35

Whole-Task Models in Education

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CONTENTS

ABSTRACT

Whole-task models support the development of educational programs for students who need to learn and transfer professional competences or complex cognitive skills to an increasingly varied set of real-world contexts and settings. They are a reaction to traditional atomistic approaches in which complex contents and tasks are reduced into increasingly simpler elements until reaching a level where the distinct elements can be transferred to the learners through presentation or practice. These approaches work well if there are few interactions between the elements, but they do not work well if the elements are interrelated because the whole is then more than the sum of its parts. Whole-task models basically try to deal with complexity without losing sight of the relationships between elements. This chapter briefly discusses the history of whole-task models. They are rooted in motor learning and sports, *andragogy* and adult learning, and Gestalt psychology. The characteristics of whole-task models in the field of educational communications and technology are also discussed. Elaboration theory, goal-based scenarios, and four-component instructional design are presented as three representative examples of whole-task models. We present empirical evidence for the effectiveness of the whole-task approach and the three example models. We conclude with a summary of findings and directions for future research on whole-task models.

KEYWORDS

Competence development: A feature of the holistic approach, indicating that educational programs should be aimed at the development of competences rather than teaching different topics in different courses.

Integrated curriculum: A curriculum based on a whole-task approach aimed at the integration of supportive contents with whole tasks, knowledge, skills, and attitudes and at integrating first-order skills with higher-order skills.

Mathemagenic methods: Instructional methods that explicitly aim at the transfer of learning; these methods encourage learners to invest effort and time in the development of general or abstract cognitive schemas.

Part-task models: Instructional models that apply an atomistic approach in which complex contents and tasks are reduced into increasingly simpler elements until reaching a level where the distinct elements can be taught to the learners.

Whole-task models: Instructional models that apply a holistic approach in which complex contents and tasks are analyzed in coherence and taught from their simplest, yet still meaningful, version toward increasingly more complex versions.

> There are contexts in which what is happening in the whole cannot be deduced from the characteristics of the separate pieces, but conversely what happens to a part of the whole is, in clearcut cases, determined by the laws of the inner structure of its whole. (Max Wertheimer, 1925)

INTRODUCTION

In the 21st century, there has been a growing interest in whole-task models of learning and instructional design. In dealing with the learning of highly complex contents and tasks, whole-task models provide an alternative for atomistic, part-task models. To deal with complexity, atomistic models analyze a learning domain into smaller pieces and then teach the domain piece by piece. Whole-task models, in contrast, analyze a learning domain as a coherent, interconnected whole and then teach it from very simple, yet meaningful wholes that are representative for the whole domain to increasingly more complex wholes. They aim to solve three basic problems in education—namely, *fragmentation*, indicating that students are often not able to combine the many pieces they have learned into coherent wholes; *compartmentalization*, indicating that students have difficulties integrating acquired knowledge, skills, and attitudes; and low *transfer of learning*, indicating that learners are often not able to apply what they have learned to new problems and new situations (van Merriënboer, 2006).

The game of tennis may serve as an example to contrast a whole-task with a part-task approach (Gallwey, 1974). In a part-task approach, practice divides the activity into pieces that are not complete in themselves; the instructor focuses on teaching the student isolated components of good tennis playing such as the grip, the stance, and the swing. A holistic approach, in contrast, works with a complete pattern of activity; that is, practice takes place in the context of the whole task, starting simply and gradually growing in complexity toward the activity being trained. As described by Strauch (1984), it might start with the student on one side of the net holding a racket and the instructor on the other side of the net. The student's first task might be to say "toss" to signal the instructor to throw the ball and to say "bounce" when the ball bounces in the student's court. The second task might be to say "toss," after which the instructor begins a toss but does not complete it; the student says "toss … bounce" anyway, anticipating continuation of the past pattern. The third task might be to say "toss" to signal the instructor to throw the ball, to say "bounce" when the ball bounces, and to say "hit" when the student would hit the ball but without making an attempt to actually hit it, and so on.

This chapter first briefly discusses the history of whole-task models. They are rooted in motor learning and sports but also in andragogy and adult learning, as well as in Gestalt psychology. Second, the characteristics of whole-task models in the field of educational communications and technology, which only became popular in the early 1990s, are discussed. Third, elaboration theory, goal-based scenarios, and four-component instructional design are presented as three good examples of whole-task models. The fourth section provides empirical evidence for the effectiveness of the whole-task approach and three example models. In the fifth and final section, conclusions are made and directions for future research on whole-task models are suggested.

BRIEF HISTORY OF WHOLE-TASK MODELS

In the field of educational communications and technology, interest in whole-task models only became evident in the late 1980s and early 1990s, but it has a much older history that is rooted, among others, in motor learning, andragogy, and psychology. In motor learning and sports, there is a history of comparing part-task and whole-task sequencing techniques for practice. In andragogy and adult learning, there is a history of holistic education and approaching the student as a whole person rather than as a learner *per se*. And, in psychology, an atomistic approach to the transfer of learning rooted in associationism has competed for a long time with a holistic approach rooted in German Gestalt psychology.

Motor Learning and Sports

The field of (psycho)motor learning has a long-lasting tradition of comparing whole-task and part-task approaches to sequence training (for reviews, see Schmidt, 1991; Wightman and Lintern, 1985). In a whole-task sequence, the learner is taught whole meaningful tasks requiring the simultaneous coordination of component skills, and the tasks become more and more complex during the training. In a part-task sequence, in contrast, the learner is taught only one or a very limited number of isolated component skills simultaneously, and new component skills to practice are gradually added. If a skill consists of the component skills A, B, and C, a further distinction can be made between a part-task sequence with forward chaining (practice A, then B, then C); a part-task sequence with backward chaining (practice C given the results of AB, then B given the results of A, then A); a part-task sequence with forward chaining and snowballing (practice A, then AB, then ABC); and a part-task sequence with backward chaining and snowballing (practice C given the results of AB, then BC given the results of A, then ABC). For example, if A, B, and C refer to driving off, maneuvering, and parking, the training schedules involve, in this order: (1) driving off, maneuvering, and parking; (2) parking after the instructor does the driving off and maneuvering, maneuvering after the instructor does the driving off, and driving off; (3) driving off, driving off and maneuvering, and driving off and maneuvering and parking; and, finally, (4) parking after the instructor does the driving off and maneuvering, maneuvering and parking after the instructor does the driving off, and, finally, driving off, maneuvering, and parking.

Furthermore, whole-task and part-task sequencing may be combined in two ways—namely, whole-part sequencing and part-whole sequencing. In whole-part sequencing, a sequence of simple to complex versions of whole tasks is developed first. If it turns out that the first whole task is still too difficult to start the training with, part-task sequencing techniques are used to divide this whole task and, if desired, subsequent whole tasks in parts. A whole-task sequence, for example, may pertain to driving a car in a training area, in a rural area, and in a city. If driving the car in the training area is still regarded as too difficult to start the training with, one might start with the component skill of *driving off* in the training area. In part-whole sequencing, a sequence of parts is developed first. If the first part is too difficult to start the training with, whole-task sequencing is used to sequence this part from simple to complex. For example, if the part-task sequence relates to driving off, maneuvering, and parking, and driving off is still regarded as too difficult to start the training with, one might start with driving off an automatic car and only then a stick-shift car.

Already in the 1960s, Briggs and Naylor (Briggs and Naylor, 1962; Naylor and Briggs, 1963) found that part-task and part-whole sequencing are most suitable for complex skills if little coordination of component skills is required (i.e., low task organization) and if each of the separate component skills is already complex of itself (i.e., high task complexity). But, for tasks with high task organization, whole-task and whole-part approaches are typically more effective. This finding is not only true for complex motor skills but also for many professional real-life tasks. Since the 1960s, overwhelming evidence has been obtained showing that breaking a complex task down into a set of distinct parts and then teaching or training those parts without taking their interactions and required coordination into account does not work because learners ultimately are not able to integrate and coordinate the separate parts in transfer situations (Clark and Estes, 1999; Perkins and Grotzer, 1997; Spector and Anderson, 2000). Performing a particular component skill in isolation is simply different from performing it in the context of a whole task. It seems to lead to different mental representations (Elio, 1986), and automaticity of a component skill that is developed as a function of extensive part-task practice is often not preserved in the context of whole-task performance (Schneider and Detweiler, 1988).

Whole-task models were developed in sports and in professions (Dreyfus, 1982; Feldenkrais, 1982; Strauch, 1984). One key issue in those models is how to deal with task complexity. Most holistic approaches introduce some notion of modeling to attack this problem. A powerful two-step approach to modeling first develops simple-to-complex models of reality or real-life tasks, and then models these models from a pedagogical perspective to ensure that they are presented in such a way that students can actually learn from them (Achtenhagen, 2001). Thus, in this view, instruction should ideally begin with a simplified but whole model of real-life task performance, which is then conveyed to the learners according to sound pedagogical principles, including, for example, the provision of learner guidance and support.

Concluding, part-task models have been found to be very effective to reduce task difficulty, but they hinder integration of knowledge, skills, and attitudes and limit the opportunities to learn to coordinate component skills. Whole-task models are better suited to learning to coordinate component skills and are preferred for tasks with a high level of organization. To deal with task complexity, simplification of the whole task and giving learners support and guidance are useful approaches.

Andragogy and Adult Learning

Whereas researchers in the field of motor learning and sports stress the idea of the whole *task*, researchers in the field of andragogy and adult learning mainly emphasize the idea of the whole *person* in his or her context. Holistic education is defined as (Rinke, 1985, p. 67):

> A functional, integrated and generalized model of education that focuses on the whole teaching-learning situation, and varies the teaching-learning strategy to meet the needs of the learner, the teacher and the situation in an effort to attain educational outcomes greater than the sum of their parts.

This approach is rooted in Holism (Smuts, 1926) and related to, for example, the contingency approach in management, which maintains that managers should vary their leadership style in accordance with the situation to improve managerial effectiveness (Graen and Hui, 2001) and holistic medicine (Graham-Pole, 2001), which avoids the piecemeal treatment of isolated symptoms and regards the patient as a whole person who is co-responsible for his or her own health care.

A first characteristic of this holistic approach is the focus on the whole person and his or her meaningful, situated behaviors in real settings. To make this point clear, suppose you have to undergo surgery. Would you prefer a surgeon with great technical skills but with no knowledge of the human body? Or would you prefer a surgeon with great knowledge of the human body but with two left hands? Or, perhaps you would want a surgeon with great technical skills but who has a horrible bedside manner and a hostile attitude toward his patients? Or, finally, would you want a surgeon who has all of the knowledge, skills, and attitudes that he learned 35 years ago but has not kept them up to date? These questions clearly indicate that it makes little sense to distinguish domains of learning (e.g., conceptual knowledge, skills, attitudes), as is often done in formal educational programs. In a holistic approach, this compartmentalization of behaviors is replaced by a focus on whole and meaningful behaviors in realistic settings, and the learning of distinct pieces of knowledge is replaced by a model of personal development and growth.

A second characteristic pertains to the co-responsibility of the learner: The educator and the learner always work together to approach each learning task or learning opportunity with its unique characteristics (e.g., context, features of the task, personality characteristics) in the best possible way. Because no one knows a learner's desires, needs, and capabilities better than the learner, co-responsibility is a prerequisite to maximizing the effectiveness of the learning process. Furthermore, learners are also expected to assume responsibility for becoming lifelong learners who are able to realize their full potential. Thus, whereas the educator is responsible for diagnosing the learner's current level of competence, including readiness to learn and degree of dependence, and for making every effort to move the learner along the learning continuum, the holistic educator does not and cannot take full responsibility for the actual learning process. This view is currently found in several forms of on-demand education, in which learners select their own learning tasks (van Merriënboer and Kirschner, 2007), and in resource-based learning, in which learners are required to track their own learning resources (see Chapter 40 in this *Handbook*).

A third and last characteristic pertains to the systemic character of educational systems, meaning that the performance or function of each element directly or indirectly has an impact on, or is impacted by, one or more of the other elements in the system. To deal with that, a holistic approach takes an integrated perspective and repeatedly adds small increments of innovation and uses multiple strategies to capitalize on their synergy. Poindexter (2003) compared it to a weight-loss program: People who try one diet, one pill, or one exercise usually do not achieve their goals. Only when a holistic approach to health is taken, including incremental changes in eating, drinking, life style, and exercise, do weight loss and fitness occur. In educational systems, the best example of a failing nonholistic approach can be found in the use of new instructional methods that focus on deep processing, understanding, and higher-order skills without changing the assessment system. Such isolated changes are doomed to fail, because the test is at least as important to determine learning behaviors as the applied instructional methods (i.e., the tail wags the dog; see Pollio and Back, 2000). To reach desired results, there should be constructive alignment of changes throughout the whole educational system (Biggs, 1996).

To conclude, in the field of andragogy and adult learning, whole-task models are mostly found in a holistic approach. Apart from a focus on whole tasks, this approach stresses development and growth of the whole person, co-responsibility of the learner and the teacher, and an integrated approach to systemic change.

Psychology and Transfer of Learning

In the field of experimental psychology, the distinction between part-task models and whole-task models becomes most evident in research on transfer of learning—that is, the ability to apply what has been learned to solving new problems in new situations (for reviews, see Adams, 1987; Annett, 1989; Annett and Sparrow, 1985; Ellis, 1965; Osgood, 1949; Royer, 1979). In the beginning of the 20th century, two approaches evolved that are still of importance to the issue of transfer of learning: the associationist approach, which is representative of a part-task model, and the Gestalt approach, which is representative of a whole-task model.

Within the associationist tradition, the identical elements theory of Thorndike and Woodworth (1901) claimed that transfer from one task to another task would only occur when both tasks shared the same parts, called *identical elements*. In general, it is assumed that the greater the number of identical parts, the greater the amount of transfer. This construction indicates that transfer is functionally related to the similarity and difference relationships between stimuli and responses in an original task and a transfer task. With respect to the transfer of learning, one current cognitive view tackles transfer problems by carefully analyzing the stimulus and response properties of the learning elements. These stimulus–response pairs are subsumed in the concept of production systems, in which the productions may also be seen as the identical parts. Transfer is predicted in so far as the performance of two tasks can be described by identical productions (Singley and Anderson, 1985, 1988). This is clearly in the tradition of the associationist approach, because it is assumed that events that share the same parts will be recognized by the learner as being similar and that the responses learned for the first event can be transferred to the second event.

Unlike the associationists who consider the concept of identical elements as the determining factor for transfer of training, Gestalt psychologists rely on mental structures that act as a "gestalt"—a whole that is more than the sum of its parts. They consider the thinking process as reorganizing or relating one aspect of a problem situation to another, which may result in structural understanding (Ash, 1998; Mandler and Mandler, 1964). This involves restructuring the elements of a whole, meaningful problem situation in a new way so a problem can be solved. Gestalt psychologists hold that transfer from one task to another is achieved by arranging learning situations so a learner can gain insight into the problem to be solved. This type of learning is thought to be permanent, and reorganized knowledge may yield transfer to new situations. Some current cognitive views also make strong assumptions about the nature of underlying memory representations. The central assumption is that learners are conceptualized as active constructors of knowledge rather than as passive recipients of information; they actively seek to make sense of the environment by imposing structure and order on stimuli encountered through direct perception and experience. Memory is conceptualized as a highly structured storage system in which information is both stored and retrieved in a systematic manner. The critical step in transfer is then the retrieval and reorganization of a relevant cognitive schema when a particular problem is encountered.

It may seem impossible to reconcile a psychological whole-task model, which explains transfer of learning as a process of interpreting cognitive schemas to reorganize whole meaningful problem situations, with a part-task model, which explains transfer as a process of applying parts (i.e., identical elements or productions) that were acquired during learning tasks to new transfer tasks. But, the fundamental distinction between controlled and automatic cognitive processing (Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977) creates the opportunity to combine both approaches in a model that distinguishes two categories of learning processes: schema construction and schema automation. For task aspects related to problem solving and reasoning, the learner is then confronted with a varied sequence of whole-task situations promoting the construction of general cognitive schemas that allow for controlled processing, such as reorganizing a new situation in such a way that it can be understood in terms of the available schemas (whole-task practice). With regard to the to-be-automated task aspects, however, the learner may *in addition* be confronted with a repetitive sequence of practice items promoting the construction of stimulus–response pairs or productions that allow for automatic processing, such as performing routine aspects of new transfer tasks (part-task practice). The reader is referred to van Merriënboer (1997) for an elaborate discussion.

WHOLE-TASK MODELS IN EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY

Part-task models dominated the field of educational communications and technology until the late 1980s. From then on, constructivist views of learning and instruction have had a major impact on the thoughts and actions of many researchers in the instructional design field. Within this context, some researchers started to work on instructional design models building on the research traditions discussed in the previous section. These models share three characteristics. First, whole meaningful tasks are seen as the driving force for learning; easy-to-difficult sequencing techniques and learner support and guidance, which may be faded as learners acquire more expertise (i.e., scaffolded), are studied as methods to deal with task complexity. Second, there is a focus on the development of the whole person (i.e., learner-centered) rather than the acquisition of isolated pieces of knowledge, and the learner is co-responsible for a process of competence development. Third, there is a renewed interest in the study of instructional methods that explicitly aim at transfer of learning.

The Integrated Curriculum

In the field of educational communications and technology, the traditional approach has for a long time been very similar to the atomistic part-task approach in motor learning and sports. Rather than breaking down a complex learning domain into component skills, it was described in terms of distinct learning goals or objectives. In a traditional objectives-driven approach (Gagné and Briggs, 1979; Landa, 1983; Scandura, 1983), the learner is taught only one or a very limited number of objectives at the same time. New objectives are gradually added to practice until all objectives have been treated. The basic assumption is that the teaching of different types of objectives (e.g., remembering a fact, applying a procedure, understanding a concept) requires different instructional methods, which is typical for outcomes-based models of instructional design (see Chapter 32 in this *Handbook*). To sequence the objectives, some kind of learning hierarchy is often used (Gagné, 1968, 1985). Such a hierarchy closely resembles a hierarchy of component skills; it has the most complex cognitive skill at its top and all of its prerequisite skills below it. Sequencing takes place from the base of the hierarchy to its top.

In the early 1990s, Gagné and Merrill (1990) identified the need to use learning goals that require an integration of multiple objectives. They proposed the term *enterprise* to denote a real-life learning activity (e.g., denoting, manifesting, discovering) in which the learner is engaged to reach such multiple objectives, and they stress the importance of enterprises to reach better transfer of learning. Their enterprises are good examples of what are referred to as *whole tasks* in this chapter, because they attempt to deal with complexity without losing sight of the separate elements and the interconnections between those elements. Van Merriënboer et al. (1992) discussed the requirements that had to be met when using whole learning tasks. They focus on the importance of sequencing whole, meaningful tasks from simple to complex and on the necessity to give learners support and guidance when they start to work on tasks at a higher level of difficulty.

Competence Development

Atomistic instructional design models usually focus on one particular domain of learning, such as the cognitive, the affective, or the psychomotor domain. A further distinction (e.g., in the cognitive domain) is the differentiation between models for *declarative learning*, with an emphasis on instructional methods for the construction of conceptual knowledge, and models for *procedural learning*, with an emphasis on methods for the acquisition of procedural skills (Andrews and Goodson, 1980). In contrast, a holistic approach aims at the *integration* of declarative learning, procedural learning (including perceptual and psychomotor skills), and affective learning (including the predisposition to keep all of these aspects up to date) and so facilitates the development of an integrated knowledge base that increases the chance that transfer of learning occurs. Many superordinate terms that encompass knowledge, skills, and attitudes have been proposed in the literature, including *expertise*, *complex skills*, and (professional) *competences*.

In current whole-task models, final attainment levels are often described in terms of competences. On the basis of a comprehensive, analytical study on the concept of competence, van Merriënboer et al. (2002) concluded that three dimensions are basic to the use of this term. The first dimension, *integrativity*, indicates that competence always combines knowledge, skills, and attitudes as well as aptitudes of the task performer. The second dimension, *specificity*, indicates that a competence is always bound to a context that can be highly specific (e.g., a profession) or more general (e.g., a career). The third dimension, *durability*, indicates that a competence is more or less stable in spite of changes in tools, working methods, and technologies.

Whole-task educational programs or integrated curricula often aim at the simultaneous development of first-order, professional skills as well as higher order, general skills such as self-directed learning—including reflection on and assessment of one's own performance, self-monitoring of task performance, and planning one's own learning trajectories. In such programs, learners are able to select their own learning tasks, so each individual learner has his or her own curriculum rather than having a one-and-the-same curriculum for all learners. In such a form of on-demand education, support and guidance given by the teacher are not limited to performing the learning tasks but are also directed toward orienting, monitoring, assessing, and planning the learning tasks.

Mathemagenic Methods

A logical result of using distinct learning objectives as the basis for instructional design is the application of instructional methods that minimize the number of practice items required, the time spent on the task, and the learners' investment of effort made to reach those objectives. Designing and producing practice items costs time and money, which are often scarce, and the learner does not have unlimited time or motivation to study. Consider the situation where students must learn to diagnose three different types of errors (e1, e2, and e3) in a complex technical system. If a minimum of three practice items is required to learn to diagnose each error, one may first train the students to diagnose error 1, then to diagnose error 2, and finally to diagnose error 3. This leads to the following training blueprint:

e1, e1, e1, e2, e2, e2, e3, e3, e3

Although this practice schedule will probably be most efficient for reaching the three objectives, thus minimizing the required time on task and student investment of effort, it also yields a *low* transfer of learning. The reason for this is that the chosen instructional method invites students to construct highly specific knowledge for diagnosing each distinct error, which only allows them to perform in the way specified in the objectives but not to show performances that go *beyond* the given objectives. If a designer is aiming at a transfer of learning, and the objective is to train students to diagnose as many errors as possible in a technical system, it is far better to train the students to diagnose the three errors in a random order. This leads, for example, to the following training blueprint:

e3, e2, e2, e1, e3, e3, e1, e2, e1

This sequence is probably less efficient for reaching the three isolated objectives than the previous one because it may increase the necessary time on task or the investment of effort by the learners. It might even require four instead of three practice items to reach the same level of performance for each separate objective. But, in the end it yields *higher* transfer of learning! The reason for this increase of transfer is that this instructional method invites students to construct knowledge that is general and abstract rather than entirely bound to the three concrete, specific errors. This better allows them to diagnose new not earlier encountered errors. This phenomenon—where the methods that work the best for reaching isolated, specific objectives are often not the methods that work best for achieving integrated objectives and increasing the transfer of learning—is known as the *transfer paradox* (van Merriënboer et al., 1997, 2006). A whole-task approach takes this paradox into account and is always directed toward reaching multiple, integrated objectives that go beyond a limited list of highly specific objectives. Whole-task approaches are characterized by the use of mathemagenic instructional methods that are accompanied with a germane cognitive load (see Chapter 31 in this *Handbook*) and give rise to meaningful learning and transfer.

EXAMPLES OF WHOLE-TASK MODELS

Based on a study of a variety of modern design theories and models, Merrill (2002a) suggested five *first principles of instruction*, stating that learning is promoted when: (1) learners are engaged in solving real-world problems, (2) new knowledge is applied by the learner, (3) new knowledge is integrated into the learner's world, (4) existing knowledge is activated as a foundation for new knowledge, and (5) new knowledge is demonstrated to the learner. The characteristics of whole-task models are clearly reflected in the first three principles.

TABLE 35.1
Overview of Elaboration Sequences in Elaboration Theory

	Conceptual	Theoretical	Procedural
Learning goal:	Learning many related concepts	Learning many related principles	Learning procedural or heuristic tasks
Sequence:	Teach broader, inclusive concepts before narrow, detailed concepts	Teach broader, inclusive principles before narrow, detailed principles	Teach simpler versions of the whole task before complex versions
	All Sequences		
Instructional approach:	Topical or spiral sequencing Integrate knowledge, skills, and attitudes Group wholes into learning episodes Give learners some control over contents/instructional method		

The first principle emphasizes that students learn better when they are involved in solving increasingly more complex real-world problems. This closely resembles a whole-task approach as well as the idea that tasks should be ordered from simple to complex, while the support and guidance given to learners decrease as they acquire more expertise. The second principle acknowledges the importance of applying newly acquired competences in real-life situations and reflects the importance of mathemagenic instructional methods that facilitate the transfer of learning. The third principle stresses the importance of integration. It is in agreement with the idea of competence growth in an integrated curriculum in which learners are co-responsible for their learning, as opposed to the one-way teaching of distinct pieces of knowledge, skills, and attitudes.

In this section, we briefly describe three example models. It is not our intention to provide an exhaustive overview of models but only to discuss a small number of models that are representative of the family of whole-task models. First, a description is given of *elaboration theory*. This forerunner of current whole-task models stresses the notion that working from simple to complex is a *sine qua non* for a whole-task approach. Second, a description is given of *goal-based scenarios*. This theory focuses on the importance of real-world applications and the transfer of learning. Finally, *four-component instructional design* is discussed as an example of a theory trying to implement all basic principles of the whole-task approach.

Elaboration Theory

Reigeluth's elaboration theory (Reigeluth, 1987, 1999; Reigeluth and Stein, 1983; Reigeluth et al., 1980; Van Patten et al., 1986) can be seen as a forerunner of the whole-task approach in educational communications and technology. The basic principle of this theory is that instruction should be organized from the simplest representation of the learning domain or task (i.e., the *epitome*, which contains the most fundamental and representative ideas at a concrete level) to increasingly more complex and elaborated representations. Originally, the theory focused on the sequencing of instructional content in conceptual and theoretical domains.

The conceptual elaboration sequence (see left column in Table 35.1) emphasizes the superordinate, coordinate, and subordinate relationships among concepts. The concept of *dog*, for example, is subordinate to *pet*, coordinate to *cat*, and superordinate to *poodle*. In a process of conceptual analysis, a conceptual knowledge structure or taxonomy is made of the learning content. This structure is translated to an elaboration sequence in which the broadest, most inclusive concepts are taught first, including the supporting content (i.e., relevant knowledge, skills, and attitudes) related to them, and subsequently the ever more narrow, detailed concepts are taught together with related supporting content. Typical approaches to sequencing are topical and spiral. In a topical approach, the content is presented in a vertical manner; for example, a student first studies the sequence pet–dog–poodle, then pet–cat–tabby, and so forth. A spiral approach, in contrast, reflects a horizontal method; for example, a student first studies the sequence pet–…, then dog–cat–…, then poodle–tabby–… and so on.

The theoretical elaboration sequence (see middle column in Table 35.1) focuses on interrelated sets of principles. An introductory course on psychology, for example, focuses on principles of human anatomy and physiology, elementary statistics, genetics, culture, and so forth. In a process of theoretical analysis, a structure is made of the learning content. Such a structure differs from a causal model because it shows principles that are elaborations of other principles, while a causal model shows principles that combine with other principles. The theoretical elaboration sequence that is derived from the theoretical structure first teaches, topically or spirally, the broadest, most inclusive and most general principles along with the supporting content, and then proceeds to teach ever more narrow, less inclusive, more detailed, and more precise principles and supporting content.

Elaboration theory clearly reflects some basic principles of whole-task models. The topical and spiral approach to sequencing works from simple to complex wholes. The combination of organizing content (conceptual, theoretical) and supporting contents aims at the integration of knowledge, skills, and attitudes. The concept of *learning episodes* is used to denote instructional units that allow for review and synthesis without breaking up the idea of a meaningful whole. And, finally, elaboration theory suggests giving learners some control over both content and instructional methods, which resembles the principle of shared responsibility. Later versions of the theory pay more attention to procedural organizing contents, with a focus on solution steps or heuristic tasks that focus on problem-solving principles, guidelines, and causal models. In a process of task analysis, a flowchart is made that depicts the steps (for a procedural task) or the principles, guidelines, and causal models (for a heuristic task) experts would use to decide what to do when. Based on this flowchart, a simplifying conditions sequence is built (see right column in Table 35.1). It begins with the simplest version of the task that is still representative of the *whole* task and ends with the most complex version of this task. This approach is also typical for the whole-task, learning-by-doing models discussed in the next two sections.

Goal-Based Scenarios

Goal-based scenarios (Schank, 1993/1994; Schank et al., 1993/1994) are the backbone of learning in Schank's learning-by-doing paradigm (Schank et al., 1999). These goal-based scenarios represent "a learn-by-doing simulation in which students pursue a goal by practicing target skills and using relevant content knowledge to help them achieve their goal" (Schank et al., 1999, p. 165). A goal-based scenario consists of the following seven essential components:

- *Goal*. Two categories of learning goals are distinguished: process knowledge and content knowledge. Process knowledge reflects the skills and attitudes necessary to solve a problem, while content knowledge considers the knowledge required to achieve the goal. A goal-based scenario best appeals to both categories.
- *Mission*. The mission of a goal-based scenario is closely related to the goal and represents the actual assignment the student has to carry out. The mission must be as realistic and motivating as possible for the students. It should resemble a real-life task that a real person would plausibly have to achieve for an important reason.
- *Cover story*. The cover story forms the incentive for the students to become engaged in practice. It should elicit students to practice the skills and attitudes and seek the information and construct the knowledge that are reflected in the learning goals.
- *Role*. The role defines the perspective the student will take in the cover story. This role should ensure that the student will achieve his or her learning goals, and it should be as realistic and appealing as possible to motivate them.
- *Scenario operations*. The scenario operations are the activities a student carries out to accomplish the learning goal. Each goal-based scenario should elicit numerous scenario operations that contain decision points so students can infer the consequences of their actions.
- *Resources*. Well-organized and easily accessible resources contain all the information (i.e., stories) that students need to achieve the learning goal.
- *Feedback*. The situated, just-in-time feedback can be derived from the consequences of certain actions, it could be given by coaches, or it can be found in the resources as domain experts' stories about similar experiences.

Elaboration theory and goal-based scenarios clearly resemble each other. Like the learning episodes in elaboration theory, goal-based scenarios provide an opportunity to integrate knowledge, skills, and attitudes in meaningful wholes. In addition, both theories stress the importance of some learner control over contents and strategies. In goal-based scenarios, teachers may design a diverse set of goals to help learners with different prior knowledge and interests acquire the same knowledge, skills, and attitudes, or learners may sometimes even be permitted to set their own subgoals. Compared to elaboration theory, however, goal-based scenarios pay far less attention to the sequencing of instruction. In contrast, there is a stronger focus on the

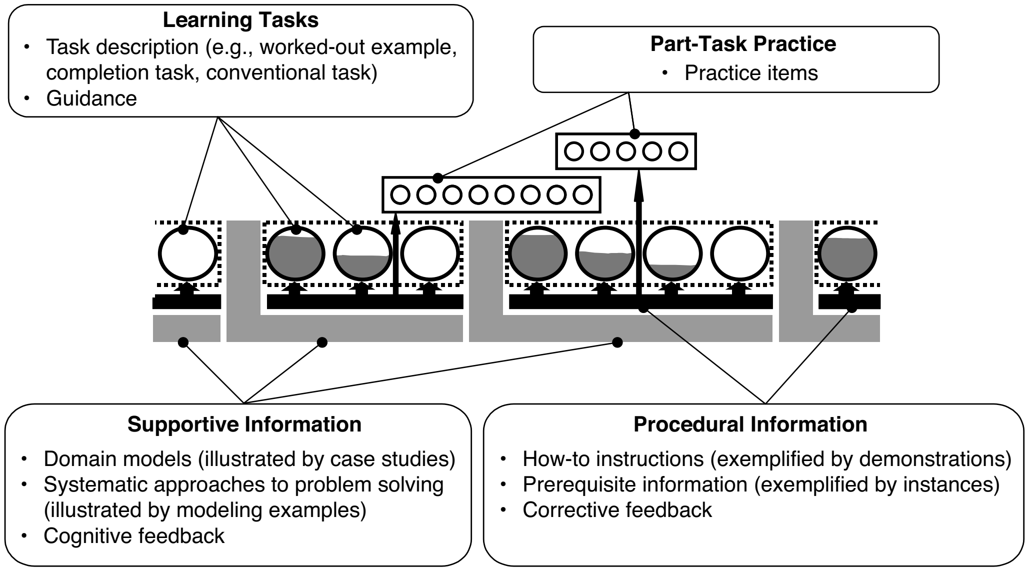

Figure 35.1 A schematic overview of the 4C/ID model and its main elements.

performance of real-life tasks in authentic contexts to facilitate the transfer of learning. This fits the basic idea that more general goals (i.e., integrated objectives) should drive the learning process, because highly specific learning objectives invite learners to apply strategies that do not allow for the transfer of learning (for the role of goals in reaching the transfer of learning, see Machin, 2002).

Four-Component Instructional Design

Van Merriënboer's four-component instructional design model (4C/ID model) (van Merriënboer, 1997; van Merriënboer et al., 2002, 2003) claims that whole-task environments for complex learning can always be described in four components:

- *Learning tasks*—Meaningful whole-task experiences that are based on real-life tasks. Ideally, the learning tasks ask the learners to integrate and coordinate many if not all aspects of real-life task performance, including problem solving and reasoning aspects, which are different across tasks, and routine aspects, which are consistent across tasks.
- *Supportive information*—Information that is supportive to the learning and performance of problem solving and reasoning for learning tasks. It describes how the task domain is organized and how problems in this domain can best be approached. It builds a bridge between what learners already know and what may be helpful to know so they can work fruitfully on the learning tasks.
- *Procedural information*—Information that is prerequisite to the learning and performance of routine aspects of learning tasks. This information provides an algorithmic specification of how to perform those routine aspects. It is best organized in small information units and presented to learners precisely when they need it during their work on the learning tasks.
- *Part-task practice*. Additional exercises for routine aspects of learning tasks for which a very high level of automaticity is required after the instruction. Part-task practice is only necessary if the learning tasks do not provide enough repetition for a particular routine aspect to reach the required high level of automaticity.

The 4C/ID model shares it focus on authentic learning tasks with goal-based scenarios. The tasks are based on real-life tasks and ask learners to combine knowledge, skills, and attitudes. As in elaboration theory, ample attention is paid to sequencing the learning tasks. To do so, learning tasks are organized into so-called *task classes*, which are ordered from simple to complex (see Figure 35.1; task classes are the dotted rectangles around a set of learning tasks). The first task class contains the simplest learning tasks that an expert might encounter in the real world yet are still whole, meaningful tasks that allow the learners to quickly develop a holistic vision of the task. Subsequent task classes contain increasingly more complex and difficult learning tasks. Learning tasks within a particular task class are equivalent in the sense that they can be performed on the basis of the same body of knowledge; each subsequent, more complex task class requires more knowledge or more elaborated knowledge for effective performance than the preceding, simpler task classes.

An additional element in the 4C/ID model pertains to the support and guidance that are given to learners (in Figure 35.1, this is indicated by the filled-in circles). When learners begin to work on more difficult learning tasks in a new task class, they first receive sizeable support and guidance from the teacher or instructional materials. Support and guidance gradually decrease in a process of *scaffolding* as learners acquire more expertise. When learners are able to independently perform learning tasks without any support or guidance up to the given standards (empty circles in Figure 35.1), they are ready to continue to a next task class with more difficult tasks.

Also characteristic of the model is its focus on the transfer of learning. Supportive information (L-shaped, light-gray shapes in Figure 35.1) relates to the idea that transfer is explained by general or abstract information that may be interpreted by a task performer to solve a new problem situation (i.e., the Gestalt approach). Conceptual models (what is this?), structural models (how is this built?), causal models (how does this work?), and cognitive strategies (how should I approach this task?) provide this kind of information. Procedural information (dark-gray rectangles with upward-pointing arrows in Figure 35.1) and part-task practice (small series of circles in Figure 35.1) relate to the idea that transfer may be explained by the application of knowledge elements that are shared between the practice and the transfer situation (i.e., the associationist approach). Procedural information tells the learner, precisely when the information is needed, how to perform routine aspects of the learning tasks. Part-task practice may provide the additional practice required to develop knowledge elements that allow the learner to perform routine aspects at a high level of automaticity. Finally, like elaboration theory and goal-based scenarios, the 4C/ID model acknowledges the importance of a certain degree of learner control over and responsibility for the learning process. In new versions of the model (van Merriënboer and Kirschner, 2007), learners are able to select their own learning tasks, as well as the supportive information and the part-task practice relevant for those tasks.

EMPIRICAL EVIDENCE FOR THE EFFECTIVENESS OF WHOLE-TASK MODELS

The previous sections presented a brief history of whole-task models, discussed the main characteristics of whole-task models in the field of educational communications and technology, and described three example models. The next sections discuss, in order, general research on the effectiveness of the whole-task approach and specific research on the effectiveness of elaboration theory, goal-based scenarios, and four-component instructional design.

Whole-Task Practice

In a review study, Wightman and Lintern (1985) investigated the effectiveness of segmentation, fractionation, and simplification techniques for part-task training. They concluded that whole-task training was generally more beneficial for learning than part-task training. Only segmentation in the form of *backward chaining with snowballing* (i.e., first the final segment of a task is practiced and prior segments are successively added during training) was as beneficial for transfer performance as whole-task training. This conclusion was confirmed by the results of a study by Wightman and Sistrunk (1987) that showed that learners who received whole-task carrier-landing training outperformed learners who received part-task training using simplification, but they did not outperform learners who received part-task, backward-chaining training. Moreover, Goettl and Shute (1996) found that a segmentation with backward-chaining approach to training is only as efficient as whole-task training if it is composed of critical component tasks. Otherwise, whole-task training leads to higher transfer test performance.

In two laboratory experiments, Detweiler and Lundy (1995) studied the effects of single-task and dual-task practice of consistent word-category mapping and spatial-pattern visual search tasks on dual-task transfer test performance. They found that dual-task practice yielded higher transfer test performance than single-task practice. Based on their findings, they concluded that target tasks that must be performed together should also be practiced together. Peck and Detweiler (2000) compared four approaches to practicing concurrent tasks related to adjusting the navigation and peripheral systems of a fictitious submarine: (1) a part-task approach, (2) a part-task chaining approach (i.e., snowballing), (3) a concurrent-chaining approach, and (4) a whole-task approach. In this experiment, part-task practice consisted of single-task trials that required an adjustment of either the navigation system or the peripheral system. In part-task chaining practice, single-task practice gradually became multi-task practice. Concurrent-chaining practice referred to increasingly complex concurrent-task practice, and in whole-task practice concurrent-task practice was required from the start. The results of this study demonstrated the beneficial effects on transfer test performance of both the concurrent-chaining approach and the whole-task approach.

To summarize, whole-task training seems to be the preferred method of instruction when it comes to complex skill acquisition. Sometimes, however, it may be desirable to include some (additional) part-task practice in the training—for example, when the whole task is dangerous or highly demanding. Roessingh et al. (2002) developed and tested a model to determine the optimal training time schedule for such a combined training. They concluded that, if one part task has to be included in the training, then more than 50% of the total training time has to be devoted to whole-task practice to maximize performance. This indicates that even in cases where whole-task practice is not the only relevant type of training it still should take up the largest part of it. An example of the successful application of combined training can be found in an experiment of Pollock et al. (2002). They compared a mixed instructional approach (i.e., first part-task practice then whole-task practice) to a whole-task approach (i.e., only whole-task practice) to teach electrical safety tests and found that novices in the domain demonstrated superior performance on a knowledge test and practical task after receiving the mixed instruction. Such a combined approach, in which part-task practice is used to supplement preponderant whole-task practice, is also found in four-component instructional design. First, though, research on elaboration theory and goal-based scenarios are discussed.

Elaboration Theory

Beissner and Reigeluth (1989, 1994) studied whether it was possible to design a course on physical-therapy treatment with combined sequencing techniques (i.e., multiple strands) as prescribed by elaboration theory. They carefully described the four-step design process. In the first step, a procedural elaboration sequence was designed using the simplifying conditions approach. Subsequently, and independent of the procedural sequence, a prescriptive theoretical elaboration sequence (i.e., understanding why principles work) and a descriptive theoretical elaboration sequence (i.e., understanding how principles work) were designed as steps two and three. Finally, these three steps were integrated into a single course sequence. Beissner and Reigeluth concluded that it is possible to have parallel elaboration sequences in one course, yielding *learning episodes* (whole tasks) that integrate relevant knowledge, skills, and attitudes. The effectiveness of this multiple-strand technique, however, was not investigated.

English and Reigeluth (1996) conducted a study that used a mixed-method approach to determine the strengths and weaknesses of elaboration theory. They revised three chapters of a book on electrical circuit analysis according to multiple-strand sequencing (combining procedural and theoretical sequences). The qualitative data (i.e., impromptu and debriefing questions) obtained in this study indicated that the sequences could be improved in the following ways: (1) Every step in the elaboration sequence should highlight the important relationships and relate each step to previous steps and knowledge, (2) students should be informed that the first step is entry level and will be followed by steps that are more complex at the start of the sequence, and (3) learners should be given some learner control over the learning materials (note that this recommendation is incorporated in the 1999 version of elaboration theory discussed earlier). Furthermore, the quantitative data (pre- and post-test results) showed that the instructional material was effective for both low-ability and high-ability students. An explorative comparison of student performance after the experimental course and the regular course on this topic indicated that students who participated in the experimental course performed better than students in the regular course.

Goal-Based Scenarios

Bell et al. (1993/1994) evaluated a goal-based scenario involving sickle cell disease known as the Sickle Cell Counselor. The Sickle Cell Counselor was installed in the Museum of Science and Industry in Chicago to evaluate its usefulness. The aim of the installation was to give museum visitors, in the course of a brief interaction, an understanding of sickle cell disease and the basic underlying inheritance mechanisms. Based on the fact that in a period of 25 days, 933 individuals spent on the average more than 7 minutes on the installation, the authors concluded that the Sickle Cell Counselor succeeded in attracting and holding onto the visitors' attention. The effectiveness of the Sickle Cell Counselor was evaluated in a subsequent study. Three groups were compared: a group that used the Sickle Cell Counselor, a group that read a pamphlet that conveyed the same information, and a control group. The group that used the Sickle Cell Counselor outperformed both the pamphlet group and the control group in role-playing performance and a paper-and-pencil test.

Another goal-based scenario, Architecting Business Change, developed for Andersen Consulting in St. Charles, Illinois, was evaluated by Kantor et al. (2000). This goal-based scenario addressed eight skills, and Kantor and colleagues conducted a needs assessment to find out the minimal proficiency level for each skill. The proficiency level ranged from *little/no ability* to *expert* and was based on ratings made by supervisors. The goal-based scenario was evaluated against those minimal proficiency levels. After working with the goal-based scenario, students were asked to rate their proficiency level before and after completing the scenario. A comparison of the minimal proficiency levels and those reported after completion indicated that students rated their proficiency level higher than minimally required for five out of eight of the trained skills. In addition, a comparison of the proficiency levels before and after completing the scenario indicated that all students rated their proficiency level higher after than before working with the goal-based scenario.

Four-Component Instructional Design (4C/ID)

In two studies, Hoogveld et al. (2001, 2003) studied the effectiveness of the 4C/ID model as an instructional systems design (ISD) approach to designing competence-based education (for applications in the medical domain, see Janssen-Noordman et al., 2006). In the first study, two groups of teachers were compared: One group was trained to use the 4C/ID model to design instruction, and the other group was trained to optimize its own design approach. After the training phase, the design quality of their educational products was measured by experts, and it was found that teachers trained to use the 4C/ID model developed qualitatively better designs than the other teachers. The second study investigated whether teams or individuals benefited more from a 4C/ID approach to designing competence-based education. It was found that low achievers benefited more from the 4C/ID model when they were working in teams, but high achievers worked as well in teams as individually.

Other researchers studied the effectiveness of 4C/ID-based instruction from the learners' perspective. Nadolski et al. (2005) focused on segmenting complex whole learning tasks in the area of law into phases. They varied the number of phases (one, four, or nine) of the whole task to determine the optimal balance between the advantages of whole-task practice and the disadvantages of cognitive overload caused by whole tasks that are too complex for learners. The results of this study showed that learners who carried out the learning task in four phases were most effective during practice as measured by the coherence and content of their practice products. Learners who carried out the learning tasks in one or four phases were most efficient during practice as measured by a combination of practice-product quality and invested mental effort. No effects were found on transfer test performance. These results were confirmed in a follow-up study (Nadolski et al., 2006) in which learners who received learning tasks that consisted of four phases outperformed learners who received tasks consisting of eight phases. The results indicate that whole learning tasks should only be segmented if this is the only possible way to diminish their complexity.

Using a model closely resembling the 4C/ID approach, Merrill (2002b) carried out a study at Thompson/NETg to validate his first principles of instruction. Three instructional scenarios for a course in Excel were developed: (1) a whole-task scenario group, (2) an e-learning group that received the existing commercial version of the NETg Excel course, and (3) a control group that only received three authentic test tasks. Statistical differences were found between the three groups on test task performance. The whole-task scenario group scored an average of 89%, the e-learning group scored an average of 68%, and the control group scored only an average of 34% correct on the test tasks. In addition, the whole-task scenario group required significantly less time to complete the three test tasks compared to the e-learning group.

A study by Lim and Reiser (2006) compared the effects of 4C/ID whole-task training and part-task training on the acquisition and transfer of a complex cognitive skill (preparing a grade book in Excel) for novices and advanced learners. They found that both novice and advanced learners achieved better whole-task performance and better transfer performance if they received the 4C/ID whole-task training. The superiority of a 4C/ID approach over other approaches was confirmed in another classroom study (Sarfo and Elen, 2005, 2006) that compared three groups who had to learn how to design a single building plan based on local conditions. The control group was taught according to an approach that was applied in technical schools in Ghana; the experimental groups were taught according to the 4C/ID approach, either with or without technology-enhanced learning. Although, the groups performed equally well on a pretest and both showed learning gains on a post-test, both experimental groups outperformed the control group on the post-test.

DISCUSSION

This chapter has discussed the historical roots of whole-task models and the main features. It has also provided three examples of whole-task models in the field of educational communications and technology and has presented research findings concerning the effectiveness of whole-task models. Overall, research findings show that whole-task models are particularly effective to teach complex skills and professional competences; however, this research also highlights two limitations of whole-task models. First, whole-task models should only be used to teach content and tasks that are characterized by a high degree of coordination—that is, many interrelationships between knowledge elements and component skills. If coordination is low, part-task models may be equally effective or even more effective than whole-task models. Second, whole-task practice should not be seen as incompatible with part-task practice. Even in a dominant whole-task approach, it may be desirable to offer additional part-task practice for routine aspects of a complex task. Furthermore, if it proves to be impossible to develop a version of the whole task that is simple enough to begin the training with, it may be necessary to work from parts that are as large as possible within a whole-part approach. In a purely holistic model, however, this would be viewed as a very last resort.

Whole-task models are relatively new in the field of educational communications and technology, and there is a clear need for additional research. On the most basic level, much is still unknown regarding the design of optimal whole learning tasks, sequencing techniques, and ways to scaffold learners who are working on the tasks. Another set of research questions pertains to learner control and self-directed learning. In a whole-task model, self-directed learners should select their own learning tasks, based on self-assessments of their performance and information regarding the tasks (e.g., difficulty, available support and guidance). Future research should investigate how learners are best guided in their process of task selection (e.g., through the use of portfolios or coaching) and encouraged to develop their self-directed learning skills. Finally, the issue of transfer of learning is central to whole-task models. Here, an interesting line of research pertains to the importance of real-life, authentic whole tasks. Although some researchers argue that it is critical to perform those tasks in an authentic environment (see, for example, Brown et al., 1989), others claims that especially early in the learning process it is not the fidelity of the environment but the psychological fidelity of the task itself that is most important.

It is clear that whole-task models today hold a prominent position in the field of educational communications and technology and, at least in Western Europe, in vocational education and training and in higher professional education. In our opinion, this is an inevitable reaction to societal and technological developments as well as students' and employers' uncompromising views regarding the value of education. Due to new technologies, routine tasks have been taken over by machines and the complex cognitive tasks that must be performed by humans are becoming increasingly important. Moreover, both the nature of and the skills required for currently available jobs are rapidly changing while the information relevant to carrying out these jobs quickly becomes obsolete. This imposes higher demands on the workforce, as employers stress the importance of problem solving, reasoning, and self-directed learning to ensure that employees can and will flexibly adjust to rapid changes in their environment. Whole-task models in education aim to reach precisely those goals.

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