Bonner, Jodi (1998). Implications of cognitive theory for instructional design.
Educational Communication and Technology Journal, 36(1), 4-14.

Implications of Cognitive Theory for Instructional Design: Revisited

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The field of cognitive science is contributing significantly to the research and theory on learning, and to the development of intelligent tutoring systems. The instructional design literature indicates an interest in cognitive theory as well as attempts to integrate it into our theory and research base. However, cognitive psychologists do not necessarily find this synthesis satisfactory. The purpose of this article is to point out the conflicts, so that instructional designers can be aware of the nature of our coexistence.

ECTJ, VOL. 36, NO. 1, PAGES 3–14
ISSN 0148-5806

The technology of instructional design has an eclectic nature in that it integrates the ideas of a number of areas such as behavioral psychology, cognitive psychology, adult learning, systems theory, and media technology. The trend in its theory base is toward a greater incorporation of cognitive theory, not just the cognitive perspective that educational psychologists such as Gagné and Ausubel present to us, but also the work of cognitive psychologists such as John Anderson and Allan Collins.

Several articles in the instructional design literature have examined the implications of cognitive theory for instructional design (Gagné & Dick, 1983; Low, 1981; Wildman, 1981; Wildman & Burton, 1981). These articles are written in an instructional design framework, addressing issues like instructional strategies, objectives, and delivery systems. They assume that the parts of an instructional design framework can at least be examined in terms of how they are influenced by cognitive theory. Now, several years later, there is still some question as to the compatibility of instructional systems design and cognitive psychology.

This article looks once again at the influences of cognitive psychology on instructional design. First, some salient aspects of cognitive theory are noted. Then, the implications of cognitive theory for common instructional design tasks are addressed. Finally, a summary and some closing comments are presented.

COGNITIVE THEORY

Gagné and Dick (1983) have summarized three of the concepts of cognitive psychology that have unquestionable relevance to instructional design. These concepts are presented here as metacognition, schemata, and stages of skill acquisition. Cognitive psychologists study experts and novices to understand these and other qualitative differences in competence. Novices and experts are defined relative to each other, so that novices are those with different knowledge or skill than experts. There are varying degrees of expertise on a continuum that is generally referred to as ranging from novice to expert. This range of expertise is similar to on-the-job training programs where an employee progresses from apprentice to journeyman to master craftsman.

Metacognition can refer to both the "cognitive strategies of learning and remembering," and "knowledge of one's own cognition" (Gagné & Dick, 1983, pp. 276–7). Simply stated, metacognitive skills are the techniques one uses to monitor oneself while solving problems, and the strategies one uses to learn. Monitoring strategies are the things one does to provide a check on one's performance, such as re-reading directions to make sure everything is covered or keeping notes of the steps taken to solve a problem. Learning strategies are the ways one goes about learning, such as outlining what is read or rehearsing a list of numbers. These kinds of skills traditionally have been neglected in teaching.

Schemata is a term used to refer to how our knowledge is represented in memory. As one learns, one alters one's schemata. Gagné and Dick (1983) have identified implications of the concept of schemata for instruction:

- New information is stored in previously formed schemata.
- Schemata strongly influence recall of previously learned information.
- A schema allows the learner to make inferences to fill the gaps in verbal information.
- Schemata are knowledge structures with both declarative and procedural components.
- It is important for the learner to be able to evaluate and modify his or her schemata.

Anderson (1985) has described three stages of skill acquisition: cognitive, associative, autonomous. In the cognitive stage, what one knows is represented as declarative knowledge. In the associative stage, what one knows is represented as procedural knowledge. In the autonomous stage, automatic processing occurs so that one is able to exhibit some skills without really thinking about them. For example, when writing a letter, a person with reading and writing skills does not have to focus on how to read and write, but on the content of the message. As knowledge is used many times, the process of knowledge compilation occurs as a number of pieces of knowledge are reduced into a single step; thus, novices initially possess small pieces of knowledge that are compiled into larger pieces on the way toward expertise. Practice is an important activity in achieving automaticity, though clear guidelines about how much practice is required to make a skill automatic have not been established. Another instructional issue is concerned with identifying which skills need to be automatic. The work of Schneider (e.g., 1985) has been concerned with differentiating between controlled and automatic processing and studying the effects of practice on these two models of processing. When skills are automatic in problem solving, they require less attention, so that one can give more attention to other aspects of solving the problem.

Cognitive psychology is concerned largely with problem-solving and complex cognitive skills, as opposed to memorization or straightforward procedural tasks. Problem solving is "behavior directed toward achieving a goal" (Anderson, 1985, p. 198). Problem-solving skills may involve both the use of general problem-solving methods or heuristics and the use of algorithms. The idea of generativity is that one develops the ability to use old knowledge in new situations, i.e., knowledge transfers within and across various domains and one is able to apply one's knowledge to solve novel problems within a domain.

For cognitive psychologists, learning is viewed as a constructive process where changes occur to the internal representation of knowledge (Wildman, 1981). Instead of learning responses, the emphasis is on learning information (Low, 1981; Shuell, 1987). Learning is viewed as an active process where experiences contribute to the development of meaning and understanding (Wildman & Burton, 1981). The most natural way to learn is through an apprenticeship type of environment where learning takes place in the context of doing (Anderson, Boyle, Farrell, & Reiser, 1984; Collins, Brown & Newman, in press). There is greater emphasis on learner control (Duchastel, 1986; Wildman, 1981), and adaptation to the learner's existing knowledge. Duchastel (1986) calls this a reactive learning environment.

Knowledge is both domain specific and non-domain specific, and learning both domain dependent and domain independent (Glaser, 1984). Higher order skills (problem-solving and metacognitive skills) are learned most effectively in the context of actually solving problems in a particular domain, such as geometry or electronics. That is why an apprenticeship environment is favorable for learning.

INSTRUCTIONAL DESIGN

The following is a list of tasks common to instructional design models (Andrews & Goodson, 1980). These tasks are used as topics to organize this section.

- Needs Assessment, Task Analysis
- Goals, Subgoals, Objectives
- Measurement
- Types of Skills/Learning
- Sequencing Goals, Subgoals, Objectives
- Learner Characteristics
- Instructional Strategies, Learning Activities
- Media Selection
- Formative Evaluation

The instructional design process can be thought of as being comprised of containers that represent instructional design tasks. There are two ways in which designers work with these tasks. One way is a process by which one works through the tasks. A designer works at a task by carrying out the activities it comprises, pours the results into the next container, works at another task, goes back to a previous task, and so on. This is a systematic and iterative process typical of instructional design. It is not based on a particular learning theory, so it does not change if the theory base changes. In addition, these containers must be filled with information, methods, techniques, and procedures; this is the part of instructional design that changes depending on the theory base. However, cognitive psychologists do not necessarily view the design of learning environments in this way. The important question for instructional design is whether and in what way designers may be limiting the design of good instruction by adhering to the systematic process.

Needs Analysis and Task Analysis

Wildman and Burton (1981) advocate a theory-based approach to needs assessment. A distinction should be made here between needs assessment and task analysis. Needs assessment, which is the determination of the gaps between actual and desired states, should be comprehensive and theory free. This part of the process should be comprehensive in order to determine a variety of needs, i.e., needs assessment should answer the question of whether discrepancies exist in performance related to complex cognitive skills, simple procedures, attitudes, motor skills, etc. It should be theory free because, ideally, the needs simply exist and are not influenced by what anyone would like to exist. For example, an analyst's interest in problem solving should not result in the need to teach problem solving unless that need truly exists.

Once needs have been identified, a theory-based task analysis should be conducted to study the performance (cognitive, motor, or attitude), because what is learned during task analysis influences the rest of instructional design. In the case of cognitive task analysis, methods are devised to investigate the specific mental processes that experts and novices use in their domain. The cognitive task analysis is not concerned with generic information processing, though that is the basis for the concern with the domain-specific cognitive processes. Like traditional task analyses, the cognitive task analysis involves subject matter experts (SMEs) in the identification of the knowledge and skills required to do a job. The cognitive task analysis focuses on cognitive skills, while traditional task analysis has focused primarily and sometimes exclusively on observable behaviors. In cognitive task analysis, cognitive processes may be inferred to some degree from what SMEs report they would do. In traditional task analysis, either little or no inferences have been made because analysts have been concerned with the observable, or when inferences have been made they have not been verified through the study of SMEs. In general, cognitive task analysis methods rely on extensive interviewing of SMEs while they are carrying out their job tasks. One method currently under refinement relies on problem generation and solution sessions with experts and novices to collect data, which is then analyzed to reveal the skills required to solve the problems (Means & Gott, 1988).

What is important about cognitive task analysis is that it identifies the cognitive skills required to be proficient at a job, then identifies those skills at various levels of competence. Traditionally, analysts have identified the skills or behaviors of experts to determine what to teach, and designers have identified the entry behaviors and characteristics of learners to provide a basis for the design of instruction. Cognitive task analysis, as input to the remaining instructional design activities, will give the instruction a different basis from what it would have with a traditional task analysis by providing a different set of skills, and skills at different levels of expertise.

Goals, Subgoals, Objectives

The specification of what one expects learners to be able to do is critical to instructional design, where much of the design process revolves around objectives. Needs assessment and task analysis inform the designer about what objectives to write. Test items and instructional activities are then developed to measure and facilitate achievement of those objectives. Instructional designers typically write measurable, performance-oriented learning objectives using words that indicate observable learner actions such as "to identify" and "to demonstrate." Cognitive psychologists do not seem to be particularly concerned with writing learning objectives, and when they do, they indicate less observable actions such as "to understand."

Low (1981) interprets Greeno's (1976) position on cognitive objectives to mean that objectives should be descriptions of content to be learned rather than descriptions of desired performance. Duchastel (1986) contends that highly specific instructional objectives are not suitable for the kinds of ill-defined domains with which intelligent tutoring systems are concerned. If the diagrams Greeno (1976) provides are to be interpreted as cognitive objectives, then a cognitive objective can be a diagram of a procedure for adding fractions. However, some cognitive psychologists contend that when such a procedure is turned into a three-part objective typical of instructional design, it is not a cognitive objective; because it is stated in measurable terms, it is behavioral.

The content to be learned and the objective generally have been separate entities, i.e, a statement of an objective does not necessarily include a full description of the content. Although objectives vary in the precision with which they are written, their purpose has been to communicate intended student performance. Descriptions of content communicate the elements and structure of what is to be learned. It is a good idea to specify both the objective and a description of the content to eliminate any assumptions that could be made about either one. Writing test items early in the design process has served this purpose in some instructional design approaches. Although one could interpret cognitive objectives as not including performance requirements, but instead focusing on the representation of what is to be learned, it would be a mistake to eliminate the performance statement because indices are needed to tell us whether the learner possesses the content or cognitive skill. The specification of objectives in terms of student performance has been a sign of progress in designing instruction, and to discontinue this practice would be ill-advised. Writing performance objectives is not behaviorist thinking; it is empirical. Perhaps what is needed is to combine the emphasis on content from cognitive psychology with the practice of writing objectives as indicators of measurable performance in order to get a more accurate picture of the desired end state of the learner.

A domain can be broken down into various pieces of knowledge, skills, and procedures. This is obviously more difficult for an ill-defined domain, such as interviewing, than for a well-defined domain, such as geometry. But being able to break a domain apart makes it manageable, and allows one to write objectives that indicate whether a learner has acquired some level of expertise in that domain. Knowing that experts and novices are qualitatively different in the knowledge and skills they possess allows the inference that one progresses through various levels of skill acquisition. Thus, it may be necessary to write objectives for the different levels. Traditionally, objectives have been written for the expert level of performance, and what is known about learner entry behaviors and characteristics has been used to design actitivies to bring the learner from the novice to the expert level. Except for testing a learner's prerequisite skills, formal data collection about novices has not been undertaken to support many instructional designs.

Measurement

By maintaining the practice of specifying objectives, but with an emphasis on cognitive objectives as indices of knowledge and skills, a head start in measurement is attained. Cognitive psychologists and measurement specialists are beginning to explore the issues related to the assessment of cognitive skills. According to Glaser, Lesgold, and Lajoie (in press), cognitive psychologists are interested in testing of a diagnostic nature, testing that provides information about a learner's level of competence and prescribes where he or she should go next in the instruction. Tests should be embedded within the instruction, and emphasis should be shifted from the analysis of test data to theory-based item writing. Instructional designers would agree with these ideas.

Types of Skills/Learning

An integral part of instructional design has been to classify objectives according to the kind of learning represented. A number of classification schemes, or learning taxonomies, exist, covering the range of possible skills (e.g., Gagné, 1985; Merrill, 1983). Classification facilitates the choice of instructional strategies. A shortcoming of existing taxonomies has been the lack of attention to interactions among learning domains. For example, in learning to interview a hostile client, both rule using and attitude learning are appropriate. Because objectives are classified as belonging to individual learning domains, the teaching of skills together may be neglected. Instructional design has addressed this issue, focusing primarily on the interactions among the cognitive, motor, and affective domains, which are seen as having supportive relationships (see Briggs & Wager, 1981; Martin & Briggs, 1986). Cognitive psychologists (Collins et al., in press) are concerned with the integration of cognitive skills, assuming that the student who can perform individual cognitive skills may not be able to perform different cognitive skills in combination.

Cognitive psychology is concerned with the study of complex mental processes such as problem solving as opposed to simple, procedural kinds of tasks. In studying problem solving, cognitive psychologists discover the declarative and procedural knowledge that experts and novices possess and determine which skills are automatic and which metacognitive skills govern the use of what each knows.

Cognitive psychologists sometimes develop a skills taxonomy that is domain specific. Specific kinds of declarative knowledge and procedural skills are identified, as well as problem-solving skills and metacognitive skills. For example, in studying electronics troubleshooting using a computer test station, analysts placed skills in the following categories: system understanding, component understanding, basic operations, intermediate operations, problem solving, and metacognitive skills (Means, Roth, & Riegelhaupt, 1986). During the task analysis, the analysts use the taxonomy to classify skills, which helps in their analysis of the skills. These classifications match up with the knowledge and skills in the cognitive psychology literature: declarative knowledge, procedural knowledge, problem solving (Anderson, 1985), and metacognitive skills (Flavell, 1976). The skills taxonomies of cognitive psychologists do not seem too different from the learning taxonomies of instructional designers.

One approach to using a skills taxonomy from a cognitive task analysis is to map it onto Gagné's (1985) learning domains. Gagné and Dick (1983) had this same idea. Figure 1 illustrates the mapping of cognitive and learning taxonomies. Many cognitive psychologists do not find this approach acceptable, largely because the classification leads to prescriptions about learning, a practice with which they disagree.

Sequencing Goals, Subgoals, Objectives

Van Patten, Chao, and Reigeluth (1987) recently published a review of sequencing methods. The designation of macro and micro sequencing is particularly helpful for thinking about this issue. Macro sequencing strategies are used to sequence lessons, units, or modules of instruction using, for example, Gagné's hierarchical structure, Reigeluth and Merrill's elaboration theory, or Bruner's spiral curriculum. Micro sequencing is concerned with the sequencing of instructional events such as presentation, examples, and practice.

White and Fredericksen (1985) are cognitive psychologists with an approach to sequencing that they refer to as progressions of qualitative models. In this approach, an expert's most complex cognitive model is broken down into a series of simpler models that are upwardly compatible. One example of this idea is in an electronic circuit tutor. Students are exposed to a series of increasingly complex circuit problems representing various levels of understanding of electronic circuit concepts. At each level, what the student knows is correct, but is only sufficient for solving certain kinds of problems. As students progress to other levels, they must add to or modify their knowledge in order to solve problems at that level. The concept of a progression of qualitative models is also being applied to an electronic troubleshooting tutor (Fredericksen, White, Collins, & Eggan, 1988).

The Reigeluth-Merrill elaboration theory (Reigeluth & Stein, 1983) proposes a sequencing approach similar to that of White and Fredericksen (1985) in that content is organized progressively from more general ideas to more detailed ones (from simple to complex). Neither of these approaches is entirely new to instructional design. Elaboration theory was influenced by other theories containing similar progressions—"Bruner's spiral curriculum, Ausubel's subsumptive sequencing, and Norman's web of learning" (Reigeluth & Stein, 1983, p. 337).

Means, Roth, & Riegelhaupt (1986)	*Cognitive Psychology Literature*	*Gagné (1985)*
System understanding Component understanding	Declarative knowledge	Verbal information
Basic operations Intermediate operations	Procedural knowledge	Intellectual skills
Problem solving	Problem solving	Problem solving
Metacognitive skills	Metacognitive skills	Cognitive strategies

FIGURE 1.
Mapping Taxonomies.

Learner Characteristics

Though there has been some interest in attribute treatment interaction (ATI) research, instructional design has not placed a great deal of emphasis on learner characteristics. This is always a sticky issue for instructional designers, who seldom have data about learners. It is generally difficult enough to get the time required for training, much less time to assess learner characteristics such as cognitive structure and prior knowledge. Learner characteristics have been dealt with in certain media selection models. For example in the Reiser-Gagné model (1983), questions address whether the learners are readers. Though designers consider what is known about learners to design learning activities, cognitive aspects of the learners are often neglected.

Instruction based on cognitive psychology is concerned with the learner's mental models, diagnosing and using them to bring the learner toward expertise. It is through experimentation with a domain that learning occurs. As the learner experiments, a tutor assesses what the individual knows and uses that knowledge as the basis for determining what needs to be learned and what instructional strategies to use. The concern is with the learner's existing schema and skills.

Instructional Strategies: Conditions of Learning and Media Selection

After determining the kind of learning one objective represents (information, rules, problem solving, etc.), and determining the instructional events (presentation, example, practice, etc.) that will comprise a lesson, the conditions of learning for implementing the events are determined. Cognitive psychologists object to this prescriptive part of instructional design. It seems to be a matter of who is in control, the instructional system or the learner. With a prescriptive system, the instruction is acting upon the learner, as opposed to the learner taking responsibility for learning. Wildman (1981) has suggested that an emphasis on the learner will require more teaching of learning strategies; this is one way to provide a means for the learner to take more responsibility for learning.

With the increase in computer-based delivery systems, learner control has become a more frequent research issue in instructional design. Duchastel (1986) has stated that learner control "is contrary in spirit to the design philosophy underlying traditional CAI systems," a comment which is applicable to other delivery systems as well. This author does not believe this is necessarily true; it depends on how creative the designer is in implementing the conditions of learning. Even when increasing learner control, the learner can be provided with activities that are based on the conditions of learning derived from research and theory about various kinds of learning. Interactivity is the key, and it is not necessarily synonymous with learner control.

In focusing more on the individual learner, designers must know more about the learner's knowledge, not only what the person knows that is correct, but also what he or she knows that is incorrect. Cognitive psychology has been concerned with diagnosing learners' misconceptions (Stevens, Collins, & Goldin, 1982; Putnam, 1987) and using them as the basis for tutoring. Instructional design has shown little concern for instructional strategies aimed at the treatment of misconceptions, except for the use of logical distractors in practice and test items, and the use of non-examples in teaching concepts.

A current emphasis in cognitively-based training is learning in the context of solving problems (Collins et al., in press). While solving problems, one can be learning declarative knowledge, procedural skills, problem-solving skills, and metacognitive skills that are both domain dependent and independent. The instructional designer would consider this to be providing a relevant context for learning when the problem-solving context is like the job environment for which one is being trained.

Instructional strategies and media selection usually occur together since there are trade-offs between them. Instructional designers are cognizant of the media selection problem and the large number of variables that can enter media selection decisions. Reiser and Gagné (1983) have offered a theory-based approach to media selection. Instructional design and instructional technology are inseparable. Instructional technology, as some professionals will point out, is concerned with the technology of the process and the theory base of instructional design as well as the variety of delivery systems. Instructional design maintains its practice in the forefront of advances in instructional delivery systems with computer-assisted instruction (CAI), interactive videodisc, and intelligent CAI (ICAI). Cognitive psychologists prefer the term intelligent tutoring systems to ICAI (Anderson et al., 1984).

Rather than showing an interest in all of the available media, cognitive psychologists are primarily showing an interest in the human as a medium and the computer as a medium. These media choices are influenced by their concern with higher levels of learning such as problem-solving and metacognitive skills. Some believe the best way to teach these kinds of skills is through a cognitive apprenticeship approach, which has been modeled in three methods: Palincsar and Brown's reciprocal teaching of reading, Scardamalia and Bereiter's procedural facilitation of writing, and Schoenfeld's mathematical problem solving (Collins et al., in press). This concern for cognitive apprenticeship underlies the interest in the human and the computer as two media suitable for applying tutoring methods to instruction. The advantage of the intelligent tutor is that it can emulate human tutors in addition to offering the advantages of computer-based media.

Formative Evaluation

Instructional designers have used two approaches to formative evaluation, the learner tryout approach (Dick, 1977) and the expert review type of approach such as the Instructional Quality Inventory (1978–80). In the expert review type of approach, instruction is evaluated against guidelines regarding aspects of the materials such as sequencing and instructional strategies. One way to use cognitive theory in formative evaluation would be to develop guidelines for instruction based on cognitive theory and use them to evaluate materials. The learner tryout approach could remain theory free.

Cognitive theorists have not proposed any specific procedures for formative evaluation. Presumably they can use the same kinds of approaches mentioned here that are used in instructional design. What they will need to consider is going beyond the debugging of instructional programs, and gathering enough learner data that allows them to state confidently that the instruction "works."

SUMMARY

For each of the topics in this article, the following statements summarize the similarities and differences in the approaches of cognitive psychology and instructional systems design. Table 1 contains a keyword comparison of these approaches.

Task Analysis

There are three basic differences between cognitive task analysis and instructional systems task analysis:

- Cognitive skills that are unobservable and of which people may not be aware are revealed in a cognitive task analysis, whereas instructional designers would not be as likely to focus on these kinds of skills.
- The methods used in cognitive task analysis are different from those used in instructional design, e.g., SMEs are asked to generate and solve problems rather than name the kinds of problems that would be encountered on the job, and the skills required to solve them.
- Cognitive task analysis includes the study of various levels of expertise from novice to expert, whereas instuctional designers have concerned themselves with studying how experts perform.

Goals, Subgoals, Objectives

Cognitive psychologists focus more on describing the content to be learned, and instructional designers focus more on describing the performance that will serve as an indicator that learning has occurred. Instructional designers focus on breaking content apart, then building on subskills to reach the larger skill, while cognitive psychologists focus on the larger skill and learning other skills in the context of learning the larger skill.

TABLE 1
Comparison of Cognitive Psychology and Instructional Design

Cognitive Psychology	Instructional Design
TASK ANALYSIS	
Unobservable, subtle tasks	Observable, obvious tasks
Method—e.g., SME talks-through problem solving	Method—e.g., SME identifies required skills
Studies levels of expertise	Studies experts
GOALS, SUBGOALS, OBJECTIVES	
Content oriented	Performance oriented
Whole-part oriented	Part-whole oriented
MEASUREMENT	
Diagnostic	Mastery
Learn and test simultaneously	Learn, then test
TYPES OF SKILLS/LEARNING	
Cognitive skill taxonomy	Comprehensive learning taxonomy: cognitive, motor attitude
Integration of cognitive skills	Interactions
SEQUENCING GOALS, SUBGOALS, OBJECTIVES	
Qualitative model progressions	Macro & micro levels—e.g., hierarchies, curriculum mapping, logical guidelines, spiral curriculum, elaboration theory
Logical guidelines	
LEARNER CHARACTERISTICS	
Based on task analysis data	Based on informal data and assumptions, testing of prerequisites
Mental models, schemata	Entry behaviors and characteristics, ATI research findings
Views learner as "dirty slate"	Views learner as "clean slate"
INSTRUCTIONAL STRATEGIES, LEARNING ACTIVITIES	
Cognitive apprenticeship/problem-solving context	Prescriptions dependent on kind of learning
Interventions based on misconceptions	Misconceptions used for item distractors, non-examples
MEDIA SELECTION	
Intelligent tutoring systems	Variety of delivery systems
Human tutor	
FORMATIVE EVALUATION	
No formal approach	Student tryout procedures, expert review procedures, research

Measurement

The focus in cognitive psychology promises to be of a diagnostic nature, with less separation between the testing and learning situations than has been the case traditionally. Instructional designers have taken more of a mastery approach in which one skill is learned before another skill is attempted. This mastery approach is not congruent with the cognitive psychologist's view of how learning occurs.

Types of Skills/Learning

The skill taxonomies of cognitive psychologists are not drastically different from instructional design taxonomies. Cognitive psychologists are focusing on the integration of cognitive skills, and on the acquisition of the higher level skills. Skill integration has not been as explicit a concern in instructional design as in cognitive psychology, though domain interactions have been addressed. Instructional designers will continue to be concerned with cognitive skills as well as motor and attitude learning. Instructional designers have not shown as much concern for metacognitive skills, especially as integrated with subject matter, as cognitive psychologists have shown.

Sequencing Goals, Subgoals, Objectives

Cognitive psychologists rely on many of the same sequencing guidelines as instructional designers. The idea of a progression of qualitative models may be only a variation on an old idea. Instructional designers have more of a concern with both macro and micro levels of sequencing because of their tendency to break apart and organize the components of instruction.

Learner Characteristics

Instructional designers have shown an interest in learner characteristics through the study of aptitude treatment interactions. Of course, all instruction is not based on the findings of ATI research. In practice, instructional designers gather informal data, make assumptions about learner characteristics, and assess entry behaviors. Cognitive psychologists are more concerned with determining the learner's mental models and schemata than instructional designers, who tend to treat the learner like a "clean slate."

Instructional Strategies, Learning Activities

Instructional designers rely on a prescriptive method of determining appropriate strategies for different types of learning. Cognitive psychologists focus on learning in a problem-solving context, and on cognitive apprenticeship as modeled in the methods of Palincsar and Brown, Scardamalia and Bereiter, and Schoenfeld. The concern in cognitive psychology for diagnosing learner misconceptions is in diagnosing them to use as a basis for tutoring. In instructional design, the use of misconceptions has manifested itself through the use of distractors in test and practice items, and through the provision of non-examples in concept and rule learning.

Media Selection

Media selection has not been a concern for cognitive psychologists; though CAI is not popular, intelligent tutoring systems are. Human tutors are also a preferred medium. Media selection continues to be a theoretical and practical concern for instructional designers, who are proponents of a variety of media.

Formative Evaluation

Cognitive psychologists have no formal approach to formative evaluation. Instructional designers have procedures for, and research investigating, both expert review and student tryout approaches.

CLOSING COMMENTS

Generally, when it comes to designing training, cognitive psychologists and instructional designers do not understand each other very well. The unfortunate thing about this is the limitation it imposes on progress in understanding learning. The purposes of instructional designers, although similar in that they aim toward understanding learning, are quite different. Instructional designers look for practical solutions to training people efficiently, which means quickly and at low cost. Cognitive psychologists are concerned primarily with the study of cognition and learning. Thus, the instructional designers' framework is different from that of cognitive psychologists. Instructional designers use the same framework to study instruction that they use to design instruction. Much of what is recommended, whether it is based on behavioral research, cognitive research, or common sense, is the same—an interesting phenomenon.

Outside of the systems approach, an aspect of instructional design to which cognitive psychologists object is computer-based instructional design systems. Some instructional designers have a problem with this idea as well. It is the world view issue. The instructional design process may be considered too complex to automate, partly because the learning process is viewed as complex. This is one place where this instructional designer could not agree more with the cognitive psychologists. This opinion stems from the complex way in which learning is viewed. Designers must be aware of what they stand to lose in developing instruction and what learners stand to lose in the instructional situation when designers try to simplify something as complex as learning. What designers need to ask about computer-based design is what the intentions are. If the goal is to provide the instructional designer with some tools for maintaining an audit trail of the product's development, perhaps these systems are legitimate. (Even so, it is likely that existing software would serve the purpose.) But if the purpose of computer-based instructional design systems is to make instructional designers and developers out of SMEs, the value of these systems is questionable. A similar view is held by many people in regard to computer-assisted instruction authoring systems—one can create a lot of boring instruction with them.

A well-known educational psychologist said that cognitive psychologists advocate old methods such as Socratic tutoring, and he does not agree that these are effective methods (Merrill, 1986). In addition, he stated that intelligent tutors were good for studying learning but not a viable delivery system. On the other side, a well-known cognitive psychologist has said that instructional systems designers have the wrong world view because they want to deliver subject matter to students instead of presenting them with an environment where they can make contact with the subject and learn it on their own (Collins, 1987). Both of these psychologists have good points. The fact that instructional designers examine cognitive psychology in the ISD framework indicates at least a partial adoption of cognitive theory. One's framework influences one's larger perspective; it constrains the way one thinks about learning, and that is not an entirely negative influence. The positive side is that one's framework provides a clear and organized way to approach learning problems. The ISD approach gives others the impression that instructional designers view learners as repositories, but that is not necessarily the case. Advocates of this approach have seen too much instruction where learners are left to muddle around until they accidentally learn something in spite of the poor presentation and disorganization of the learning situation. Instructional design is about making learning relevant and efficient, and about making teaching effective. Instructional design undoubtedly will remain an eclectic practice that will draw from cognitive psychology as well as other disciplines, and this selective variety will continue to be viewed as a strength.

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