" is based on the integration of dissonances (Norman, 1982).

As individuals scan the learning environment, the new information and interpretations they acquire change their cognitive frames of reference, which in turn affect how they will scan that environment. According to El Sawy & Pauchant, (1988) the key to understanding the role of cognitive frames of reference in learning was in studying their shifts. They operationalized this concept in data structures they called templates, which represented an organization's "cognitive frame of reference".

We contend that, like an executive information system (EIS), a VOLS should facilitate continuous environmental scanning in an environment considered turbulent (For discussions of organizational turbulence, See Teece, Pisano, & Shuen, 1997; Bourgeois & Eisenhardt, 1988; 1986; and Briggs and Peat, 1989; Demerkien & Ghoul (2010). In the context of vigilant online learning systems (VOLS), turbulence connotes the continuous stream of new information about the evolving state of each student's (or each class's) performance, plus the shifts in their cognitive frames of reference, as well as new learning opportunities appearing continuously cyber-space. We contend that a VOLS should facilitate user template shifting, which in turn should facilitate the identification and shaping of their related issues. A VOLS design, similar to what Walls et al (1992) proposed for a vigilant EIS, should model issues as attention organizers, where issues can be anything that could affect student learning interests, as well as the interests of all other types of system users (e.g. course authors, administrators, monitors).

We propose that a VOLS can model issues in a manner analogous to the environmental issues discussed in Dutton and Webster(1988), where issues were defined as events, developments, or trends which have a potential consequence for an organization, and which may be identified as either threats or opportunities (See also Jackson and Dutton 1988; Heath & Nelson, 1986; King, 1987). We contend that a vigilant online learning system (VOLS) should incorporate features of an executive information system, where the organization is the university, and the "executives" are the system users, including students. Furthermore, we contend that a VOLS should facilitate the management of each student's learning issues as well as strategic issues for the university, department, class, or course.

We argue that, in turbulent environments such as a large online undergraduate college classes, the decision-making process is appropriately viewed by the participants as a process of attention to issues with varying and shifting priorities. Issues are dynamic entities that evolve over time. They go through a life cycle from birth to death, which consists of four stages: discovery, emergence, maturity, and fading (Walls et al, pp. 49). According to King (1987), issue management involves identifying an issue, dealing with the way it affects stakeholder interests, and influencing its evolution to the maximum degree of cost/effectiveness. Facilitating and managing the issue life cycle has been suggested as a requirement of a vigilant information system (Walls et al, 1992).

El Sawy and Pauchant (1988) described how organizational issues tracking could be made operational via the concepts of templates, triggers, and twitches. It was said that decision makers perceive an issue through a cognitive frame of reference, which they termed template. The process of environmental scanning was represented by changes in these templates, which they termed twitch. That study concluded that the management process of environmental scanning (and hence decision-making) could be improved by stimulating and managing the process of template shifting. We contend that a VOLS should improve the learning of ordinary online undergraduate

college students (and entire classes) by facilitating and managing the process of template shifting in regards to learning objectives. Similarly, we argue that a VOLS should improve the decision making of policy makers, course authors, and system administrators by facilitating and managing the process of template shifting in regards to policy formation.

In the El Sawy & Pauchant (1988) study, the organizational issue explored was the business potential posed by the (then emerging) cellular the telephone market. The decision maker's CFORs were elicited periodically from a group of decision makers. Template components included a set of verbal descriptions (constructs) of N bipolar dimensions that described the plot, or theme of the template. The template constructs were things like whether or not the market would perceive cell phones to be only toys; or if the phones would be reliable; or how much they would cost, etc. A trigger is a stimulus which impinges upon a template and which may cause it to twitch. A trigger was described by its information, source, and latency. For example, a trigger for a university administrator might be information suggesting that a Pascal programming class can no longer be competitive in the market. A trigger for a student might be the realization that his learning style suggests he join an internet community of interest, or new knowledge of which job skills are most in demand. Another student trigger might be the result of an exam score. A trigger's source denotes where the information was obtained. Its latency is the extent to which a trigger has interaction effects with future triggers. A highly negative latency means the trigger has stimulative effects on template shifting in the presence of future triggers. Positive latency means the trigger has a temporary inhibiting effect. In other words, a latent trigger may be one that shows its effect only in the future. A twitch is a change in a template caused by a trigger. A twitch contains a descriptor, a magnitude, and drivers. The El Sawy & Pauchant study identified the following three basic types of twitches:

- substitution twitches, which add a new construct to the template and/or drop an existing construct;
- articulation twitches, which combine two existing constructs to form a new construct and/or branch an existing construct into two new constructs; and
- tuning twitches, which change the orientation and/or magnitude of positioning on an existing construct.

The El Sawy paper concluded that, "given that the explicit operationalization of template twitching is possible in a form amenable to computer-based storage and processing, it would be a fruitful venture to build an expert system for group tracking of emerging issues"(El Sawy & Pauchant, pp. 461).

In summary, the decision support literature suggests the environmental tracking process, and hence decision-making, can be improved by helping decision makers manage the issue tracking process. We contend that a VOLS should incorporate theses features, and that doing so could improve student learning as well as the tactical decision making of all other types of VOLS users.

To help clarify the concepts of issues tracking and templates, below are some examples of templates that might be developed for a particular VOLS. Accordingly, each template construct describes a part of the paradigm through which an individual (or group) perceives the external environment. These constructs can be thought of as ideas that might influence that person's decision-making. Table 7 represents a possible template for an average undergraduate college student. It was derived from the model of e-learning success proposed by Holsapple & Lee-Post (2006, pp. 74.) Their student survey found the six constructs in table 7 to be the most important predictors of student satisfaction with online courses. On the other hand, table 8 shows a template representing perceptions of a student's dominant learning style. This perception could affect the choice of student learning content. These

Table 7
Elements of a Design Theory of Vigilant Online Learning Systems Meta-design product Derived from Vigilance theory

eLearning Readiness Template					
1	low	←	GPA	→	high
2	low	←	Course load	→	high
3	low	←	Prerequisite performance	→	high
4	low	←	Technical competence	→	high
5	low	←	Study habits	→	high
6	low	←	Life style compatibility	→	high
7	low	←	Online learning experience	→	high
8	low	←	Attitude towards online courses	→	high

Table 8
Meta-design product
Derived from Vigilance theory

Learning Styles Template

1	low	←	Diverging	→	high
2	low	←	Assimilating	→	high
3	low	←	Accommodating	→	high
4	low	←	Converging	→	high

perceptions could be of a course monitor, course author, student, or the VOLS itself. Table 9 shows a template representing factors influencing how students might perceive their own academic performance. This kind of template could affect student decisions. Table 10 shows a template concerning an instructor's perception of a student's performance. Finally, table 11 depicts factors influencing a policy maker's perception of the issue of decreasing course enrollment. (Note that these particular templates are not part of a design theory. They are merely examples of one possible VOLS design that is consistent with VOLSDT.)

However, the concept of vigilance typifies a much more active, alert and action-directed capability than merely issues tracking. There must also be the capability for decision makers to act even when rapid feedback is not available. Thus, a vigilant online learning system should have both closed loop and open loop control mechanisms (Walls et al, 1992). We propose that open loop control can be achieved by a simple time-out heuristic that could be elicited from

system policy makers. Such a heuristic could simply state the maximum time that system action can be delayed due to a lack of environmental feedback. There should also be a template data structure that includes issue descriptor(s), directive(s) to other system users, response(s) to directives, and critical indicator(s). A critical indicator is an empirical parameter that helps describe and track an issue (El Sawy et al, 1988). A VOLS should also have the ability to add and delete templates as well as the ability to add delete, and modify critical indicators.

Tables 12 and 13 lists, the ideas discussed in the last few paragraphs as VOLS meta- requirements, and meta-designs. Note that, to allow investigation of critical indicator behavior over time, a VOLS should have a mechanism to link sources of information to critical indicators, as well as automatic maintenance of template history. For adequate

Table 9
Meta-design products
Derived from Vigilance theory

Psycho-social Template

1	low	←	grade anxiety	→	high
2	low	←	confidence in studying ability	→	high
3	low	←	experience with subject matter	→	high
4	low	←	confident with [subject	→	high
5	low	←	Facility with language	→	high
6	low	←	Confidence in finances	→	high
7	low	←	Test anxiety	→	high

Table 10
Meta-design product
Derived from Vigilance Theory

Student Performance Template

1	low	←	Formative assessment results	→	high
2	low	←	Summative test results	→	high
3	low	←	Assignment lag time*	→	high
4	low	←	Schedule compliance**	→	high
5	low	←	Study habits	→	high
6	low	←	Learning process cycle time***	→	high

*Assignment lag time is the time that elapses between when a particular assignment is given and the time when work begins.

**Schedule compliance is a measure of the extent to which a student tends to follow the course schedule.

***Learning process cycle time is the mean time a student takes from the start of a learning module to its successful completion

Table 11
Meta-design product
Derived from Vigilance Theory

Course Enrollment Template

1	low	←	University enrollment	→	high
2	low	←	Local population	→	high
3	low	←	Course demand	→	high
4	low	←	Population income	→	high
5	low	←	Local area network bandwidth	→	high
6	low	←	University budget	→	high
7	low	←	Faculty quality	→	high
8	low	←	Student quality	→	high
9	low	←	Student job placement	→	high
10	low	←	Student retention	→	high
11	low	←	Facilities quality	→	high

system control, a senior decision maker (e.g. course author or administrator) should have the ability to pass on to his subordinate (e.g. student) information useful in taking action based upon the outcome of the issue tracking process. Thus, the VOLS should have a mechanism to add a subordinate directive to a template, and a mechanism to pass the template to the subordinate for his action. Furthermore, the VOLs should track of the resolution of a problem derived from an issue. Therefore, the VOLS should have a mechanism for a subordinate (e.g. student) to respond to a directive, and a mechanism to help the superior (e.g. course monitor) monitor the subordinate's progress on a directive.

ONE POSSIBLE VOLS DESIGN

In review, we have discussed the meta-requirements and meta-design products of a theory of design we call vigilant online learning systems design theory (VOLSDT). Because there a many possible individual designs consistent

Table 12
Elements of a Design Theory of Vigilant Online Learning Systems
Meta-requirement product
Derived from Vigilance Theory

MR8	A VOLS should support issue representation in the form of triggers, templates and twitches.
MR9	A VOLS should support both open and closed loop control.
MR10	A VOLS should support the issue management life cycle.
MR11	A VOLS should support elicitation and maintenance of heuristics from policy makers, course authors, system administrators, and students.
MR12	A VOLS should support the learning and decision making of different types of users including course administerators, system administrators, course monitors, and students.
MR13	A VOLS should derive traceable recommendations from inferences drawn from its evolving internal knowledge base.
MR14	A VOLS should use heuristics to take independent actions (such as course content selection) when necessary.
MR15	A VOLS should facilitate periodic monitoring of proposed actions in response to directives.
MR16	A VOLS should facilitate the tracking of the resolution of a problem derived from an issue.
MR17	A VOLS should facilitate the mandatory elicitation and maintenance of all template information.

with this design theory, perhaps it would be instructive at this point to sketch one possible design. (See figure 1.)

VOLSDT calls for systems with several types of users, including course authors, system administrators, course monitors, and students. Course monitors are agents that intervene in the learning process only sporadically on an exceptional basis. These agents could be course authors, course administrators, or organizational policy makers.

The system designed in figure 1 controls the learning process, and consists of at least three primary subsystems, the I/O) (input/output) processor, the inference engine, and the ETL (extract, transform, and load) module. This module extracts environment information from the I/O

Table 13
Elements of a Design Theory of Vigilant Online Learning Systems Meta-Design products*
Derived from Vigilance Theory

MD6	template data structure including issue descriptor, multiple critical indicators, directives, and responses
MD7	expert system to monitor and facilitate student learning via alerts, directives, triggers
MD8	link of information sources to critical indicators**
MD9	data structure for template history
MD10	template sharing among stakeholders, including concurrent access, and atomic transactions
MD11	communication of responses to directives
MD12	directive status data structure
MD13	suggestion data structure
MD14	system command data structure
MD15	expert system engine, including expert knowledge extractor

*Data structures and algorithm types

**A critical indicator is a parameter that describes an issue, and can help track it.

process, then transforms, and stores it in the knowledge base according to the document object models (DOMs). The knowledge base evolves over time, and contains the complete histories of template elicitations, issues, twitches, triggers, learning objects, expert heuristics, and links to cyber-space learning objects.

The choice of DOMs should be configurable by the system administrator, and would include models such as the Sharable Content Object Reference Model (SCORM), which supports content portability via extensive cataloguing using metadata (Bohl, Schelhase, and Sengler & Winand 2002). Another possible DOM might be the IEEE Learning Technology Standard Committee (LTSC) reference model, IEEE P1484.1. This model has five layers that focus on reusability and portability, and specify structures for storing ratings of e-learning system sources. (O'Droma, M. S., Ganchev, I. & McDonnell, F. 2003). Another possible model could the IMS model from the Instructional Management Systems project (IMS, 2007). It is another approach to defining technical specifications to promote interoperability between e-learning systems.

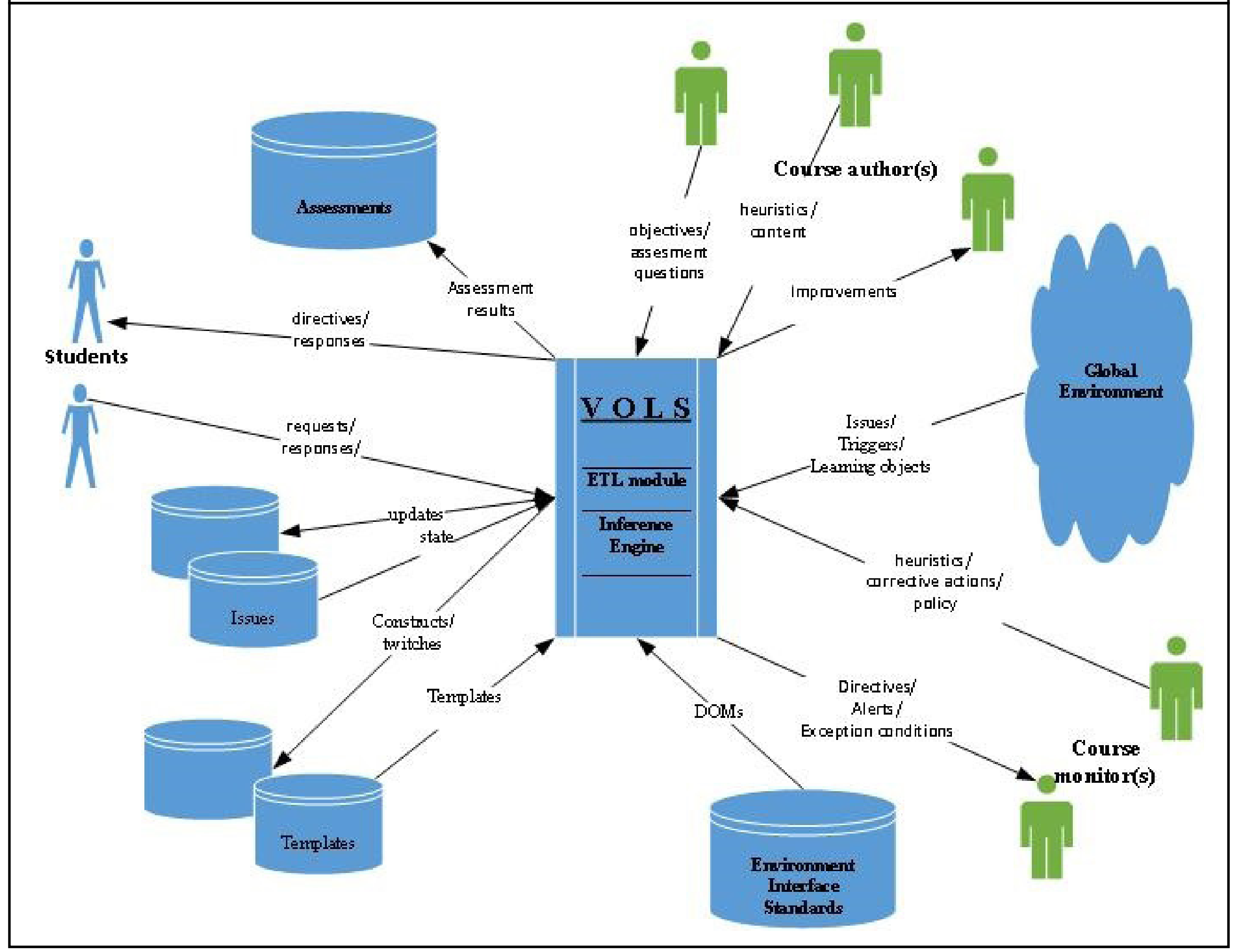
Table 14
Examples of
Testable Design Product Hypothese
Derived from Vigilance Theory

H1	It is feasible to design an online course management system to accommodate issue representation in the form of triggers, templates, and twitches.
H2	It is feasible to design an online course management system to accommodate environmental scanning techniques that have been proposed for EIS.
H3	Students using a VOLS will be more satisfied than students using a traditional course management system.
H4	It is feasible to design an expert system capable of monitoring and facilitating student learning.
H5	Students using a VOLS will perform better on summative assessments than students using a traditional course management system.
H6	Students using a system that accommodates the issue management life-cycle, will be more satisfied than students using a system that does not accommodate these features , etc.
H7	Course monitors using a system that supports the issue management life cycle will be more satisfied than course monitors using a system that does not support these features (because they will be able to more quickly and better target their responses to exception conditions).etc.

After The VOLS extracts and stores information from experts such as professors, practitioners, course authors, and administrators; the inference engine facilitates the learning process as follows. First, it adds reads real-time state information from the environment (including that from all users) to its knowledge base. Then it draws inferences, which it translates, into helpful recommendations, directives, instructions, etc. output to the appropriate users and knowledge bases. Triggers would impinge upon the VOLS, as it scans the environment. These triggers include student assessment results, internal policy directives, and templates obtained from user surveys.

Note that such surveys are of vital importance to a VOLS, which by definition, operates mostly without a human intervention. These surveys are transformed into templates that represent users' cognitive frames of reference. Thus, because a VOLS would be designed to replace many of the soft skills of effective human instructors, the user surveys should be mandatory. Over time, the VOLS, may find that a user's (or group's) cognitive frames of reference

Figure 1
One Possible Design of a Vigilant Online Learning Systems



have twitched, creating issues. The VOLS then tracks these, and if one becomes potentially counter-productive, then an alert directive would be issued to the appropriate user(s). Then these directives would be used to select a course of action, which in turn would affect the learning environment. If, in the opinion of the VOLS or of a course monitor, this action has the potential to affect other users negatively, an action authorization request would go to a human system administrator. This control architecture is similar to what was proposed for vigilant information systems in Walls et al (1992, pp. 52).

In review, this paper has thus far discussed examples of three of the four elements of the design meta- products portion of a complete theory of vigilant online learning system design. (Note that the design meta-process component is beyond the scope of this paper.) The first element was the kernel theory. The second element was the set of meta-requirements derived from the kernel theory. The third element discussed was the set of meta-design products (or simply meta-designs) which specify the types of algorithms and data structures needed for the class of designs.

The final design product to be discussed here is a set of examples of testable design hypotheses generated by the VOLSDT. As discussed earlier, any design theory, in the tradition of Nagel (1961) and Dubin (1978), should generate empirically testable hypotheses. These are tested when a system is physically constructed and acceptance tested. As you may recall, a design theory is a prescriptive synthesis of kernel theory, which says how a design process can be carried out in a feasible effective manner. Thus, these testable hypotheses are merely simple transformations of the meta-requirements. Table 14 shows a few examples.

SUMMARY

In summary, this paper began by reviewing the latest news concerning the state of online higher education in the U.S. The initial enthusiasm of administrators towards purely asynchronous online undergraduate education has begun to diminish in light of reports of high dropout rates and poor learning outcomes. The paper then argued that one reason for these unfortunate results is the limited capabilities of traditional course management systems such as Blackboard, Moogle, Udacity, and Coursersa. We argued that a vigilant online learning system (VOLS) would be more appropriate for younger immature online college students than would a traditional online course management system (OCMS) such as Blackboard or Udacity. A VOLS would learn about, and act upon student attributes that traditional OCMS ignore – attributes such as cognitive frames of reference, and learning style. In addition to functions of traditional systems, VOLS add the capability to facilitate (or eventually to replace) many of the soft skills of an effective undergraduate classroom instructor.

The paper then presented the classic definitions of design theory and vigilant information systems theory. These definitions revealed that design theories are composite theories based on kernel theories from the natural sciences, social sciences, and mathematics.

The paper then presented a theory of online course management systems design. This class of system designs was termed vigilant, to distinguish them from that of traditional course management systems. This theory consisted of a set of design meta-requirements, meta-design products, and testable design product hypotheses.

CONCLUSIONS AND CONTRIBUTIONS

In conclusion, it has become apparent that today's popular course management systems such as Blackboard, Moogle, Coursera, and Udacity are not appropriate for the ordinary young, immature college student. The author hopes that this paper will be a guide to software developers and academics who will study how to design and build the next generation of online course management systems, vigilant online learning systems. To our knowledge, this is the first paper to address this subject, and the first to use the term VOLS. In addition to functions of traditional system, a VOLS would learn about, and act upon student attributes that traditional online course management systems (OCMS) ignore – attributes such as cognitive frames of reference, and learning style. This paper extends the concept of recommender systems for higher education (Paulsen, M. F. (2003). (Peiris, D. & Gallupe, B).

In addition to recommending student actions, a VOLS would replace many of the soft skills of an effective undergraduate classroom instructor. Such instructors leverage their knowledge of human learning, via a dialectic process, to develop ideas about how individual students learn, and then communicate with them in a way that facilitates their individual learning process. The paper argued that, although there has been much study of the human learning process, it has not been leveraged by traditional online course management systems. Nor has there been a much work on a design theory to guide VOLS research. As suggested by Simon(1981), and Walls et al (1992), we feel that the development of rigorous information systems design theory is possible, and should include both meta-design products and meta-design process components—each traceable to the kernel theory.

Another contribution of this paper is its synthesis much of the relevant kernel theory—including decision support systems, organizational issues tracking, learning theory, and vigilant information systems.

This paper provides a starting point for a widely accepted VOLS design theory. Future research could complete the theory by expanding the meta requirements and meta design products so as to include the best ideas from experts in higher education, psychology, sociology, computer science, and information systems. It is hoped that this paper will provide a means for researchers to envision the possibilities of VOLS, and a means to study them systematically.

Especially important will be the integration of new learning objects in today's turbulent open education environment. This research will undoubtedly overlap with the study of knowledge management systems (Alavi & Leidner, 2001), and their interface to online learning systems and to the semantic web (Maedche & Staab, 2001). Also very important will be detailed descriptions of the design process component of a VOLSDT – a subject beyond the scope of this paper. Future research could also examine more precisely how to leverage the cognitive frames of references of all types of VOLS users, not just students. Another line of future research could be the expansion of VOLSDT to include the type of online learning design products other researchers have proposed (For one example see Peiris & Gallupe (2012)). Also needed will be longitudinal research involving building prototype VOLS and then testing them against online learning success criterion such as presented in Holsapple & Lee-Post, 2006).

We hope that this paper has molded existing literature into components of a well-constructed design theory of vigilant online learning systems. These kinds of systems would be designed for the ordinary undergraduate online college student – the student yet to mature into the self-

taught learner that does well with purely online courses. This paper, to the author's knowledge, is the first to address the design of such systems. We hope that it will lead to the construction of systems that will fill some of the vacuum created by college courses absent human instructors.

We feel that purely online courses for the ordinary undergraduate college student will never be as effective as classroom courses led by excellent instructors. However, we think that today's OCMS can be greatly improved, given the right investment. We hope that this paper has contributed at least a small advancement in online course management systems design.

REFERENCES

Ahmad, A., & Lajoie, S. (2001). *The integrated learning model: A design experiment in web-based instruction*. Paper presented at the Artificial Intelligence in Education: Advanced Models for Learning for the Wired and Wireless Future, Amsterdam.

Alavi, M., Leidner, D (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. MIS quarterly, 25(1).

Alavi, M. (1994). Computer-mediated collaborative learning: An empirical evaluation. *MIS Quarterly*, *8*(2), 159–175.

Allen, E. Seaman, J. (2013). Changing Course: Ten Years of Tracking Online Education in the United States, *Sloan Consortium*. Retrieved June 24, 2014 from http://sloanconsortium.org/publications/survey/changing_course_2012,

AACSB (2010). AACSB member schools are increasing online program offerings. In *eNewsline: Management education news from AACSB*. Tampa: AACSB International. Retrieved 7/28/14 from http://enewsline.aacsb.edu/archives/2010/vol9-issue3-datadirect.pdf.

Beck, Robert J. (2009). What Are Learning Objects? *Center for International Education*, University of Wisconsin-Milwaukee,, retrieved 7/25/2014 from http://www4.uwm.edu/cie/learning_objects.cfm?gid=56-10-23

Bohl, O., Schelhase, J., Sengler, R. & Winand, U. (2002). The Sharable Content Object Reference Model (SCORM) – A Critical Review. Paper presented at the *International Conference on Computers in Education (ICCE'02).*

Boulding, K. (1956). *The Image*. Ann Arbor, Michigan: University of Michigan Press.

Bloom, B., Engelhart, M.; Furst, E.; Hill, W, & Krathwohl, D. (1956). Taxonomy of educational objectives: The classification of educational goals. *Handbook 1: Cognitive domain*. New York: David McKay Company.

Bourgeois, J. & Eisenhardt, K. (1988). Strategic decision processes in high velocity environments: four cases in the microcomputer industry. *Management Science*. 34(7), 816-835.

Briggs, J. & Peat, D. (1989). *Turbulent Mirror*. New York: Harper & Row.

Chua, B. & Dyson, L. E. (2004). Applying the ISO 9126 model to the evaluation of e-learning systems. Paper presented at the 21st ASCILITE Conference. Retrieved July 14, 2014 from http://www.ascilite.org.au/conferences/perth04/procs/pdf/chua.pdf.

Codd, E. (1970). A relational model for large shared data banks. *Communications of the ACM,* 13(6), 377-387.

Crosby, P.B. (1979). *Quality Is Free: The Art of Making Quality Certain*. New York: McGraw-Hill.

Demirkan, H., Goul, M., & Gros, M. (2010). A reference model for sustainable e-learning service systems: Experiences with the Joint University/Teradata Consortium. *Decision Sciences Journal of Innovative Education*, *8*(1), 151–189.

Dubin, R. (1978), *Theory Building*. New York: Free Press.

Dutton, J. and J. Webster (1988). Patterns of interest around issues: the role of uncertainty and feasibility. *Academy of Management Journal*. 31(3), 663-675.

El Sawy & Pauchant, T. (1988) Triggers, templates and twitches. *Strategic Management Journal,* 9(1), 455-473.

Flagella, J. (1966). *The Development Psychology of Jean Piaget*. New York: Van Nostrand.

Friedman, T. (2013). The professors' big stage. *NY Times*, Mar. 6. Retrieved 7/27/2014 from http://www.nytimes.com/2013/03/06/opinion/friedman-the-professors-big-stage.html?_r=1&

Goffman. B. (1974). *Frame Analysis*. New York: Harper and Row.

Greeno, J. & Hall, P. (1997). Practicing representation: Learning with and about representational forms. *Phi Delta Kappan*, *78*(5), 361–367.

Grimmelmann, J. 2013. MOOCs over already. *Baltimore Sun*, Dec. 26. Retrieved June 24, 2014 from http://articles.baltimoresun.com/2013-12-26/news/bs-ed-moocs-20131226_1_udacity-courses-moocs-great-courses .

Hall, P. & Greeno, J. (2008). Conceptual learning. In T. Good, (Ed.), *21st Century education: A reference handbook* (pp. 212-221). Thousand Oak, CA: Sage Publications.

Heath. R. & Nelson, R. (1986). *Issues Management: Corporate Public Policymaking in an Information Society.* Beverly Hills, CA.*:* Sage Publications.

Holsapple, C. & Post, L. (2006). Defining, assessing and promoting eLearning success: An information system perspective. *Decision Sciences Journal of Innovative Education*, 4(1).

Huber. G. (1984). The Nature and Design of Post-Industrial Organizations. *Management Science,* 30(8), 928-951.

IEEE. (2005). IEEE Standard for Learning Technology-Extensible Markup Language (XML) Schema Definition Language Binding for Learning Object Metadata. Retrieved 7/25/2014 from http://ieee-sa.centraldesktop.com/ltsc/.

IMS (2007). Learning Resource metadata specification. *IMS Global Learning Consortium*. Retrieved 7/24/2014 from http://www.imsglobal.org/metadata/.

ISO (1991). Information technology-Software Product Evaluation-Quality characteristics and guidelines for their use. *International Organization for Standardization Specification*. Retrieved 7/24/2014 from http://www.cse.dcu.ie/essiscope/sm2/9126ref.html.

Ioannou, A., & Hannafin, R. (2008). Course management systems: Time for users to get what they need. *TechTrends*, 52(1), 46-50.

Ioannou A. & Hannafin. R. (2008). Deficiencies of course management systems, do students care? *The Quarterly Review of Distance Education*, 9(4), 415-425.

Jackson. S. & Dutton, J. (1988). Discerning threats and opportunities. *Administrative Science Quarterly,* 33(3), 370-387.

Jaggars, S. (2006). Online courses in community colleges. *Communication Education, 55* (1). Retrieved 3/14/2013 from http://ccrc.tc.columbia.edu/Online-Education-Instructional-Technology.html.

Juran, J. M. (1988). *Juran on Planning for Quality*. New York: Free Press.

Kim, K. & Bonk, C. (2006). The future of online teaching and learning in higher education: The survey says. *Educause Quarterly, 4*(9), 22–30.

King, W. (1987). Strategic issue management. In W. King and D. Cleland (Ed). *Strategic Planning and Management Handbook*. New York: Van Nostrand Reinhold.

Klein, M. & Methlie, L. (1995). *Knowledge-based decision support systems with application in business 2e*. New York: John Wiley and Sons.

Kolb, D. (1981). [C] *Learning style inventory*. Boston, MA.: McBer and Company.

Kolb, D. (1984). *Experimental learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.

Konak, A., Clark, T. & Nasereddin, M. (2014). Using Kolb's experiential learning cycle to improve student learning in virtual computer laboratories. *Computers & Education* 72(1), 11–22.

Kuhn. T. (1970). *The Structure of Scientific Revolutions.* Chicago. IL: University of Chicago Press.

Lewin, K. (1942). The psychology of learning. In Henry, Nelson B. (Ed.). *The forty-first yearbook of the National Society for the Study of Education: Part II,* (pp. 215-242.). Chicago, IL: University of Chicago Press.

Maedche, A. & Staab, S. (2001). Ontology learning for the semantic web. *IEEE Intelligent systems*, 16(2), 72-79. Washington DC: IEEE Computer Society.

Mason. R. & Mitroff, L. (1981). *Challenging .Strategic Planning Assumptions.* New York: Wiley Publishing.

Minsky, M., (1975). A Framework for Representing Knowledge. In P.H. Winston (Ed.). *The Psychology of Computer Vision*. New York*:* McGraw-Hill.

Molenda, M., & Bichelmeyer, B. (2005). Issues and trends in instructional technology: Slow growth as economy recovers. In Orey, M., McClendon, J, & Branch, R. (Ed.). *Educational media and technology yearbook*. Englewood, CO: Libraries Unlimited.

Nagel, E. (1961). *The Structure of Science. New York:* Harcourt, Brace & World.

Norman, D. *(1982). Learning and Memory*, San Francisco. CA: W. H. Freeman.

O'Droma, M.., Ganchev, I. & McDonnell, F. (2003). Architectural and functional design and evaluation of e-learning VUIS based on the proposed IEEE LTSA reference model. *The Internet and Higher Education*, 6(3), 263-276.

OEDB. (2007). *Online Education Database*. Houston, TX.: Oedb.org. Retrieved 3-1-2013 from http://oedb.org/open/.

Peiris, D. & Gallupe, B. (2012). A conceptual framework for evolving recommender online learning systems. *Decision Sciences Journal of Innovation Education*, 10(3), 389–412.

Pappano, L. (2012). The Year of the MOOC. *NY Times*, Nov. 2. Retrieved 3/29/2013 from http://www.nytimes.com/2012/11/04/education/edlife/massive-open-online-courses-are-multiplying-at-arapid-pace.html?pagewanted=all&_r=0\.

Paulsen, M. F. (2003). Recommender online learning systems. *Online education and learning management systems*. Norway: NKI Forlaget. 412-422.

Perna, L., Perna, A., Ruby, A. Boruch, R., Wan, N., Scull, J. Evans, C. &Ahmad, S. (2013). The Life Cycle of a Million MOOC Users. *University of Pennsylvania*. Retrieved 7/24/2014 from *http://www.gse.upenn.edu/pdf/ahead/perna_ruby_boruch_moocs_dec2013.pdf.*

Piaget, J (1970). *Science of education and the psychology of the child*. New York: Orion Press.

Pondy. L. (1984). Union of rationality and intuition in management action*. In S. Srivastva and Associates (Ed.). *The Executive Mind: New Insights on Managerial Thought and Action. San Francisco. CA:* Jossey-Bass.

Rosenthal, A. (2013). The trouble with online college. *NY Times*, Feb. 19, A 22. Retrieved 7/29/2013 from http://www.nytimes.com/2013/02/19/opinion/the-trouble-with-online-college.html?_r=0.

Schank. R. and R. Abelson (1977). *Scripts, Plans. Goals, and Understanding:* Hillsdale, NJ: Lawrence Erlbaum Associates.

Shrivastava. P. and I. Mitroff (1983). Frames of reference managers use: a study in applied sociology of knowledge. *Advances in Strategic Management.* , 161-182.

Simon, H.A. (1981). *Sciences of the Artificial.* Cambridge, MA: MIT Press.

Simmering, M., & Posey, C. (2009). Computer self-efficacy and motivation to learn in a self-directed online course. *Decision Sciences Journal of Innovative Education*, *7*(1), 99–121.

Sprague, R., & Carlson, E. (1982). *Building Effective Decision Support Systems*. Englewood Cliffs, NJ: Prentice Hall.

Stephenson, J. (2001). Learner-managed learning: An emerging pedagogy for learning online. In J. Stephenson (Ed.), *Teaching & learning online: Pedagogies for New Technologies* (pp. 219–224). London: Kogan Page Ltd.

Teece, D., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal,* 18, 509–533.

Walls, J., Widmeyer, G. & El Sawy, O. (1992). Building an information system design theory for vigilant executive information systems. Information Systems Research, 3(1).

Wang, T. (2007). What strategies are effective for formative assessment in an e-learning environment? *Journal of Computer Assisted Learning*, 23(3), 171–186.