Chapter
12

New Instructional Theories and Strategies for a Knowledge-Based Society

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Industrial nations are undergoing massive changes as they evolve into post-industrial societies (Bell, 1973; Toffler, 1980). These changes are being brought about by the development of information technology, which has transformed the industrial sector of the economy and has spawned the knowledge-work sector (Duffy, Rogerson, & Blick, 2000). Just as the percentage of the workforce in agriculture dropped dramatically in the early stages of the industrial age, so the percentage in manufacturing has been declining dramatically over the past few decades, while the percentage doing knowledge work has been increasing dramatically. As Reich (1991) pointed out, even in manufacturing companies, a majority of the jobs today entail working with knowledge rather than materials. Just as the industrial age represented a focus on, and extension of, our physical capabilities (mechanical technology), so the knowledge (or information) age represents a focus on, and extension of, our mental capabilities (intellectual technology). Employees need to be able to think about and solve problems, work in teams, communicate, take initiative, and bring diverse perspectives to their work (Reich, 1991; Toffler, 1980). The prevalence of such knowledge work makes effective learning paramount.

However, this massive societal transformation is creating very different learning needs from those which our educational and training systems (herein referred to as "learning systems") were designed to meet. The success of learners in our schools, universities, and corporate training programs depends on our ability to redesign those learning systems to meet the new learning needs of the knowledge age (Reigeluth, 1994). This chapter explores the kinds of changes that are needed in our learning systems, with a particular emphasis on changes in instructional theories and strategies required for effective learning in the knowledge age.

KEY MARKERS FOR CHANGES IN OUR LEARNING SYSTEMS

Because the need for fundamental changes in our learning systems is driven by massive changes in our knowledge-age society, we must look at the ways our society in general—and its learning needs in particular—are changing in order to determine what features our learning systems should have. Table 12.1 shows some of the major differences between the industrial age and the emerging knowledge age. These differences, or "key markers," have important implications for how our learning systems should be structured, what should be taught, and how it should be taught.

TABLE 12.1
Key Markers That Distinguish Industrial-Age and Knowledge-Age Organizations

Industrial Age	Knowledge Age
Standardization	Customization
Bureaucratic organization	Team-based organization
Centralized control	Autonomy with accountability
Adversarial relationships	Cooperative relationships
Autocratic decision making	Shared decision making
Compliance	Initiative
Conformity	Diversity
One-way communications	Networking
Compartmentalization	Holism
Parts-oriented	Process-oriented
Planned obsolescence	Total quality\
CEO or boss as "king"	Customer as "king"

Note. From Reigeluth (1999b), with permission.

According to Reigeluth (1999b), as indicated by Table 12.1, students in our current school systems are typically treated as if they are all the same and are all expected to do the same things at the same time (standardization). Consolidated districts are highly bureaucratic and centrally controlled. Students get insufficient preparation for participating in a democratic society. Leadership is vested in individuals according to a hierarchical management structure, and all those lower in the hierarchy are expected to obey their superiors. Our current school systems usually foster adversarial relationships, not only between teachers and administrators, but also between teachers and students, and often between teachers and parents. Students are typically molded (implicitly or explicitly) to be passive learners and passive members of their school community. Learning is highly compartmentalized into subject areas that often have little apparent relevance to students' lives.

These common features of current school systems are also found in higher education and corporate training systems, and they are not unique or specific to the United States. These features of school systems should change (and are indeed beginning to change), for they are counterproductive—harmful to our citizens and our society—in the knowledge age.

The "key markers" shown in Table 12.1 provide us with a general idea of the ways in which learning systems—and the instructional theories and strategies that guide their design—need to change. However, there are other changes that provide a clearer picture of the ways instructional theories need to change: (a) the growing complexity of tasks; (b) the increasing reliance on collaboration in performing tasks; (c) the growth of Web-based learning; (d) the increasing power of performance support systems; and (e) the emergence of personal tutor systems. The remainder of this chapter is devoted to discussing the implications of each of these five changes for instructional theories and strategies.

COMPLEX COGNITIVE TASKS

As our society evolves deeper into the knowledge age, our systems are becoming more complex, and the tasks we are called on to perform are becoming ever more complex (Caine & Caine, 1997). The lower levels of learning—information and procedures—by themselves are inadequate to deal with such complexity. Learners must develop deep understandings, complex causal dynamics, highly conditional heuristics (rules of thumb or guidelines), and powerful metacognitive skills (Merriënboer, 1997). These higher levels of learning require instructional theories and strategies different from those typically used in our learning systems today.

The first challenge in teaching these higher levels of learning is to discover what to teach. This task is made especially difficult by the tacit (unconscious) nature of much of that knowledge. The field of instructional development has done a fine job of generating techniques for analyzing the simpler forms of knowledge: information and procedural (or "routine") tasks. However, we are in dire need of better methods for analyzing complex cognitive (or heuristic) tasks. Reigeluth and colleagues attempted to synthesize and extend the knowledge in this area through the development of the heuristic task analysis (HTA) method (Lee, 2002; Lee & Reigeluth, 2003; Reigeluth, 1999a). HTA includes guidance for eliciting, analyzing, and representing various kinds of knowledge—often tacit—that experts use in performing complex cognitive tasks. However, much work remains to be done to develop more powerful tools in this area.

A second challenge in teaching these higher levels of learning is to not overwhelm learners with the great complexity of real-world tasks. Although it is important for instruction to utilize authentic tasks, it is counterproductive to provide too much complexity to the learner at once (Pollock, Chandler, & Sweller, 2002; Vygotsky, 1978). Reigeluth (1999a) attempted to synthesize and extend the knowledge in this area through the development of the Simplifying Conditions Method. It offers guidance on identifying the simplest real-world version of a complex cognitive task, identifying progressively more complex versions of the task (along with identifying the conditions that make each version more complex), and organizing the versions in a way that ensures both a simple-to-complex sequence and some degree of learner choice as to which dimensions of complexity to elaborate on first (or next).

A third challenge in teaching these higher levels of learning is to use instructional strategies and theories that most powerfully foster each type of learning: deep understanding, complex causal dynamics, heuristics, and metacognitive skills. For deep understanding, the work of David Perkins (Perkins & Unger, 1999), Howard Gardner (Gardner, 1999), and other researchers (Spector & Anderson, 2000; Wiske, 1998) provides some insights as to instructional strategies that may help most to foster such learning. Those strategies include selecting generative or significant topics for study, selecting and publicly stating goals for understanding, using entry points (based on multiple intelligences) to engage students in the topic, portraying the topic in a number of ways, engaging students in performances for understanding, and providing ongoing assessment of understanding.

For highly conditional heuristics and complex causal dynamics, the work of researchers like van Merriënboer (1997) and Spector (2000, 2001) provides some knowledge about what instructional strategies and theories may help most to foster their acquisition. These include a macro-level sequence of whole tasks (skill clusters), meso-level sequencing comprised of simple to complex cases for a single task, and instruction for specific cases (or problems). The latter includes a variety of product-oriented problem formats (e.g., worked-out problems, reverse problems, conventional problems) and process-oriented problem formats (e.g., modeling examples, process worksheets, use of cognitive tools) (van Merriënboer, 1997). Simulations are particularly valuable for fostering the acquisition of complex causal dynamics. In addition to learning from "playing" a simulation, it is sometimes useful to have learners create their own simulations using such tools as Stella, StarLogo, and NetLogo (Milrad, Spector, & Davidsen, 2002; Spector, 2000).

For metacognitive skills, several researchers (Hacker, Dunlosky, & Graesser, 1998; Hartman, 2001; Weinert & Kluwe, 1987) provided some ideas as to what instructional strategies and theories may help most to foster their development. These include promoting students' metacognitive awareness by providing explicit instruction about metacognitive knowledge and metacognitive strategies, providing tasks or problems that require metacognitive skills, providing models of metacognition, engaging students in self-regulated learning activities (e.g., planning, self-questioning, self-monitoring, self- assessment, reflection, revision), engaging students in collaborative thinking (e.g., dialogue or discussion, collaborative decision making, collaborative planning or writing, study group), providing feedback, and using motivational strategies for enhancing students' self-efficacy. Given the two fundamental aspects of metacognition—awareness of and control over one's thinking (Hartman, 2001)—it is critical for instructional designers or teachers to help students to develop skills for planning, monitoring, evaluating, and revising their thinking and learning as well as their metacognitive knowledge (domain-general and/or domain-specific).

COLLABORATIVE TASKS

As our society evolves deeper into the knowledge age, it is becoming increasingly apparent that knowledge work is more effective when done in collaboration with other workers. This places on our learning systems new learning demands that go far beyond a new course in a curriculum or training program—it requires the use of collaborative learning as an instructional strategy that helps learners to improve their collaboration skills as an integral part of learning other skills or knowledge. Several researchers (Bruffee, 1993; Nelson, 1999) provided some ideas as to what instructional strategies and theories may help most to foster effective collaborative learning. There are various kinds of collaboration, as well as approaches to collaborative learning. For example, the use of consensus groups for collaborative learning includes five major steps (Bruffee, 1993):

- Divide a ... class into small groups, usually of about 5 learners.
- Provide a task, usually designed ahead of time, for the small groups to work on.
- Reconvene students into a plenary session to hear reports from the small groups and ... negotiate a consensus of the class as a whole.
- Lead students to compare the class's plenary consensus with the current consensus of the knowledge community....
- Evaluate explicitly the quality of students' work. (p. 21)

WEB-BASED LEARNING

The Internet represents a powerful tool for more than information retrieval—it is also a powerful tool for providing interactive, dynamic, multimedia instruction (Khan, 1997). However, such instruction is fundamentally different from classroom instruction for many reasons. Unlike face-to-face instruction, there is less pressure to give all students the same instruction at the same time. Its technological strengths (e.g., asynchronous communication capabilities) and weaknesses (e.g., difficulty of natural, real-time group discussions) require a different mix of instructional methods than classroom instruction. But perhaps most importantly, the remoteness of the learners and the flexibility of the medium put more onus on the learners to direct their own learning. This also creates greater demands for fostering intrinsic motivation.

The net effect of these factors is a greater need for methods of instruction that engage the learners in authentic tasks that are relevant to their personal needs and goals. Such methods include problem-based learning and self-regulated learning. This also creates greater demands for learning from one's peers through such methods as team-based learning and peer review of student work. Many researchers (Barrows, 1985; Hannafin, Land, & Oliver, 1999; Jonassen, 1999; Khan, 1997, 2001; Nelson, 1999; Schank, Berman, & Macpherson, 1999; Schwartz, Lin, Brophy, & Bransford, 1999) provide some ideas as to what instructional strategies and theories may help most to foster these kinds of learning. These include such methods as:

- Clarifying the learning goals.
- Presenting an appropriate problem, mission, or challenge.
- Having students engage in such activities as generating ideas, sharing multiple perspectives, and conducting research.
- Providing such resources as worked examples, information, cognitive tools, and collaboration tools.
- Providing coaching, scaffolding, and feedback or formative assessment.

PERFORMANCE SUPPORT SYSTEMS

Information technology has improved the power and flexibility of electronic performance support systems (EPSSs) as tools to provide just-in-time support for performance on the job (Gery, 1991). Such just-in-time support can work very well for relatively routine tasks that do not require fast performance, but for routine tasks that need to be automatized and for highly complex cognitive tasks, EPSSs need to take on a highly instructional, rather than purely informational, role. For example, some skills require much practice to become sufficiently automatized for an employee to perform well under the time constraints and other constraints of the task (Neves & Anderson, 1981). Neves and Anderson (1981) and Salisbury (1990) provided some ideas as to what additional instructional theories and strategies are needed to help automatize routine tasks. These include such methods as:

- Use lots of practice to automatize routine tasks.
- Provide practice on a small subset of items at a time (e.g., 7 plus or minus 2).
- Determine mastery by speed of response as well as accuracy of response.

- When an item is mastered, a new item should be introduced.
- Practice should be "spaced" at different times rather than concentrated all at once. When practice is resumed, it should resume where the learner left off.
- Systematically review items that have already been learned. Each time a review item is answered correctly, there should be a longer delay before it is reviewed again. Over time, the ratio of review items to new items should increase.
- Use mnemonic devices or memory devices to make the learning more meaningful.

Also, complex cognitive tasks frequently require an expert to have a deep understanding of causal models and systemic interrelationships whose acquisition requires considerable exposure (van Merriënboer, 1997). Compounding this challenge is the difficulty of identifying the frequently tacit heuristic knowledge that experts use to perform complex cognitive tasks (discussed earlier). Once such tacit heuristic knowledge is discovered, instructional theories and strategies should be built into EPSSs to help novices internalize it. Several researchers (van Merriënboer, 1997; Spector, 2000, 2001) provide some ideas as to what instructional strategies and theories may help most to foster learning of complex cognitive tasks. They were discussed earlier, in the section Complex Cognitive Tasks.

PERSONAL TUTOR SYSTEMS

One of the most promising developments of the knowledge age is our growing knowledge about how to create an electronic *personal tutor* for learners. It would be a personal tutor in the sense that the instruction would be customized to the individual learner's needs, interests, and learning style. It would be adaptive in that it would constantly monitor and improve its selection of instructional methods for the learner. But it would also allow the learners to play a major role in designing their own instruction by selecting from a menu of methods or at least a menu of specifications for the methods that the personal tutor system selects. The personal tutor system would, of course, provide advice and feedback about the learner's selections, so the learner would be coached to improve his or her learning strategies.

For this kind of personal tutor system to be feasible, it is important for the system to separate instructional methods from content and then combine them in appropriate ways (Merrill & ID2 Research Group, 1996). For example, there is ample research evidence that to teach a skill, it helps to tell the learner what to do (a generality), show the learner what to do (an example), and have the learner do it (practice) with immediate feedback (Merrill, 1983). The system needs a knowledge base about what to teach (*knowledge components*), it needs a knowledge base about how to teach (*strategy components*), and it needs to maintain current knowledge about what the learner knows and how the learner learns best.

The research of Merrill (1997, 1998, 2001) provides some ideas to guide the design of this kind of personal tutor system:

- Knowledge components that exist universally across all subject areas are identified as "entities (things), actions (procedures that can be performed by a student on, to, or with entities or their parts), processes (events that occur often as a result of some action), and properties (qualitative or quantitative descriptors for entities, actions, or processes)," as well as parts, kinds, and properties (Merrill, 2001).
- Each of these knowledge components has its own types of subcomponents, such as a name, a description, and/or a consequence.
- The primary strategy components include *tell* (to present general information to the student), *show* (to demonstrate specific information), *ask* (for the student to recall information), and *do* (for the student to use knowledge in a specific situation).
- There are other strategy components for sequence and for learner guidance.
- Instruction occurs in the form of *transactions*, which require the appropriate combination of knowledge components with strategy components for a given instructional goal.

Merrill developed ID Expert[1] with *transaction shells,* which provides a proof of concept for creating powerful personal tutor systems that can work efficiently across subject areas (Merrill, 1998).

CONCLUSION

As we evolve deeper into the knowledge age, this massive societal transformation is creating learning needs very different from those that our educational and training systems were designed to meet. For the success and stability of our society, it is essential that we redesign those learning systems. The key markers of our societal transformation provide some guidance as to how our learning systems should be redesigned. Additional guidance can be found in other changes more closely related to learning systems: the growing complexity of tasks, the increasing reliance on collaboration in performing tasks, the growth of Web-based learning, the increasing power of performance support systems, and the emergence of personal tutor systems.

The broader societal transformation we are undergoing places our society in a vulnerable state. That vulnerability requires the development of effective learning systems that can help us meet the new learning needs. It is clear that instructional theorists have begun developing knowledge to guide the transformation of learning systems based on all these changing needs and tools, but much more work remains to be done to develop such knowledge. There is also the formidable task of using that knowledge to redesign our learning systems. We can meet these challenges. We must meet these challenges. But do we, as a society, have the will to meet these challenges? Do you have the will to help?

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[1]This has become a commercially successful system marketed by Leading Way Technology.

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