Retrospective and Prospective Images on the Relationship Between Educational Technology and Systems Science

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Abstract

The contribution of systems science is of critical importance as a foundational paradigm and theory, which has extensive influence on the growth of theories and practices of educational technology. While based on systems science, which evolves and develops through convergence and divergence, educational technology, however, does not reflect these changes. This paper reviews the main concepts and theories of systems science as the basis theory of educational technology and explores new methods for the paradigm and methodology of systems science to support educational technology by analyzing and linking educational technology and systems science. One of the major implications of systems science is that educational technology deals with a variety of educational and systems, and each system is unique. Based on this, one alternative direction that educational technology suggests is that, although it has provided solutions to resolve current problems, it should develop to the point where it is able to construct preventative measures in the future.

Keywords: educational technology, systems science, multimedia, cyberspace, constructivism

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I. Introduction

Systems science has served as a foundation and paradigm for the development and growth of educational technology. Systems science, the parent theory, has undergone various changes and developments with criticism and self-reflection; however, educational technology has been criticized for its lack of growth and self-reflection. This self-reflection, depending solely on the systems paradigm and methodologies of early behavioral sciences and absolutism, can serve the current educational technology as a catalyst for the growth of educational technology. It is high time to review the existing paradigms, theories and methodologies that underpin the very foundation of systems science, and this should be linked to voluntary changes within educational technology. Through this, educational technology will be able to interact with the very root of its origin, receiving fresh insights and possibilities. This paper explores the methods in which systems science can effectively support the growth of educational technology by 1) reviewing the special qualities of systems science as a basis theory of educational technology, 2) examining the major theories and concepts of systems science and 3) analyzing the current educational technology in relation to the systems science paradigm.

II. Review of the Systems Paradigm of Educational Technology

Systems science has been applied to educational technology since the 1950s (Saettler, 1990; Finn, 1956; Finn, 1965; Seels & Richey, 1994). Great increases in language labs, programmed instruction, the simultaneous use of various media, and instructional computers in the '50s and '60s gave birth to systems approaches that focus on integrated systems and processes. In the 1960s, the "total systems approach" was coined to explain interaction between human beings and machinery in organization theory (Saettler, 1990).

In the 1970s the Association for Educational Communications & Technology (AECT) defined educational technology as a systematic method that designs, executes and
evaluates the whole process of learning and instruction according to specific learning
goals based on human learning and communication theories (Commission on Instructional
and AECT (1972) value the word, systematic, as a major concept of educational
technology, and it is the most common word in their definitions. Ely (1973) also
pointed out that a systematic approach, a study of means, and a field directed toward
some purpose are the three core concepts in the various definitions of educational
technology. It is clear that early educational technology with systems approach's
adaptation was in line with absolute and recursive characteristics that pursue structural,
analytical and stage approaches.

Since the 1970s, the term, systems approach has been used to explain procedures
reflecting goals and means perspectives with heavy links to linear and behavioral
concepts in instructional systems design and development and educational planning. As a
result, numerous people in the educational technology circle considered the term as a
systematic, anti-creative and a mechanical approach that enables easier management of
projects (Romiszowski, 1996). This systems approach is a practical methodology with
strong systematic and phase characteristics, and it has served as a concrete model,
especially in the area of instructional system design. The most popular model is that of
Dick and Carey.

Some systems scientists, such as Banathy, advocated systemic perspective, systemic
philosophy, systemic research and systemic methodology by suggesting an instructional
systems design that embodies expansionism and active, non-linear, synthesis-orientation
and holistic mode thinking, rather than classic scientific thinking of an analytic,
restorative and linear causality approach. However, practical philosophers in particular
within the educational technology circle have considered this model as an excessively
complicated model without practicality. As a result, this model never became part of the
educational technology mainstream.

According to the definition and area of educational technology, as recently recognized by
AECT, the design area of educational technology evolved from instructional psychology through the adaptation of systems theory into the instructional systems design area. Design in this context is defined as follows. Design embodies both systemic approach (macro level) and each step within it (micro level). ISD is a typically linear and reoccurring process that demands consistency and completeness at every stage. In ISD, process is as important as outcome since the validity of the outcome depends on the process (Seels & Richey, 1994).

Even the latest definitions reiterate the importance of process, stage, linear aspect, recurrence, completeness, consistency and balance, signaling a focus on analytical, closed and determinist methodology rather than on general systems theory of wholeness, dynamic interaction, self-control and openness.

Saettler (1990) points out that Gagne and Briggs's instructional systems model and other models are not or rarely related to general systems theory, but that the assumptions and provided processes are 'guidelines or tips' more related to instructional design and system analysis than to instructional 'systems' design. Yet, according to Saettler, educational technologists and curriculum designers are trying to rationalize their program design approaches with general systems theories.

III. System Science

Systems inquiry is valued as a study that introduced new thinking, overhauling the classic science paradigms of analytical thinking, reductionism, and determinism. Systems paradigms embody synthetic thinking, emergence, communication and control, expansionism, and teleology. First, synthetic thinking conceptualizes the object (system) of understanding as a part of a bigger whole comprised with one or more parts, not as a whole that should be divided to be understood. Second, another new concept brought by systems inquiry is expansionism, as an alternative for reductionism, and this suggests that ultimate understanding is not something palpable but an ideal stage to which learners
can get continuously closer. Continuous progress toward ultimate understanding is
decided by the scope of understanding on a bigger and more comprehensive whole.

Third, the idea of non-deterministic causality (Singer, 1959) developed subjective teleology -
a conceptual system in which teleological concepts, such as free will, free choice, free
function and free intention can be functionally defined and integrated in science
(Cavallo, 1979).

Romiszowski (1981) points out that systems approach has evolved from general systems
theory and cybernetics as a creative and heuristic approach in understanding and
improving complicated and probable systems. The following section will review: 1) how
much the current educational technology reflects systems theory, 2) how much the gap
exists between these two areas, and 3) the possibility of integration by studying
important theories that seem to be related to current educational technology among
other various trends in systems studies.

1. General Systems Theory

As previously mentioned, many researchers have reviewed the validity of numerous
traditional instructional systems models, including models of Gagne & Briggs and Dick &
Carey in relation to General Systems Theory (GST). However, studying the paradigms
and core concepts of GST makes it clear that these models are not or rarely related to
GST but are related only to part of it to some extent, such as wholeness, negative
feedback and boundary concepts.

Biologist Ludwig Von Bertalanffy realized the limitation of reductionistic scientism and
introduced GST as an inter-discipline focused on wholeness and dynamic interactions.
He is one of the scientists who paid early attention to the difference between closed
systems and open systems. Differentiation of open/closed systems has served as a
foundation for systemic thinking and has been helpful for the paradigm shift away from
the absolutism of Newtonian science. Since this development, GST has served as a
foundation for various systems theories and methodologies and has evolved and expanded
into various philosophies, theories and methodologies in numerous academic areas. Soft systems theory with strong characteristics of methodology developed basic philosophy and theories of GST into a concrete solution for problems of Human Activity Systems (HASs). GST gave birth to the following concepts that define the essential characteristics of systems.

1) Wholeness
Systems developed by organic creatures and human beings are unified wholes with integrated and sustaining rules and regulations. Properties of a system are not the simple sum of subsystems or sub-elements but those of the whole system. For example, a human being has a heart, hands and feet, but what defines a human being as a living organism is not each organ but the integrated whole system. Identities and functionality of social systems, such as family, learning community and enterprise can be understood as a holistic entity, not as an independent and separate concept.

2) Openness and Boundary
Organisms including the universe, mankind and living creatures as well as systems made by human beings do not exist in a closed universe. They can exist without falling apart into pieces because they have the ability to exchange information, energy, and substances with their environment through permeable boundaries. One conceptual method of this boundary is to perceive the point of structural change as a distinctive boundary between one system and its outside environment or sub-elements and other elements within a system. This conceptualization implies that the outside structures of energy, substance and information are significantly different from the inside structure.

3) Dynamics
Systems function has a generic characteristic of emergence, since each part of a system interacts with at least one of the others. In other words, systems function because of interaction among parts and not because of specific parts or subcategories. Changes within an organization depend on interactions and structural relations of subgroups, not on individuals. It is also a characteristic of GST that conceptualizes systems dynamics in relation to inter-connectivity.
4) Feedback
The prerequisite for system feedback is that there are two different types of feedback: negative and positive. Negative feedback corrects systems to return within the radius accepted by a controlling mechanism when the system deviates from self-determined or programmed objectives or status. Through this mechanism, negative feedback redirects or reverts the changes, thereby maintaining equilibrium or stabilizing the system. Negative feedback encourages more stable, adaptive and goal-oriented systems. For instance, it maintains temperatures or stable speed. Positive feedback guides the system to the changing direction of output (the current status), thereby maintaining growth or reduction. As a result, the loop of positive feedback makes the system depart from the previous status or equilibrium and, if this positive feedback remains unaddressed, can bring about the destruction of the system.

5) Interconnectivity
The perspective that everything is interconnected suggests that every system is not isolated but interdependent and interconnected and that the causalities are often not linear. More extreme GST argues that the system evolves as a result of interaction with its environment and co-evolves with the environment due to its generic characteristic of interconnectivity. It means that the environment changes due to interaction with its sub-elements. Banathy (1991), Gareth Morgan (1986) and Birch (1990) are some of those who advocated the co-evolution of systems.

6) Equifinality
Equifinality is a system's ability to ensure that systems reach the same end, even with different starting points and different methods (Bertalanffy, 1956). Equifinality implies that systems are moving toward a common goal, and it is adoptive since it has self-regulation and autopoiesis. Moreover, it has significant meaning in the management of human beings and organizations. Equifinality also suggests that there cannot be one single correct way but that there can be various right ways, depending on the changing conditions of the environment. Therefore, prescribing a single strategy or method to achieve specific goals and excessive adherence to that method would not be efficient.
2. Soft Systems Theory

Unlike hard systems theory with systems engineering and operations research for the resolution of technical issues, soft systems theory views human systems and social systems as a soft system. In particular, the distinction between hard systems and soft systems seems to be related to the work of Checkland and Churchman. These two researchers suggest theories and approaches for dealing with human activity systems (HASs) in which any output cannot be predicted, and factors outside the designer's control can emerge in the inner system, within the framework of soft systems concepts.

1) Soft Systems Methodology (SSM)
Checkland argues that natural science methodologies cannot be applied to ill-structured issues and further suggests a systems methodology called CATWOE to study soft systems. CATWOE considers sub-elements, such as customers, actors, transformation processes, weltranschauung, owners, and its environmental constraints in studying issues. As it is well proclaimed in this model, basic conditions of soft systems theory are sustained and iterative methodologies and directions of changes and execution are set by stakeholders' various views and values through dialogues and discussions.

2) Systems Design
Banathy is one of the strong advocates who view soft systems theory and its methodology as the most ideal educational planning and instructional system design. Emerging design inquiry seems to be dynamic and wholistic; iterative and integrative; spiral and interactive; participative, dialogue-oriented and consensual (Banathy, 1987, P95). His systems methodology is a spiral design with a use-designer approach (Banathy, 1987; Banathy, 1991; Lee, 1995).

The concept of 'user = designer' is based on the belief that systems can be most successful, executable and productive and that the commitment for execution is the most binding force if it is managed by future users of the system. The spiral design model has four serial spirals that go through the 'design solving space', the 'knowledge base',
and the 'design evaluation space' of system inquiry (Figure 1). The first spiral focuses on the core definition of the system, the second spiral is the development of specifications for the future systems, the third spiral is the ideal system design for functions, and the fourth spiral is the systems design that provides the ability to implement systems and human abilities to the functions. A series of questions are exteriorized in relation to each spiral, and these questions are essential tasks and programs for inquiry. Arrows on the spiral are for both sides, since inquiry is both feedforward and feedback. Regardless of when it is completed in the course of systems inquiry, design can have an impact on what we did earlier and reformulate previously developed solutions. At the same time, systems pertain to feedforward, since they provide the foundation for selection of specific designs with continuous inquiry. In addition, each spiral is composed of various decision/choice points where alternatives are generated and reviewed (Banathy, 1991; Lee, 1995).

Banathy (1998) suggested that HASs, such as family, learning systems, instructional systems and educational systems have five different types of systems based on (1) closeness and openness, (2) simplicity and complexity, (3) mechanical and systemic characteristics, and (4) unitary and pluralistic objectives. First, a closed system is a system with limited and a well-defined interaction with its environment and operates within a well-defined protected space. An open system does not mean it is entirely open without boundary; rather, it has significant interactions and exchanges with its environment. Second, a restricted system has very few clearly defined variables and a small number of decision-making levels. A complicated system has a large number of variables, sub-elements and multiple decision-making levels. Third, a mechanical system has parts containing prior importance, and it operates in stable and fixed relations. A systemic system has dynamic relations among its sub-elements. Interaction and results of this interaction of this system are the most important characteristics of the system. Fourth, a unitary system has clearly defined intentions and objectives. A pluralistic system has various intentions and objectives and conflicts among them.

The combination of these four dimensions can lead to five different types of systems: (1)
rigidly controlled systems, (2) deterministic systems, (3) purposive systems, (4) heuristic systems and (5) purpose seeking systems (Banathy, 1991). First, rigidly controlled systems are closed with restricted and well-controlled interaction with its environment. These systems have a single intention, clearly defined objectives and operate mechanically. They do not have room for self-direction. Second, deterministic systems are unitary since they are open to their environment but still have stronger characteristics of closeness and clearly defined objectives. Human beings in this system have limited freedom in the system operation and methods; therefore, this system is less mechanical. It has a few different decision-making levels and is therefore a bit complicated. Relations among sub-elements can experience small numbers of minor changes. Third, purposive systems are still unitary with defined objectives, but they have freedom of choice for functional objectives and methods. Changes of this system are gradual and affected by its environment, and it therefore sits in the middle in terms of openness compared to other systems. It has multiple hierarchies, being complicated and systemic, and top-down control. Fourth, heuristic systems are more or less pluralistic since they decide their own goals under the general guideline. They are open to changes based on the interaction with their environment and often generate these changes. Basic characteristics of their structured inner arrangements and operations are complicated and systemic. Lastly, purpose-seeking systems are ideal-seeking, directed according to their visions of the future. They are open and have the capability to co-evolve with the environment as a partner. They are complicated, systemic, and pluralistic since they define their policies and intentions and continuously explore new goals and activity boundaries within the environment.

3. Cybernetic Theory

Cybernetics is a stream of systems theory and has evolved through first-order cybernetics and second-order cybernetics. Cybernetics has the closest connection with educational technology among various system theories (Winn, 1975). It is a mechanism of early cybernetics system control with a feedback concept. In particular, second-order cybernetics provides strong supporting concepts to a constructivistic position (Bopry, 1999). It is
shown in <Table 1. Complimentary Focus of First-order and Second-order Cybernetics (Bai, 1999)>
that the two streams of cybernetics have different but complimentary perspectives.

1) **First-order Cybernetics**
First-order cybernetics is a perspective of using feedback as a controlling mechanism. This perspective quantifies information, considering that it moves from one place to another and ignores the contents, meaning, and intention of the information (Gleick, 1987). First-order cybernetics deals with systems issues through technical rationality based on traditional objectivism and absolutism. First-order cybernetists stands in a position to observe phenomenon and suppose that descriptions of what they describe about the phenomenon are those about their experiences with the phenomenon. As a result, systems are objects to be observed. This perspective is interested in internal communication and control, and it focuses on a causal feedback mechanism with a cyclical process of self-organization and self-regulation. This principle has laid the foundation for computer/cognitive science and is viewed as the neural network approach in computer science.

2) **Second-order Cybernetics**
Foerster (1984) coined the word second-order cybernetics. First-order cybernetics focuses on
feedback while second-order cybernetics on reflexivity; therefore, the latter tries to understand and solve phenomena through their relations with other systems. Second-order cybernetists include themselves as a part of phenomena and systems to be observed (Foerster, 1972). Therefore, this perspective leads us to consider that context, contents, meaning and intention of information are at the center of the observance, thus reiterating the importance of language, culture and communication as analysis methods in order to observe and describe the phenomenon. Second-order cybernetics tries to inquire about the meaning of cognition and communication through the concept of self-reference in the natural sciences, social sciences, the humanities, information sciences, and social practice areas such as design, education, organization, art, management and politics.

2) Autopoiesis Theory

Autopoiesis theory, coined by Maturana and Varela, is a type of second-order cybernetics. It explains the essential qualities of living systems in contrast to non-living systems. It is a complex and delicate theory, which explains cognition, self-consciousness, language, human behaviors, and living systems as the entity experiencing continuous autopoiesis processes (Luhmann, 1995). Autopoiesis systems are autonomic since they do not depend on an external production process and have a characteristic of self-reference due to self-defined structure (Mingers, 1997). Autopoiesis theory explains the importance of relations, meaning and communication of systems through the concept of structural coupling.

3) Structural Coupling

Structural coupling is the coexisting relationship with structural interaction between two systems or between me system and its environment. This relationship occurs when these systems experience iterative interaction within the environment while maintaining their identities (Mingers, 1997). All social systems have structural coupling among their organisms that fine-tune their behaviors with other systems, human social systems, such as family. Within these systems, regular patterns of behavior are manifested through structural coupling of system members (Mingers, 1997), and the formations of harmonious relations, i.e. consensual domain, are possible through communication via language or
other linguistic behaviors.

4) Meaning and Communication
When social systems are viewed as a structural pattern of behaviors (Luhmann, 1995), a social system has to make choices to survive and grow within its complex structure. This process of choice is affected by various factors. However, it makes decisions as an autonomous body. This decision-making enables a system to construct an independent meaning itself. A social system, also called as system of sense, communicates with other systems by assimilating their meanings, that is, by sharing the method for reducing the complexity of each sub-element or system. Systems sometimes communicate in order to reinforce their accumulated sense, to replace the existing meanings or to adapt themselves to the environment. This method leads systems to be more complicated, thereby making them more differentiated from their environments (Bausch, 1997).

5) Self-reflection
Systems become more flexible as their internal complexities increase, so that they better recognize the contingency of choices. As a result, systems start learning not only about themselves but also about their environments and, as time goes, use this self-reflection and self-examination capability to devise sub-systems that are controlled by themselves to deal with environment.

IV. Implications of Systems Science

Although systems science has grown and developed with an evolutionary manner through conversion and diversion since the 1960s, educational technology has lacked reflection of these changes and growth. Comparison approaches, such as systemic vs. systematic and hard system vs. soft system, on which the educational technology society puts great emphasis, do not hold significant meanings anymore. The presiding systems approach of educational technology reflects a linear and goals-means approach related to absolutism and behaviorism and does so in instructional systems design in particular.
Romiszowski (1996) pointed out that systems technology lost its popularity in educational technology and experienced misunderstandings in the 1980s.

Reviewing concepts and terms of systems science that have been applied to educational technology raises a question about whether system theory, particularly general system theory, has actually served as the pillar of educational technology and whether it is fully understood or not. If systems science is the foundation of educational technology, the educational technology academic should be more adoptive to the development of system paradigms and methodologies and should use that theoretical development as the basis for practices of educational technology. Fortunately, faced with a variety of changes, educational technology, especially the ISD area, is showing signs of changes and self-reflection (Wilson, 1997; Wilson, 1999; Ritchie and Earnest, 1999). It airs a voice of reconsideration to present new directions at least in three areas.

(1) Excessive inclination to determinism: traditional instructional systems design models widely accepted and utilized are linear, based on behaviorism and reflecting goals-means approaches. These models are overly simplified and thus lack flexibility (Saettler, 1990; Richey, 1995). Instructional systems design theories and their models based on rational and 'mechanical rationales' (Schon, 1987) imply problems of not appropriately reflecting the design process of expert instructional systems designers. Experts are highly flexible and very adaptive in application of their knowledge to real problems (Nelson, Magliaro & Sherman, 1988; Nelson & Orey, 1991; Thiagarajan, 1976). They do not simply apply formulated theories but develop their own models by discarding unnecessary factors with their own discretion and synthesizing models and ideas (Tessmer & Wedman, 1992; Wedman & Tessmer, 1990). Then, instructional systems design theories with their prescription adherence to design procedures and final products are conceptually cornered.

(2) Gap with context: instructional systems design theories and models are traditionally based on the perspectives that learning becomes most efficient when a learner is trained away from daily business and tasks. In addition, instructional systems design models sometimes do not reflect how training is designed and developed in the 'real world'
(Dick, 1995). Instructional systems development should be more responsive to market demands. Gustafson (1991) and other researchers suggested difficulties in applying standardized instructional systems design models to school environments and pointed out the need for models based on differences between schools and enterprises.

(3) Excessive process orientation: learning principles and theories have always been integrated into traditional micro design models, such as Gagne's learning events and Merrill's CDT, and have been recommended to be grafted to instructional systems design methods. However, many experts have expressed their concerns over the typical tendency of those instructional designers who stress the general design 'process' as emphasized in design models but overlook the implementation of learning principles (Winn, 1989).

Systems theory experienced a loss of recognition in the 1980s, but fortunately made a strong rebound in the 1990s. There are some movements to adopt system theories and systemic thinking as a macro solution to educational problems (Banathy, 1991; Reigeluth, 1988, 1992; Lee, 1995; Lee, 1995) and adopt systems theory as a methodology to support constructivistic learning environment systems design and hypermedia and cyber educational systems design.

Romiszowski (1996) suggested the following important roles of systemic approach in the above areas. Systemic perspectives of cybernetics make it possible to understand the complexity of real problems related to all the endeavors of restructuring and innovation and to present clear visions. Meanwhile, from the perspective of constructivism, instructional systems design has shifted its focus to knowledge-base creation that can be commonly used under the learner's control from teacher's control due to the multiplicity of learners' intentions and capabilities. Its focus shift to systemic analysis of knowledge structure should also be considered. In particular, hypertext-based knowledge-base creation is a task that depends on highly sophisticated systemic thinking.

V. Systemic Characteristics of Multimedia and Cyberspace
There are increasing demands for educational technology to deal with ill-defined problems and highly open systems, such as design, operation and evaluation of hypermedia and cyber educational systems. As a result, analyzing system types and applying interventions and methodologies appropriate to the types are in our field.

Cyberspace has its unique characteristics. Openness, time-space independence and multiplicity are some of the important characteristics that command our attention. Multimedia applications provide users with endless paths and variations and massive information. Compared with the web, however, they are relatively closed systems. Their scope for storage capacity is limited; thus, multimedia applications contain only what designers provide. As a result, learners have freedom to navigate within the multimedia environment, but each of their choices is predetermined by the designers. Unlike multimedia, applications in cyberspace are not stand-alone but open systems that can be indefinitely linked according to multiple intentions and situations of users. In general, designers cannot make users take specific paths to materials in cyberspace that they designed and provided, and users can have direct access to any page in cyberspace. In addition, it is not possible for designers to predict who future users will be and how they will make use of these materials.

In cyberspace, users can create links to other sites that designers have not originally intended, and it has became easier to share, develop and access information due to the intrinsic qualities of cyberspace which transcends time and space. Functions of supporting many-to-many communication through listservs, discussion groups and conferencing can create social systems for learning and, ultimately, enable us to realize collaborative learning and group dynamics.

Information and structures are easily changed in cyberspace. In the case of the web, different types, versions and configurations of browsers can generate web pages with very different appearances independently from designers' intentions, and the contents of the web are potentially indefinite (Jones & Farquhar, 1997). Cyberspace is a communication tool for people with common interests, and this function can be very useful in
educational and academic activities, such as performing cooperative learning activities, inviting experts into cyberspace and holding seminars. Community building is a basic attribute of cyberspace that can serve as the foundation for cyber education theories, design and implementation. The function of supporting many-to-many communication allows equal opportunities for everyone to express opinions in an open structural environment; on the contrary, however, it has the potential of creating messages and as a result chaos.

According to the system types suggested by Banathy, cyberspace seems to have the qualities of most heuristic and purpose-seeking systems. It is a complex and pluralistic system with the nature of wholeness, openness, dynamics, interconnectivity, equifinality, positive feedback, feedforward, morphogenesis, development, self-adaptation, autopoiesis, cooperation, learning and communication. Members in this system build their own meanings by exchanging information through language. That is, they operate as an autonomic entity that constructs knowledge.

Highly complex and open structures of multimedia and particularly cyberspace demand overhauling traditional learning and instructional theories of absolutism. This is because the characteristics of relativity, transformation, connectivity, interaction, uniqueness and non-formality, and digital are overwhelmingly too strong to be understood and supported by traditional paradigms and theories. Therefore, it commands alternative methodologies, paradigms and theories that can properly interpret these phenomena. As Romiszowski (1996) suggested, creation of a hypertext knowledge-base depends on a high level of systemic thinking to analyze structures of specific knowledge domains, to design appropriate methods representing those structures into database, and to enable various future utilization to get maximum benefits from the current design output. The distance education experts, Bates (1996) and Moore and Kearsley (1996), have pursued theories and implementation based on systems approach, perhaps because they understand the enormous influence of system characteristics of cyberspace. As the space for distance education becomes more like complex social systems, deep understanding of system perspectives and theories will become an inevitable task of educational technology.
Jones and Farquhar (1997) understand that the openness of web significantly affects design principles, thus making design extremely difficult. Unlike the design of basically close systems - for example, traditional instructional design or stand-alone application design - the web inevitably relinquishes a significant part of empowerment that used to be in the hands of instructional designers to users. They classified the loss of control in terms of technical control and curriculum control.

Loss of technical control: Users' hardware qualities related to displays, such as monitors and screen control functions and capabilities, regardless of software qualities. Log-on speed and reliability can also bring about significant limitations to most of the users. Materials can be displayed in different ways and navigation can be affected as well, according to the software installed by users. Users can control user environments, such as window sizes, fonts and types, and background colors, at their discretion based on their browsers. In the web environment, almost every control that used to belong to the designers lie in the hands of users.

Loss of curriculum control: Users in an open system like the web have more autonomy in utilizing information. The most significant freedom for the users in the hypermedia environment is of sequencing information. The ultimate pursuit of hypermedia is eliminating restrictive, linear and designer-driven sequences to allow user-driven sequencing.

VI. Systemic Characteristics of Constructivism

The rise of constructivism in educational technology laid a foundation for better understanding of basic concepts and philosophy of systems science. Constructivism is a learning theory that does not provide necessary methodologies to directly challenge mechanical design perspectives and implementation trends that have dominated this academia and resolve problems. Constructivistic learning theories themselves cannot provide practical solutions to various problems that require design decisions. For example, what kinds of decisions can be made based on what standards for a learning community
in which values among learners are extremely conflicting? If learning materials are extremely transformative, how can we provide them to learners so that they can utilize these materials? System approaches and methodologies will be able to emerge as practical solutions, which enable constructivistic learning theories to realize substantial roles in educational systems.

Constructivism enhances interest in the learning environment, learning community design, learner-centered instructional theories and ill-defined learning domains, thus increasing the need for theories which design these systems. Bopry (1999) and Knuth and Cunningham (1993) discussed the characteristics of constructivistic design based on systems approach. Intrinsic qualities of learning and learning communities based on constructivism can be categorized as follows (Lee, 1996).

Bopry (1999) discussed the implications of autonomous systems theory, one stream of second-order cybernetics theories in educational technology, particularly in practice of constructivistic educational technology. She took the main concepts of second-order cybernetics which include (1) structural determination, (2) structural coupling, (3) effective action and (4) organizational closure and suggested them as concepts supporting constructivistic educational design.

Knuth and Cunningham (1993) designed the following seven principles based on the hypothesis that learners are observing systems with structural determination, informational closure, and structural coupling. (1) All knowledge is constructed and learners relatively experience its constructedness. (2) Multiple worlds are possible; thus multiple perspectives are possible. (3) Knowledge is an effective action and a process. (4) Learning is embedded in the structural coupling. (5) Knowledge is not dependent on signs, which are languages. (6) Worldviews can be inquired and changed through tools and means. (7) Our knowing about how to know is the most ultimate human achievement.

Instructional design or educational design in a constructivistic context should be considered as designing complex social systems as a learning community, structured by various main and supporting elements, rather than simple instructional programs design. When
understanding various natures which emerge for a social systems as a complex of various components learning to maintain and grow, people better appreciate that systems theory can provide basic concepts and methodologies for design, such as dialogue, languages and culture that are necessary to optimize learning.

VII. New Direction for Educational Technology

This paper reviewed the main streams of systems science and constructivism and multimedia environments that are gaining more weight in educational technology in relation to systems science. The results suggest that systems science still, or even more so, provides essential perspectives and methodologies to educational technology. The most meaningful insight enabled by systems science is that educational technology has various types of educational situations and that each system is unique. Therefore, various methodologies and tools appropriate for various system types should be considered; for this, macro knowledge base should be created and shared within educational technology society. Based on these lessons from systems science, new alternative directions for educational technology can be suggested as below. The essence of the new direction is that educational technology has so far pursued prescriptions to resolve educational issues and problems; from now, however, it should pursue proscription (that is, design).

1. Situation-specific problem-solving methods and design should be pursued.

Systems' uniqueness suggests that educational systems and instructional systems design should be created within each community; that is, situation-specific. Each community is unique, and thus each needs a unique design; therefore, one design created within a specific community cannot be transferred to another community without reflection and alterations. Fortunately, there have been substantial efforts to better understand the influence of 'situations' and develop theories and models for instructional systems design in accordance with this uniqueness. In particular, constructivist psychology features the fact that learning process and knowledge construction is determined by generic
characteristics of the environments where the learners belong. Learning environments include all physical, situational and human factors that may influence learners' learning and performance after it (Vazquez-Abad & Winer, 1992).

Systems approach pursuing situation-specific designs considers dynamics of broader contexts and is more independent from design procedures and more creativity (Banathy, 1987; Romiszowski, 1981; Rowland, 1993). As a result, it enables a more flexible design. R2D2 model (Recursive, Reflective Design and Development Model) (Willis, 1995) introduced as an alternative instructional systems design model can be acknowledged as an effort to enhance the possibility of situation-specific designs by pursuing recursive and non-linear design process.

2. Design approaches and methodologies and tools suitable for the target system types should be selected.

Based on the perspectives that each system is unique, specific systems techniques and methodologies should be suggested to deal with the problems emerging in different types of systems. Flood & Jackson (1991), for example, recommended taking operation research, systems analysis or systems engineering for simple-unitary situations and taking interactive plans and soft systems methodology for complex-pluralistic situations. They also suggested Banathy's design methodology for purpose-seeking systems and heuristic systems based on Banathy's classification. But they argued that design methodology is not suitable for coercive systems where their subsystems do not share common interests, conflict in values, and disable genuine agreements do not agree in means and goals. I agree with this argument, since Banathy's design methodology is based on a very idealistic systems approach which lacks conceptual and methodological considerations, system factors with conflict and power dynamics. Methodologies of second-order cybernetics should provide valuable approaches to development and operation of either multimedia and cyberspace based learning systems or highly learners-directed open systems.
3. Expansion of participatory design and organizational learning abilities for
design should be pursued.

When all stakeholders in instruction and learning systems are considered to be learners,
breaking away from fragmentary and traditional perspective of a learner pertains
significant importance in learning systems design. In order to design human activity
systems, like learning and instructional systems through participatory (user = designer)
design approach, even capability development of organization is needed. Individual and
group capabilities for design are prerequisites for design performance, and they includes
design thinking and abilities of using appropriate approaches, methods and tools
(Banathy, 1991; Lee, 1995).

4. Pluralistic design approaches should be pursued.

Systems approaches provide a pluralistic perspective of "and/ both", rather than a unitary
perspectives of "either/or". Since a variety of solutions are possible depending on
changing conditions of the environment, there is no need to prescribe a single strategy
or method and excessively adhere to the execution of this prescription. Banathy reminds
us that if a systems design should occur within an existing system context, we cannot
put the effort solely on redesigning it while giving up on the existing system. Rather,
he argues that we also need to pay attention to 'here and now' interests so that the
current system can enhance its efficiency and effectiveness.

VIII. Concluding Remarks

Educational technology demands designs based on learning perspectives, social systems
designs for human learning, rather than designs based on instructional perspectives.
Now we can find the real value of educational technology, no longer in instructional
design, but in creating a supporting environment for learners to construct their own
knowledge; this design task is a really structured problems, which are fundamentally
open system problems. Then, educational design, as suggested by Bopry (1999), will be a more appropriate term than instructional design. In-depth understanding of system theories can provide powerful methodologies for educational technology to resolve learning and education problems which are ill-defined and complex. That is because system perspectives and methodologies provide foundations needed for defining nature which educational technology should deal with and for considering interventions appropriate to their nature. More specifically, they identify the natures and functions of sub-elements and provide support for human learning system designs in the future.

However, it should be made clear that we should break away from the traditional practice of adhering to 'systematic' and 'systemic' comparison. The main streams of systems science is not much involved in comparison between systematic and systemic characteristics of a system; rather we should understand system types based on systemic concept according to the combination of different variables, and suggest methodologies suitable to each unique system type. As previously discussed in the section 'New Direction for Educational Technology', it will be desirable to focus our efforts on identifying system types and solving problems through methodologies suitable to those types.

References


Pennsylvania Press.


