

**EDUCATIONAL TECHNOLOGY
KNOWLEDGE ASSESSMENT**

Editor
Marmar Mukhopadhyay



- of the National Society for the Study of Education, Part I. Chicago: University of Chicago Press, 1964.
- Radhakrishnan, S., *The Principal Upanshihuds*. New Delhi: Harper Collins, 1998.
- Reiser, R.A., The concept and evolution of educational technology, in Gagne, R.M. (ed) *"Instructional Technology: Foundation" Foundations* Lawrence Erlbaum Associates Publishers, London, 1987.
- Reiser, Robert A., *Instructional Technology: A History* in Gagne Robert M. (ed.), *Instructional Technology: Foundations* Lawrence Erlbaum Associates Publishers, London, 1987.
- Saettler, P., *A history of instructional technology*. New York: McGraw-Hill 1968.
- Singh, L.C. and Jaimini, N., *Teaching Strategies*, in NCERT, *Fifth Survey of Research in Education*, New Delhi: NCERT, 1997.
- Stakenas R.G, Kaufman R., *Technology in Education: Its Human Potential*, Phi Delta Kappa, 1981.
- Strain, J., *Pathways to a Profession Designing Instruction for Instructional Designers*, In Parer, M.S., *Unlocking Open Learning*, Victoria: Monash University, 1994.
- UNESCO, *Learning: The Treasure Within*, Paris: UNESCO, 1996
- Van Patten, J., *What is Instructional Design*, in Johnson, K.A. and Foa, L.J. *Instructional Design: New Alternatives for Effective Education and Training*. New York, Macmillan, 1989.

Instructional Systems Design

CHARLES M. REIGELUTH and B.J. BEATTY

What is Instructional Systems Design?

"Instruction" is defined broadly as anything that intentionally facilitates human learning and development of any kind, including that which facilitates a learner's construction of knowledge—instruction subsumes construction. "Design" is a process whereby instruction is brought into being. And "systems" conveys two meanings: (1) that instruction should be viewed as a system and (2) that a systems approach should be used to design instruction. Therefore, instructional systems design is a field dedicated to helping people to do a better job of facilitating human learning and development of all kinds. To fulfill this mission, its knowledge base addresses both process and product (or means and ends) for facilitating human learning and development

The product knowledge base is concerned with what the instruction should be like as it unfolds with the learner. This is referred to as instructional design theory. The process knowledge base is concerned with how instruction should be planned and instructional resources developed prior to its occurrence with learners. It includes knowledge about such activities as analysis, design, development, implementation, and evaluation (Gagnóe & Briggs, 1974; Dick & Carey, 1996). The process knowledge base has been described extensively elsewhere (see e.g., Gustafson & Branch, 1997) and will not be addressed here. Rather, this chapter will provide an overview of what instructional theory is and what sorts of changes it is currently undergoing.

Department of Education, Indiana University, USA.

Descriptive vs. Design Theory

Most educational research studies focus on descriptive knowledge: describing the learning process, instructional process, or outcomes that result from the use of an instructional process. Unfortunately, this kind of knowledge is not directly useful to teachers and other instructional designers, who are interested in knowing what methods of instruction to use in a particular situation. This kind of goal-oriented knowledge is called design science (Simon, 1969) or design theory (Reigeluth, 1983; 1999) and is generated through decision-oriented inquiry (Cronbach & Suppes, 1969) and formative research (Reigeluth & Frick, 1999), in which the major criterion is preferability rather than validity.

Instructional design theory offers methods of instruction that will be most likely to foster the desired learning outcomes in different situations. These methods are not 100 per cent guaranteed to result in the desired outcomes, but they have been found effective in similar situations. There are several important aspects of the instructional situation that may influence which methods will work best. One is values or philosophy about learning and instruction. Values can concern either the content (goals) or the methods (means) of instruction. If an educator designing instruction for a history course values learning community, for example, s/he is likely to choose instructional methods that draw students together to collaborate. If an educator values self-regulated learning, s/he is likely to choose methods that emphasize self-awareness, self-control, self-evaluation, and goal setting. Some instructional methods may be effective for multiple sets of values and goals, but typically a method is consistent with one particular set of values. Thus, it is important for a design theory to include a statement of the values upon which it is based.

A second important aspect of the instructional situation to consider when choosing methods is the desired outcomes. It is helpful to think in terms of two kinds of outcomes. Learning outcomes represent what is being learned, whereas instructional outcomes represent criteria for judging how good

the instruction is. Regarding learning outcomes, different types of learning are often best fostered by different types of instructional methods. Therefore, learning outcomes (or goals) are an important basis for selecting methods. Instructional outcomes fall into three categories: effectiveness, efficiency, and appeal (Reigeluth & Merrill, 1979). In many cases, one method may be the most effective but not the most efficient or appealing, and so on. Therefore, the desired instructional outcomes are also important for selecting methods.

A third aspect of the instructional situation is the conditions under which a method will likely work better than other methods. Conditions are beyond the control of a teacher or instructional designer, and they may include student characteristics, content characteristics, learning environment characteristics, and instructional development constraints. For example, in web-based instruction, regular and frequent student access to specific communication technologies, such as a web-based bulletin board system, is a condition that must be met for social interaction to be an effective method (Beatty, 2002).

To summarize, instructional design theories present guidelines that indicate which instructional methods are likely to work best, considering the educator's values, the desired learning and instructional outcomes, and the conditions under which the instruction will take place. Instructional design theories provide guidance to educators on how to teach, in contrast to curriculum theory's focus on guidance about what to teach and learning theory's focus on describing how people learn (largely internal cognitive processes).

New Demands on Instructional Theory

There has been much discussion over the past few decades about the shift in paradigm from an industrial-age worldview to an information-age worldview, and the resulting impact of this shift upon education (Ackoff, 1981; Banathy, 1991; Bell, 1973; Reigeluth, 1994; Toffler, 1970, 1980, 1990). This shift also impacts Instructional Systems Design (ISD) as a field (Reigeluth

& Nelson, 1997). Paradigm shifts occur when fundamental changes arise in major characteristics of a system (Kuhn, 1996). The fundamental changes that distinguish the industrial-age and information-age paradigms of education and training include the following:

- Shift from a concern for standardization to a concern for customization
- Shift from central, bureaucratic control to autonomous, team-based management
- Shift from adversarial relationships to collaborative relationships
- Shift from autocratic decision making to shared decision making
- Shift from valuing compliance to valuing initiative
- Shift from a desire for conformity to an appreciation for diversity
- Shift from one-way communication to networked communication
- Shift from compartmentalization (or departmentalization) to integration (holism)
- Shift from product orientation to process orientation
- Shift from planned obsolescence to a concern for total quality
- Shift from teacher-centered instruction to learner-centered instruction

In our current industrial-age systems of education and training, the focus is typically on sorting students: holding time constant and thereby forcing achievement to vary, and using standardized norm-referenced tests. In an information-age system the focus is on learning: allowing learning time to vary so every student can reach mastery, using performance-based, criterion-based assessments, and having students' assume some responsibility for directing their own learning. These key characteristics of information-age instructional theories are described in more detail later in this chapter.

Given this shift in our educational and training systems, it is incumbent upon instructional design theory to offer guidance as to how to create powerful information-age, learner-centered instruction. What instructional methods should be used for this new set of values, goals, and conditions? Next, we describe several instructional theories that fit the information-age characteristics.

Promising Types of Theories

Each of the types of design theory described below has been developed as the Information Age paradigm has emerged over the past few decades. Of course, there are many more types of theories than we have room to describe here.

Self-Regulated Learning Theories

Self-regulated learning theories cultivate self-regulation skills in students to help them become more effective life-long learners (Knowles, 1990; Pintrich, 1995), and they support the use of those self-regulation skills. Self-regulation skills include determining whether or not material being studied is being understood and whether or not a particular study strategy is effective. Self-regulated learning has been defined as active, goal directed, self-control of behaviour, motivation, and cognition for academic tasks by an individual student (Pintrich, 1995).

In the classroom, instructional strategies that have been effective in teaching self-regulated skills include: encouraging students to set assessment or performance criteria and select assignments, teaching students how to recognize when they need help and then how to seek help appropriately, modeling self-regulatory skills for students, asking students to reflect on their own self-regulatory experiences and habits in an essay, and many others (see e.g., Corno & Randi, 1999). Additionally, some instructional theories include strategies to help teachers develop self-regulatory skills such as using a purposive cycle of planning, enacting and reflecting on their teaching methods.

Problem-Based Learning Theories

Problem-based learning (PBL) refers to instruction that revolves around students' engagement in solving authentic problems using a rich set of true-to-life resources, such as news articles, domain experts, and field reports. PBL has been practiced informally for a long time, but was implemented formally in educational settings only as recently as the late 1960's (Barrows, 1986). Educators are using PBL approaches in various content domains, including the fields of medicine, law and management.

Some of the key features of PBL instructional theory include the use of authentic, ill-structured problems that reflect the true complexity of the content domain, providing learning resources that the student explores in their actual (not simplified) form, allowing the student to control his or her own learning process, evaluating learning outcomes using performance assessment, and incorporating student reflections about their learning process (Savery & Duffy, 1996). A major feature of PBL is that the role of the teacher changes from a central, controlling role to one more like a coach. In a PBL environment, the teacher assists the student only when needed—prompting, probing, challenging assumptions and assertions, helping students assess their learning, and encouraging students to take control of their own learning.

Social Interaction Theories

Social constructivist learning can be defined as learning that occurs as students create (construct) understandings of their world through interaction with others, such as fellow learners and experts (Bonk & Cunningham, 1998; Cobb, 1994; Duffy & Cunningham, 1996). Social constructivist values and related learning goals and characteristics include: meaningful learning, collaborative problem solving, relevance to the student, multiple perspectives, collaborative reflection, self-regulation, and learning communities or communities of practice (Lave & Wenger, 1991).

In *socio-cultural learning*, students engage in learning activities that address the social, cultural, and historical contexts of the students' environment (Vygotsky, 1978). Learning is understood to be an inherently social process but takes place within a learner's "zone of proximal development," the conceptual region just beyond an individual's capability to perform (or think) without external support of some kind. In order to operate in this zone, interaction with an external agent, such as a teacher, more capable peer, or expert, is prescribed. Some of the common aspects of socio-cultural-based instructional theory include guidance for student-centeredness, peer collaboration, the use of scaffolding, teacher-student and student-student dialogue, and consideration of the socio-historical context in the learning environment.

Simulation Theories

Simulation, or virtual world, is an effective instructional strategy to use when a "real" environment is not available for the educational experience, or when time or expense can be considerably reduced. Simulations may be highly complex, relying on high-powered technology-based systems to simulate the flight deck of an aircraft, for example. Simulations may also be simple and "low-tech," such as a paper-based activity simulating an economic exchange. Simulations provide a safe place for learning where mistakes can be used as "learning moments." Students are able to review, reflect, and try again. Using simulations, educators put students into appropriately constructed situations having features that are authentic in key ways, enabling contextualized and effective learning.

Instruction for Effect

For too long, the ISD field and educators in general have ignored learners' needs that were not directly related to cognitive outcomes. A growing realization that learners suffer if they do not undergo more than cognitive development (Goleman, 1995), and that the educational program should overtly teach other aspects of human development, have led

to increased support for, and interest in, instructional theories for teaching in the *affective domain*, focusing on subjects such as emotional intelligence, attitude formation, morality, self-concept, personality development, spiritual development, feelings, and motivation, in formal and informal learning environments (Beane, 1990; Martin & Reigeluth, 1999).

Design theories have been developed to offer guidance on how to teach such affective topics more effectively. For example, one instructional program, focused on a child's social, ethical, and intellectual development, implements instructional strategies such as using classic literature that is rich in social and ethical themes to teach reading, using cooperative learning groups to develop social skills and ethical values, and using problem-solving approaches to solve disciplinary problems in school (Lewis, Watson & Schaps, 1999). This theory integrates affective instruction particularly well, since it addresses three major components at once (social, ethical, and intellectual).

Universal Principles of Instruction

Are there universal principles of instruction that should be followed no matter what the specific instructional context is? Reigeluth and Nelson (1997) described commonly-used "basic methods" of instruction, which are scientifically proven instructional strategies and tactics that have been used successfully in many different instructional theories. These basic methods, however, vary from one type of learning to another. For example, to teach all but the simplest skills, "tell, show, and do" (generality, demonstration, and practice with feedback) are basic methods that enhance the quality of instruction.

In recent years, Merrill (2000) has outlined what he calls "first principles of instruction" that he proposes universally enhance the effectiveness of all instruction. They include:

- *Problem-centered*—Learners should be engaged in solving real problems.
- *Activation of prior experience*—Relevant prior knowledge should be activated.

- *Demonstration*—New knowledge should be demonstrated to the learner.
- *Application*—New knowledge should be applied by the learner.
- *Integration*—New knowledge should be integrated into the learner's world.

Such foundational principles are very general and do not provide detailed guidance to a designer or teacher, and they should likely be implemented in vastly different ways for different situations. Nevertheless, the possibility of their existence for *all* effective instruction is exciting.

Implementing ISD: Limitations and Opportunities

Instructional theory has been implemented in many settings to meet the needs of both education and training providers. However, there are many settings that do not effectively utilize instructional theory. In this section we describe some of the reasons for this underutilization and some of the encouraging leverage points that instructional theory provides that may lead to improvements in instruction in the future.

Systemic Problems and Incompatibilities

Instructional programs in education and training are systems within a larger system, such as a corporation, school, or other institution. Also, the instructional system interacts on a peer level with other systems within the larger system. If changes in one system are not coordinated with changes in related systems, incompatibilities and systemic conflicts are inevitable. For example, if an academic department in a school decides to implement a new instructional program that involves using Internet-based resources through the school network, but doesn't coordinate with the information technology department to determine the effect on the rest of the school network, overload may result, causing network degradation for them and other users.

Systemic problems may occur due to differences in philosophical beliefs among stakeholder groups, also. For

example, in some schools authentic, portfolio assessment was implemented to replace the traditional A-B-C-D-F grading system. The students and parents were provided with an extensive, written assessment that highlighted each student's strengths and weaknesses, with recommendations for follow-on studies. In some of these schools the parents reacted negatively. Many parents wanted to know their student's class rank more than they wanted a meaningful assessment of his or her performance and needs. As a result, some schools have switched back to the old way of evaluating students.

Obstacles to Implementation

Besides systemic issues, there are many other obstacles to the adoption of ISD theories. Two that we will expound upon here are teacher training and interest, and student assessment systems.

One significant obstacle to the implementation of new instructional design theories is the lack of sufficient *teacher training* and sometimes a lack of significant teacher interest. New instructional theories are often developed as part of a research program at a university or other research institution. Rarely does the funding include widespread programs to train teachers in the field how to implement the instructional theory. New and promising design theories are developed, published, possibly debated in the ISD community, and then (too often) ignored by the key implementation stakeholder, the teacher. Other times a new instructional program is given to teachers and trainers to implement, but the teacher or trainer decides to use only part of the program, or decides to use pieces of several different (and possibly incompatible) programs.

Another obstacle to significant change in instructional systems is the assessment system. In education, for example, traditional assessment systems include letter or numerical grades, advancement to the next level based upon age and "seat time" rather than learning, and a concern more for sorting students than for assessing true learning needs and progress. In training, there has traditionally been an overemphasis on counting attendance and positive trainee reviews as the key

indicators of training quality. In each of these settings, this reliance on traditional, industrial-age methods of assessment tends to block the adoption of instructional methods and systems more attuned to the learning-focused paradigm.

Leverage Points and Catalysts

Even though there are many obstacles to change, there are also opportunities for change. Next, we will discuss several leverage points and catalysts that may be used to facilitate the changes needed to advance the use of instructional theories. They include technology-enabled or enhanced instruction and new assessment systems.

Technology-Enabled or Enhanced Instruction

One of the major leverage points is the use of advanced technology to enable learning-focused instructional theories. Two areas of technology-based instruction that we will address here are Computer Supported Collaborative Learning (CSCL) and online (Internet-based) systems.

CSCL Systems

CSCL systems are designed to enable collaborative learning among students through the use of computer-based systems for communication, sharing files and common workplaces, and other group collaborative efforts (Koschmann, 1996). CSCL systems have been used in many different educational settings, including school-based computer labs, computer-equipped classrooms, educational field trips, museums and other informal educational sites, and distance education programs.

One example of a CSCL system that enables new instructional methods is a system that connects students from various countries and different schools in a common project (Siegel & Kirkley, 1998). In this project, each participating class sent environmental data to all the other classes, and each class plotted worldwide climate trends. Computer-mediated communication systems facilitated rapid communication

among students and scientists from around the world. New technologies such as these (computer support for communication and file sharing) are accentuating the need for new types of instruction.

Online Systems

Online systems not only support CSCL applications, but enable other new kinds of instruction as well. One significant leverage point is the ability of an online system to provide anytime, anywhere access to instruction that has been customized to meet the particular needs of each student, including those of collaboration and social interaction.

For example, consider an online system designed to provide instruction in sales techniques for a worldwide corporate training audience. A well-designed online system can evaluate the specific training needs of individual students and send them personalized, individualized instruction (such as web pages) when and where they choose to learn. An online instructional system like this enables and promotes several learner-centered aspects of the new paradigm of instruction: individualization, self-pacing, and flexible (and responsive) access.

New Assessment Systems

In most educational systems, the student assessment subsystem is an obstacle to new instructional methods, as discussed previously in this chapter. However, a different kind of assessment system could be a powerful catalyst to foster information-age instructional methods. The assessment system is key because it tends to drive the entire instructional (or learning) process. If it is a performance-based, untimed, criterion-referenced test, teachers would use learning-focused instructional methods to help students to acquire new skills and understandings. Students would continue to work on mastering a criterion until they reach the pre-established standard, so that they would be successful even if they learn at a slower rate. Clearly, assessment systems have an important influence on instruction.

Catalysts like these can help spur the use of instructional theory for crafting truly learner-centered instruction to meet the needs of information-age learners.

Design Theory-Easier to Use

Instructional design theory is easier to use than descriptive learning theory, since design theory provides guidance on what methods of instruction to use when, rather than describing how learning happens. While descriptive theory is useful in creating design theory, it is often very difficult to determine how to teach according to a particular learning theory, without an accompanying design theory based on the learning theory. Design theory provides the practical link between theories about learning and educational (or instructional) practice. For example, a learning theory such as schema theory explains how new knowledge is built into schemata through such processes as accommodation, tuning, and restructuring (Norman, 1976). An accompanying design theory, however, will include specific instructional methods that are most useful for stimulating those processes, such as providing an "advance organizer" (Ausubel, 1968) or activating a meaningful learning set (Mayer, 1979).

Into the Future

Accelerating and Deepening

We expect the paradigm shift described earlier to continue, accelerating and deepening as changes affect all aspects of life. Contributing to this shift will be advances in the power of technology, increased access to technology and services, better understanding of how to use technology effectively in education and training, and new ways of both instructing and designing instruction based on the learning-focused instructional theories discussed previously. The key markers described earlier lead us to believe that several areas of research and practice are likely to have a particularly important influence on the development of future instructional theories: virtual reality, ubiquitous computing, Web-based instruction, learning and knowledge objects, multi-channel learning, and knowledge management.

Virtual Reality

Virtual reality (VR) instructional systems use high performance computers and newly designed interfaces to provide virtual—as opposed to actual—experiences to learners. VR systems commonly use wearable computers and displays in their attempts to immerse the learner in an experience as close to actual as possible. The goal is for the learner to suspend his or her disbelief and interact with the instructional environment as if it were real. Potential instructional applications for VR include those similar to simulations: where the “real” learning experience is not readily available due to access, expense, safety, time requirements, or some other constraints (e.g., exploring the interior of a glacier). Since many applications of VR rely upon powerful and complex computing systems, we expect that VR systems will become more prevalent in instruction as computer technologies advance and become less expensive. As powerful VR systems become available, more instructional methods for making best use of them will surely be developed.

Ubiquitous Computing

Ubiquitous computing refers to computing applications that are so common that they seem to be everywhere, part of the general landscape of life. These applications may be embedded in larger systems, often performing their functions without being noticed at all, as in our cars, for example, and our TV sets. In schools, computers were once relegated to computer labs and the library. Now, computers are in classrooms, homes, libraries, museums, backpacks, and even shirt pockets. And coupled with telecommunications and the Internet, those computers increasingly allow access to instruction any time and any place. This is placing new demands on instructional theory, particularly in the form of “on-demand” and “just-in-time” instruction (see discussion below).

Web-Based Instruction

Web-based instruction has emerged over the past decade as one

of the most important developments in instructional technology. Learning “online” will continue to become more common, both in formal instructional settings and informal learning environments. Since the early 1990s, the capabilities of the web have evolved from simple presentation of information to dynamic, interactive, multimedia presentations and rich learning environments that facilitate social interaction and enable collaboration (Khan, 1997). To take advantage of these expanding capabilities, instructional theory must develop guidance on ever better ways of teaching and learning that focus on collaboration, social interaction, and multiple experiences with content to reshape the learning experience (Bates, 2001).

Learning Objects

A recent development in education and training places an emphasis on creating reusable “learning” objects (RLOs, or sometimes just “learning objects”) and building instruction by combining RLOs in different ways to meet one’s instructional objectives (see e.g., Wiley, 2001). Usually, each RLO is designed to “teach” one complete learning objective and includes instructional media (text, graphics, animations, etc.), practice, feedback, and assessment as needed. The Advanced Distributed Learning (ADL) initiative, sponsored by the United States government, is coordinating a major effort to standardize the creation and technical labeling of learning objects so that each is reusable in as many specific contexts as possible (ADL, 2001). The ADL initiative has created the technological foundation that will enable the widespread reuse of RLOs, but there has been little emphasis on how best to design instruction using them. This is a major challenge for instructional theory and research.

Multi-Channel Learning

Multi-channel learning involves the use of multiple channels of instruction, such as formal school, after-school tutorial programs, parent-assisted homework, audio or video lessons on tape, and distance learning media. The goal of multi-channel systems is to provide the most effective mix of instructional

channels to each learner (Mukhopadhyay & Parhar, 2001). Some forms of multi-channel learning have been practiced for a long time in many cultures around the world, but formal recognition of multi-channel learning as a legitimate "educational program" option began only in the early 1990's. This approach has been very effective in several large educational programs, including the INNOTECH program in the Philippines and the OLSET program in South Africa (Anzalone, Sutaria, Desroches & Visser, 1995). This is an important approach for instructional theory to address.

Knowledge Management

Knowledge management is an emerging field concerned with the management of knowledge in an organization, especially as it relates to employee performance (Davenport & Prusak, 1998). Knowledge management systems are designed to identify and capture relevant information (knowledge) from expert employees, and then transfer that knowledge to those who need it in order to perform well, quite often the less experienced employees. One of the most useful functions of successful knowledge management systems is their ability to manage "just in time" learning requirements.

Just-in-time Knowledge Management

"Just in time" knowledge management systems specialize in providing just the needed information (knowledge) at just the right time to the requestor. For example, experienced maintenance personnel repairing complex machinery, such as an airplane, may need just a small amount of very specific information to complete their task, but they need it immediately. In a classroom, a student may be struggling to learn a new complex cognitive skill, such as using the second derivative to calculate the speed of a particle. A just-in-time system might recognize a point of difficulty that the student is experiencing and provide a helpful suggestion or a slight correction, enabling the student to learn the skill.

Just-in-time systems complement more traditional training

systems that provide knowledge "just in case" the student needs it at some point in the future. Typical classroom instruction falls into the just-in-case category, but a great deal of the knowledge may never be needed for actual practice, and students are typically less motivated for just-in-case instruction. This has led to the recognition of the value of just-in-time instruction, and instructional theory should take this into account.

Electronic Performance Support Systems

Electronic performance support systems (EPSSs) are a powerful tool for just-in-time learning. They can provide workers with just the right type of information (e.g. conceptual explanations, steps in a procedure, or past performance data) at just the right place (e.g. on the shop floor, as part of a computer software screen, or at the site of an experiment) in just the right amount and at just the right time. EPSSs can support levels of employee performance that may not normally be possible due to the complexity or sheer volume of information. This is an important function as many jobs increase in complexity and the volume of information increases in the Information Age.

EPSSs may be standalone systems or may be embedded in the performance tool itself. For example, an EPSS may be designed to assist teachers in choosing from among dozens of possible instructional theories and methods. Another form of EPSS is the "Help" system packaged as a menu selection in the main software package.

Embedded in Authentic Performance

Knowledge management systems are focused on authentic practice that is embedded in job performance. One of the main challenges in corporate training environments is to capture the corporate knowledge that is distributed (or shared) among the experienced employees and transfer that knowledge to newer, less experienced employees. The "communities of practice" perspective can facilitate this transfer of knowledge.

Communities of practice form when people carry out practices in social groups on a regular (and often frequent) basis. Communities of practice include members with varying levels of expertise, from the experts, who form the core of the community, to the novices, who are just starting to learn the practices of the community (Lave & Wenger, 1991). Sometimes, instructional designers are asked to "design" a community of practice. However, communities of practice are complex social organizations that are not well understood. Much more research and instructional theory development are needed.

Given the options for a knowledge management system to use communities of practice, EPSSs, or some other type of system, instructional theories are needed to help instructional designers decide which options to use and how to make best use of each.

Formative Research to Create Design Theory

Given the need to develop a wide variety of additional instructional theories for the Information Age, we would like to address the use of formative research to create such theories. The formative research methodology is a relatively new research method that can be used to create or improve existing design theory through testing its application in a specific case. This type of research aims to determine what methods work well in the theory, what methods don't work well and thus need to be improved, and how the design theory can be improved.

Formative research is a kind of case study research, action research, developmental research, and grounded theory development. The underlying logic of formative research, according to Reigeluth and Frick (1999), is that

... if you create an accurate application of an instructional-design theory (or model), then any weaknesses that are found in the application may reflect weaknesses in the theory, and any improvements identified for the application may reflect ways to improve the theory, at least for some subset of the situations for which the theory was intended. (p. 636)

In formative research, there are six major steps that the researcher follows (Reigeluth & Frick, 1999): 1) choose an existing design theory, or delimit the scope for a new theory; 2) design an instance (case) of the theory or select a case within the scope; 3) analyze the case in order to identify what works well and what needs to be improved; 4) identify improvements for the case based on formative evaluation data; 5) repeat the data collection for another part of the case or another case entirely, to explore whether the improvements generalize within the scope of the theory, and repeat the cycle again; and 6) suggest improvements for the design theory based on the experience of the case. There are variations in these steps depending on: a) whether the design theory already exists or is being developed from scratch, b) whether the case is created by the researcher or is/was created independently, and c) whether the case has already occurred or is occurring as the research is being conducted (Reigeluth & Frick, 1999).

Conclusion

As was indicated at the beginning of this chapter, instructional systems design is a field dedicated to helping people to do a better job of facilitating human learning and development of all kinds. This is a young field, and as we evolve deeper into the Information Age, instructional theories will be needed to offer guidance for taking full advantage of the opportunities that new technological developments afford to better meet the needs of individual learners.

REFERENCES

- Ackoff, R. (1981). *Creating the corporate future*. New York: John Wiley & Sons.
- ADL (2001). *Sharable content object reference model*. Available online: <http://www.adlnet.org/>. Last visited September 2002.
- Anzalone, S., Sutarja, M., Desroches, R., and Visser, J. (1995). Multi-channel learning: A note on work in progress. *ED Journal*, 9(6), pp. J3-J7.
- Ausubel, D.P. (1968). *Educational psychology: A cognitive view*. New York:

- Holt, Rhinehart and Winston.
- Banathy, B.H. (1991). *Systems design of education: A journey to create the future*. Englewood, NJ: Educational Technology Publications.
- Barrows, H.S. (1986). A taxonomy of problem based learning methods. *Medical Education*, 20, 481-486.
- Bates, T. (2001). *National strategies for e-learning in post-secondary education and training*. Paris: UNESCO International Institute for Educational Planning.
- Beane, J.A. (1990). *Affect in the curriculum: Toward democracy, dignity, diversity*. New York: Teachers College, Columbia University.
- Beatty, B.J. (2002). Social interaction in online learning: A situationalities framework for choosing instructional methods. Unpublished dissertation, Indiana University, June 2002.
- Bell, D. (1973). *The coming of post-industrial society: A venture in social forecasting*. New York: Basic Books.
- Bonk, C.J., & Cunningham, D.J. (1998). Searching for learner-centered, constructivist, and sociocultural components of collaborative educational learning tools. In C.J. Bonk & K.S. King (Eds.), *Electronic collaborators: Learner-centered technologies for literacy, apprenticeship, and discourse* (pp. 183-208). Mahwah, NJ: Lawrence Erlbaum Associates.
- Cobb, P. (1994). Constructivism in mathematics and science education. *Educational Researcher*, 23(7), 4.
- Corno, L. & Randi, J. (1999). A design theory for classroom instruction and self-regulated learning? In C.M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (Vol II) (pp. 293-318). Mahwah, NJ: Lawrence Erlbaum Associates.
- Cronbach, L.J., & Suppes, P. (Eds.) (1969). *Research for tomorrow's schools: Disciplined inquiry for education*. Toronto: Macmillan.
- Davenport, T.H. & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.
- Dick, W., & Carey, L. (1996). *The systematic design of instruction*. 4th ed. New York: Harper Collins.
- Duffy, T.M., & Cunningham, D.J. (1996). Constructivism: Implications for the design and delivery of instruction. In D.H. Jonassen (Ed.), *Handbook of research for educational communications and technology: A project of the Association for Educational Communications and Technology* (pp. 438-456). New York: Simon & Shuster Macmillan.
- Gagne R.M., & Briggs L.J. (1974). *Principles of instructional design*. New York: Holt, Rinehart & Winston.
- Goleman, D. (1995). *Emotional intelligence: Why it can matter more than IQ*. New York: Bantam Books.
- Gustafson, K.L., & Branch, R.M. (1997). *Survey of instructional development models*. 3rd ed. Syracuse, NY: ERIC Clearinghouse on Information and Technology.

- Khan, B.H. (Ed.) (1997a). *Web-based instruction*. Englewood Cliffs, NJ: Educational Technology Publications, Inc.
- Knowles, M.S. (1990). Fostering competence in self-directed learning. In R.M. Smith and Associates (Eds.), *Learning to learn across the lifespan* (pp. 123-236). San Francisco: Jossey-Bass.
- Koschmann, T. (Ed.) (1996). *CSCIL: Theory and practice of an emerging paradigm*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Kuhn, T.S. (1996). *The structure of scientific revolutions*, 3rd ed. Chicago: University of Chicago Press.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.
- Lewis, C., Watson, M., & Schaps, E. (1999). Recapturing education's full mission: Educating for social, ethical, and intellectual development. In C.M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (Vol II). (511-539). Mahwah, NJ: Lawrence Erlbaum Associates.
- Martin, B.L., & Reigeluth, C.M. (1999). Affective education and the affective domain. In C.M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (Vol II) (pp.485-509). Mahwah, NJ: Lawrence Erlbaum Associates.
- Mayer, R.E. (1979). Can advance organizers influence meaningful learning? *Review of Educational Research*, 49, 371-383.
- Merrill, M.D. (2000, in press). First principles of instruction. *Educational Technology Research and Development*.
- Mukhopadhyay, M., & Parhar, M. (2001). Instructional design in multi-channel learning systems. *British Journal of Educational Technology*, 32(5), 543-566.
- Norman, D.A. (1976). *Memory and attention: An introduction to human information processing*. New York: John Wiley & Sons, Inc.
- Pintrich, P.R. (1995). Understanding self-regulated learning. In P.R. Pintrich (Ed.), *Understanding self-regulated learning* (pp. 3-12). San Francisco: Jossey-Bass
- Reigeluth, C.M. (1983). Instructional design: What is it and why is it? In C.M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status* (pp.3-36). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Reigeluth, C.M. (Ed.) (1999). *Instructional-design theories and models: A new paradigm of instructional theory* (Vol II). Mahwah, NJ: Lawrence Erlbaum Associates.
- Reigeluth, C.M., & Frick, T. (1999). Formative research: A methodology for creating and improving design theories. In C.M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (Vol II) (pp.633-651). Mahwah, NJ: Lawrence Erlbaum Associates.

