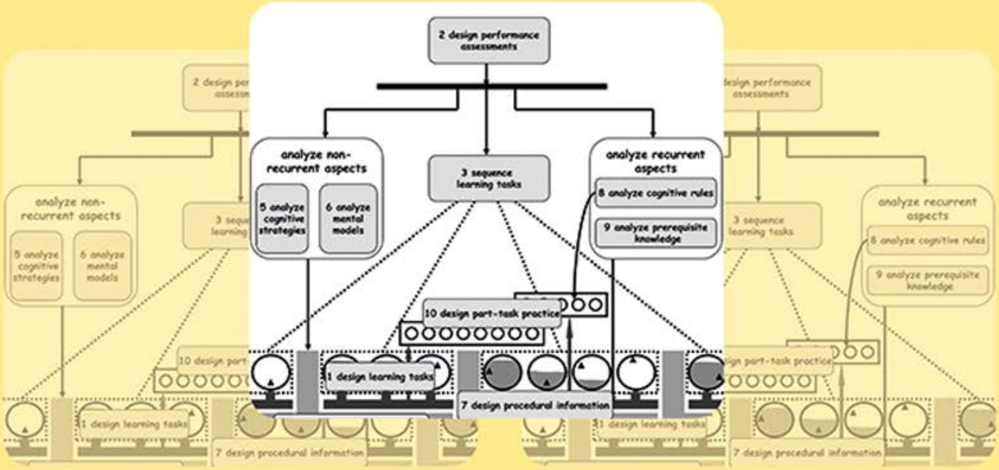
TEN STEPS TO COMPLEX LEARNING

THIRD EDITION



A SYSTEMATIC APPROACH TO FOUR-COMPONENT INSTRUCTIONAL DESIGN

JEROEN J. G. VAN MERRIËNBOER
AND PAUL A. KIRSCHNER

ROUTLEDGE

Ten Steps to Complex Learning

Ten Steps to Complex Learning presents a path from an educational problem to a solution in a way that students, practitioners, and researchers can understand and easily use. Students in the field of instructional design can use this book to broaden their knowledge of the design of training programs for complex learning. Practitioners can use this book as a reference guide to support their design of courses, curricula, or environments for complex learning.

Now fully revised to incorporate the most current research in the field, this third edition of *Ten Steps to Complex Learning* includes many references to recent research as well as two new chapters. One new chapter deals with the training of 21st-century skills in educational programs based on the Ten Steps. The other deals with the design of assessment programs that are fully aligned with the Ten Steps. In the closing chapter, new directions for the further development of the Ten Steps are discussed.

Jeroen J. G. van Merriënboer is Professor of Learning and Instruction at Maastricht University, the Netherlands, where he is Research Director of the Graduate School of Health Professions Education (SHE). He also holds honorary positions at the University of Bergen in Norway and the Open University of the Netherlands. He has published over 300 journal articles and book chapters in the areas of learning and instruction and medical education.

Paul A. Kirschner is Distinguished University Professor and Professor of Educational Psychology at the Open University of the Netherlands, as well as Visiting Professor of Education with a special emphasis on Learning and Interaction in Teacher Education at the University of Oulu, Finland. He has published more than 300 journal articles, books, and book chapters in the areas of learning, instruction, and collaborative learning.

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A Systematic Approach to Four-Component Instructional Design

Third Edition

Jeroen J. G. van Merriënboer
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About the Authors

Jeroen J. G. van Merriënboer (1959) is full Professor of Learning and Instruction at Maastricht University, the Netherlands, where he is Research Director of the Graduate School of Health Professions Education (SHE). He also holds honorary positions at the University of Bergen, Norway, and the Open University of the Netherlands. He holds a Master's degree in experimental psychology from the VU University of Amsterdam and a PhD degree in instructional technology from the University of Twente. Van Merriënboer specializes in cognitive architecture and instruction, instructional design for complex learning, holistic approaches to instructional design, and the use of Information and Communication Technologies (ICT) in education. He has published over 300 journal articles and book chapters in the areas of learning and instruction and medical education. More than 35 PhD candidates completed their theses under his supervision. He serves on the editorial board of highly ranked scientific journals such as *Cognitive Processing*; *Computers in Human Behavior*; *Educational Research Review*; *Educational Technology Magazine*; *Educational Technology Research and Development*; *International Journal for Virtual and Personal Learning Environments*; *Journal of Computing in Higher Education*; *Learning and Instruction*; and *Technology Instruction Cognition and Learning*. His prize-winning monograph *Training Complex Cognitive Skills* (1997) describes his four-component instructional design model for complex skills training and offers a systematic, research-based approach to designing environments for complex learning. He received several awards and prizes for his scientific work; apart from prizes for publications and PhD supervision, he was declared World Leader in Educational Technology by Training Magazine and he received the International Contributions Award from the Association for Educational Communications and Technology.

Paul A. Kirschner (1951) is University Distinguished Professor and Professor of Educational Psychology at the Open University of the Netherlands as well as Visiting Professor of Education with a special emphasis on Learning and Interaction in Teacher Education at the University of Oulu, Finland. He has published over 300 scientific articles in the areas of learning and instruction and at the moment of this writing has supervised 37 PhD candidates who have successfully completed their theses under his supervision. He is an internationally recognized expert in the fields of educational psychology and instructional design. He is Research Fellow of the Netherlands Institute for Advanced Study in the Humanities and Social Science. He was President of the International Society for the Learning Sciences (ISLS) in 2010–2011 and a member of both the ISLS CSCL Board and the Executive Committee of the Society, and he is an AERA Research Fellow (the first European to receive this honor). He is currently a member of the Scientific Technical Council of the Foundation for University Computing Facilities (SURF WTR) in the Netherlands and was a member of the Dutch Educational Council and, as such, was advisor to the Minister of Education (2000–2004). He is chief editor of the *Journal of Computer Assisted Learning* and associate editor of *Computers in Human Behavior*. In addition to this book he has co-written the very successful book *Urban Legends About Learning and Education*, which is also available in Dutch and Swedish. He also co-edited two other books (*Visualizing Argumentation* and *What We Know About CSCL*). His areas of expertise include interaction in learning, collaboration for learning (computer-supported collaborative learning), and regulation of learning.

Preface

Twenty-five years ago, the award-winning article *Training for Reflective Expertise: A Four-Component Instructional Design Model for Complex Cognitive Skills* (Van Merriënboer, Jelsma, & Paas, 1992) described the first precursor of the *Ten Steps to Complex Learning*. Five years later, in 1997, the first author published his award-winning book *Training Complex Cognitive Skills*. That book presented a comprehensive description of a training design system for the acquisition of complex skills or professional competencies, based on research conducted on the learning and teaching of knowledge needed for jobs and tasks in a technologically advanced and quickly changing society. The basic claim was that educational programs for complex learning need to be built from four basic interrelated components: learning tasks, supportive information, procedural information, and part-task practice. Each component was related to a fundamental category of learning processes, and prescribed instructional methods for each component were based on a broad body of empirical research.

Whereas *Training Complex Cognitive Skills* was very well received in the academic field of learning and instruction, practitioners in the field of instructional design frequently complained that they found it difficult to systematically design educational programs based on the four components. The article *Blueprints for Complex Learning: The 4C/ID Model* (Van Merriënboer, Clark, & De Croock, 2002) was the first attempt to provide more guidance on this design process. The systematic approach described in this article was further developed in the first edition of the book *Ten Steps to Complex Learning* (2007), which can best be seen as a complement to the psychological foundation described in *Training Complex Cognitive Skills*. The Ten Steps describes a path from a training problem to a training solution in a way that students, practitioners (both instructional designers and teachers), and researchers can understand and use. This book was a great success and has been translated in whole into Korean and Chinese and in part into Spanish. It has also spawned a Dutch language analog, of which the latest edition was published in 2017.

This third, revised edition of the *Ten Steps to Complex Learning* is different from the previous edition in at least three important ways. First, a new chapter (Chapter 14) on the training of domain-general skills, also called 21st-century skills, has been added. Although the Ten Steps focuses primarily on training domain-specific complex skills or professional competencies, it also provides excellent opportunities for teaching domain-general skills, that is, skills not bound to one particular task domain. One example of a domain-general skill that is fully integrated in the Ten Steps is *task selection*, where in a system of on-demand education self-directed learners can select learning tasks that best fit their own learning needs, yielding individualized learning trajectories based on the results of frequent (self)-assessments. For educational programs based on the Ten Steps, this new chapter discusses the training of self-regulated learning skills and self-directed learning skills (in addition to task-selection skills, also information literacy skills and deliberate practice skills), as well as other thinking skills and social skills.

Second, another new chapter (Chapter 15) has been added on the design of *programs of assessment*. In the Ten Steps, the backbone of the educational program is formed by learning tasks, and performance assessments of those tasks are preferably gathered in a development portfolio to measure learners' whole-task performance at particular points in time as well as their gradual progression toward the final attainment levels of the program. The assessments are primarily formative, meant to support learning, although assessments of unguided/unsupported tasks can also be used in a summative way. The Ten Steps assumes that when learners demonstrate that they are able to carry out tasks in a way that meets all of the standards, they must also have mastered the underlying—supportive and procedural—knowledge and routine skills. There might, however, be reasons for assessing learners not only on the level of whole-task performance, but also on the levels of acquired knowledge (i.e., remembering and understanding) and part-task performance. Therefore, this new chapter aims to illuminate what a complete program of assessment might look like in a whole-task curriculum based on the Ten Steps. The focus of this chapter is on summative assessment, that is, assessment in order to make pass/fail and certification decisions.

Third, a great number of smaller and larger changes and additions were made. The literature and references have been completely updated and, where relevant, the newest insights from the field have been included. The sections on cognitive feedback (Chapter 7) and corrective feedback (Chapter 10) have been rewritten to highlight the link between available assessment information, feedback, and the diagnosis of naïve or intuitive knowledge. Concrete examples and cases were added where useful. Several figures and tables have been added or revised. And in the final chapter, a broader perspective on the future of the Ten Steps is taken by discussing new developments in blended learning and game-facilitated curricula, mass customization and big data, intertwining domain-general skills in the training blueprint, motivation and emotion in programs based on the Ten Steps, and instructional design tools.

The structure of this book is straightforward. Chapters 1, 2, and 3 provide a concise introduction to the *Ten Steps to Complex Learning*. Chapter 1 presents a holistic approach to the design of instruction for achieving the complex learning required by modern society. Chapter 2 relates complex learning to the four blueprint components: learning tasks, supportive information, procedural information, and part-task practice. Chapter 3 describes the use of the Ten Steps for developing detailed training blueprints. Then, each of the Ten Steps is discussed in detail in Chapters 4 through 13. The new Chapter 14 discusses the teaching/training of domain-general or 21st-century skills in programs based on the Ten Steps, and the new Chapter 15 discusses the design of summative assessment programs that are fully aligned with the Ten Steps. Finally, Chapter 16 positions the Ten Steps in the field of the learning sciences and discusses future directions.

Practitioners in the field of instructional design may use this book as a reference guide to support their design of courses, materials, and/or environments for complex learning. In order to make optimal use of the book, it may be helpful to consider the following points:

- It is probably best for all readers, regardless of their reason for using this book, to study Chapters 1, 2, and 3 first. They introduce the four blueprint components and the Ten Steps.
- Chapters 4 through 13 describe the Ten Steps in detail. You should always start your design project with Step 1, but you only need to consult the other chapters if these steps are required for your specific project. Each chapter starts with general guidelines that may help you decide if the step is relevant for your project or not.
- The new chapters are relevant for readers with a specific interest in training domain-general skills (Chapter 14) or designing programs of assessment (Chapter 15). Minimum requirements for assessment (performance assessment of learning tasks; Step 2 in Chapter 5) and teaching domain-general skills (task selection by the learner in on-demand education; Step 3 in Chapter 6) are already an integral part of the Ten Steps.

If you are a student in the field of instructional design and want to broaden your knowledge of the design of training programs for complex learning, you are advised to study all chapters in the order in which they appear. For all readers, whether practitioner or student, we tried to make the book as useful as possible by including the following:

- Each chapter ends with a brief *Summary* of its main points and design guidelines.
- Key concepts are listed at the end of each chapter and included in a *Glossary*. This glossary contains either pure definitions of terms that might not be familiar and in certain cases may be more extensive (in the case

of seminal or foundational concepts, theories or models) and contain background information. In this way, the glossary can help you organize the main ideas discussed in this book.

- In a number of chapters, you will find *Boxes* in which the psychological foundations for particular design decisions are briefly explained.
- Two *Appendices* with example materials are included at the end of this book.

Acknowledgments

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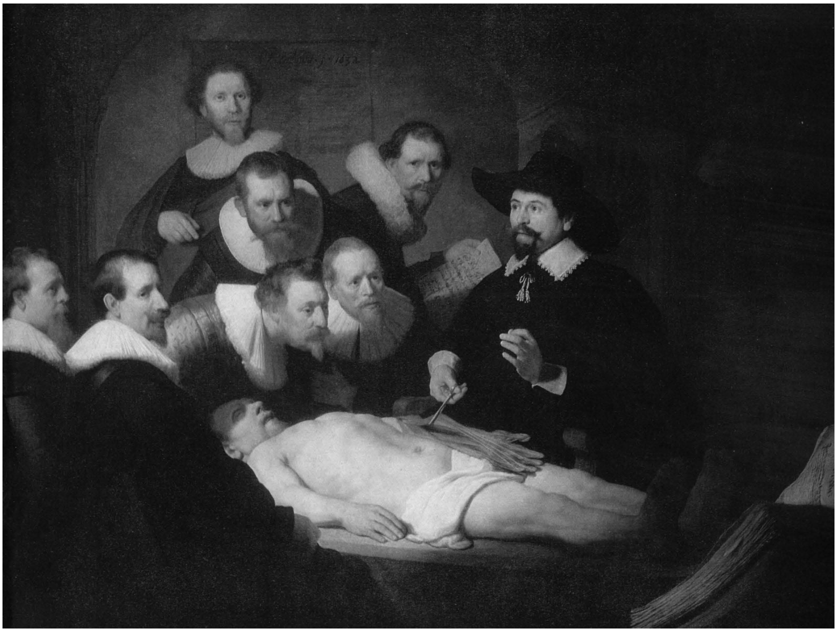
Jeroen J. G. van Merriënboer and Paul A. Kirschner
Maastricht/Hoensbroek, April 2017

Chapter 1

A New Approach to Instruction



When Rembrandt van Rijn painted *The Anatomy Lesson of Dr. Nicolaes Tulp* in 1632 there was very little known about human anatomy, physiology, and morphology. The tools of the trade were rudimentary at best and barbarian at worst. Medicine was dominated by the teachings of the church where the human body was regarded as a creation of God, and the ancient Greek view of the four humors (blood, phlegm, black bile, and yellow bile) prevailed. Sickness was due to an imbalance in these humors, and treatments, such as bleeding the patient or inducing vomiting, were aimed at restoring the balance of these four humors. Surgical instruments were basic. A surgeon would perform operations with the most basic set of instruments: a drill, a saw, forceps, and pliers for removing teeth. If a trained surgeon was not available, it was usually the local barber who performed operations and removed teeth. The trained surgeon was more an 'artist' than a 'scientist'. For example, because there were no anesthetics, surgeons prided themselves in the speed with which they operated; just a few minutes for a leg amputation. As far as progress toward new knowledge of anatomy, physiology, morphology, and medical techniques was concerned, it was very slow if at all. Although the microscope existed it was not powerful enough to see bacteria, and thus there was no progress in understanding the cause of disease. This meant that there was also little improvement in medical treatments.

Compare this to the situation today where hardly a day goes by without new medical discoveries, new diseases, new drugs and treatments, and new medical and surgical techniques. Just a generation or two ago, medicine, medical knowledge and skills, and even attitudes of medical practitioners toward patients and the way patients approach and think about their doctors were radically different than they are today. It is no longer enough for surgeons to master the tools of the trade during their studies and then apply and perfect them throughout their careers. Competent surgeons today (and tomorrow) need to master complex skills and professional competencies—both technical and social—during their studies and never stop learning throughout their careers. This book is about how to design instruction for this complex learning.

1.1 Complex Learning

Complex learning involves integrating knowledge, skills, and attitudes; coordinating qualitatively different constituent skills; and often transferring what is learned in school or training settings to daily life and work settings. The current interest in complex learning is manifest in popular educational approaches that call themselves inquiry, guided discovery, case method, project based, problem based, design based, team based, and competency based, many of which have no solid basis in empirical research (Kirschner, Sweller, & Clark, 2006). Theoretical design models promoting complex learning are, for example, cognitive apprenticeship learning (Collins, Brown, & Newman, 1989; Woolley & Jarvis, 2007), first principles of instruction (Merrill, 2012), constructivist learning environments (Jonassen, 1999), learning by doing (Schank, 2010), and the four-component instructional design model (4C/ID; Van Merriënboer, 1997). Though these approaches differ in many ways, they share a focus on learning tasks based on real-life authentic tasks as the driving force for teaching, training, and learning. The basic idea behind this focus is that such tasks help learners integrate knowledge, skills, and attitudes, stimulate them to learn to coordinate constituent skills, and facilitate transfer of what is learned to new problem situations (Merrill, 2012; Van Merriënboer, 2007).

The interest in complex learning has been rapidly growing since the beginning of the 21st century. It is an inevitable reaction of education and teaching to societal and technological developments as well as students' and employers' uncompromising views about the value of education and training for updating old knowledge and skills to prevent obsolescence (Hennekam, 2015) and learning new ones. New technologies have allowed routine tasks to be taken over by machines, and the complex cognitive tasks that must be performed by humans are becoming increasingly complex and important (Benedikt-Frey & Osborne, 2017; Kester & Kirschner, 2012). Moreover, the nature of currently available jobs is not only changing because other skills are needed but also because the information relevant to carrying out those jobs quickly becomes obsolete. This poses higher demands on the workforce, with employers stressing the importance of problem solving, reasoning, decision making, and creativity to ensure that employees can and will flexibly adjust to rapid changes in their environment.

Two examples might drive this home. Many aspects of the job of an air traffic controller have been technically automated over the last decade. But even though this is the case, the complexity of what these controllers have to do is greater than ever before due to the enormous increase in air traffic, the growing number of safety regulations, and the advances in the technical aids themselves (see Figure 1.1). The same is true for the family doctor who

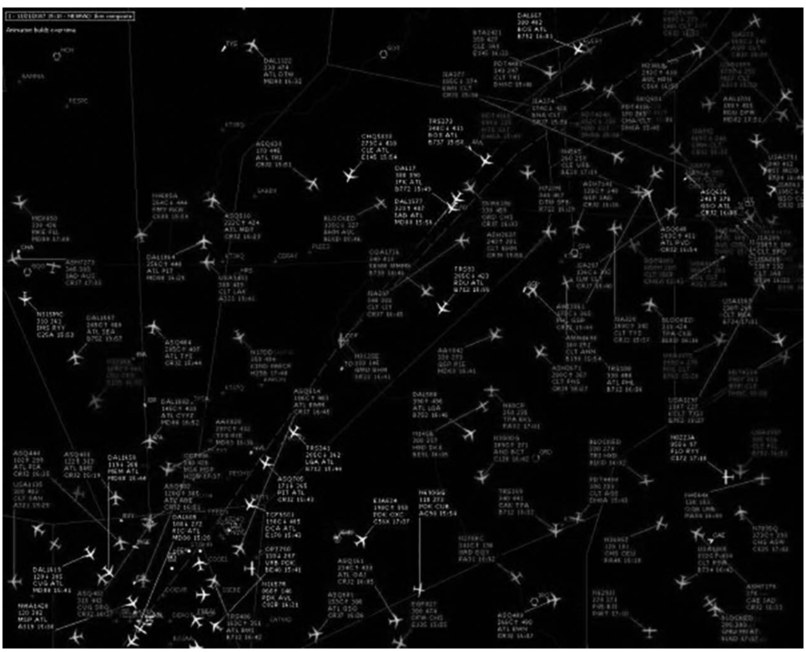


Figure 1.1 Air traffic control screen.

not only needs to care about physical, psychological, and social aspects of his or her patients but who is also confronted with a much more varied collection of clients with different cultural backgrounds, a flood of new medicines, tools and treatments, and issues dealing with registration, liability, insurance, and so forth.

The field of education and training has become increasingly conscious of these new demands posed by society, business, and industry. In response to these demands, there has been a concomitant increase in the attempts to better prepare graduates for the labor market and help them develop *adaptive expertise* (Carbonell et al., 2014). The aforementioned educational approaches that stress complex learning and the development of professional competencies throughout the curriculum are trying to reach this goal. But educational institutes lack proven design approaches. This often results in the implementation of innovations that undeniably aim at better preparation of students for the labor market but that do so with varying degrees of success (Dolmans, Wolfhagen, & van Merriënboer, 2013).

An often-heard student complaint is that they experience their curriculum as a disconnected set of courses or modules, with only implicit relationships between the courses and an unclear relevance of what they are supposed to learn for their future professions and why. Often, as a compromise with those instructors who want to 'teach their subject areas,' curriculums implement a separate stream in which problems, projects, cases, or other learning tasks are used for the development of complex skills or competencies; hopefully in a, for the student, recognizable and relevant situation. However, even in those curriculums, students have difficulties relating what they are required to do in this stream to both the theoretical coursework, which is typically divided in traditional subjects, and what they perceive to be important for their future professions, which often lies at the basis of the learning tasks. Not surprisingly, students have difficulties combining all the things they learn into an integrated knowledge base and employing this knowledge base to perform real-life tasks and solve practical work-related problems once they have graduated. In other words, they do not achieve the envisioned and required 'transfer of learning' or 'transfer of training' (Blume et al., 2010).

The fundamental problem facing the field of instructional design is the inability of education and training to achieve this necessary transfer. Design theory must support the development of training programs for learners who need to learn and transfer professional competencies or complex skills acquired in their study to an increasingly varied set of real-world contexts and settings. The *Ten Steps to Complex Learning* (from this point on referred to as the *Ten Steps*) claims that a holistic approach to instructional design is necessary to reach this goal (cf. Tracey & Boling, 2013). In the next section, this holistic design approach is discussed along with why it is thought to help improve transfer of learning. This discussion is followed by a positioning of the instructional design model discussed in this book in the field of learning and instruction and a description of the main elements of the model, that is, its four components and the ten steps. Finally, an overview is given of the structure and the contents of the book.

1.2 A Holistic Design Approach

A *holistic* design approach is the opposite of an *atomistic* one, in which complex contents and tasks are continually reduced to simpler or smaller elements such as facts and simple skills. This reduction usually continues to a level where each of the elements can be easily transmitted to the learners through presentation (of facts) and/or practice (of skills). Though such an approach may work well if there are not very many interactions between the elements, it does not work well if the elements are closely interrelated. When this is the case, *the whole is more than the sum of its parts*, because it not only contains the elements but also the relationships between these elements. This is the basis of the holistic approach. Holistic design approaches attempt to deal with complexity without losing sight of the interrelationships between the elements taught (Van Merriënboer & Kester, 2008). Using a holistic design approach can offer a solution for three persistent problems in the field of education, namely, compartmentalization, fragmentation, and the transfer paradox.

Compartmentalization

Instructional design models usually focus on one particular domain of learning, such as the cognitive domain, the affective domain, or the psychomotor domain. A further distinction, for example in the cognitive domain, is the differentiation between models for declarative learning, emphasizing instructional methods helping learners to construct conceptual knowledge, and models for procedural learning, emphasizing instructional methods helping learners to acquire skills. This *compartmentalization*—the separation of a whole into distinct parts or categories—has had disastrous effects on education.

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 would you want a surgeon with great technical skills, but who has a horrible bedside manner and a hostile attitude toward patients? Or, finally, a surgeon that has all of the knowledge, skills, and attitudes that were learned 35 years ago, but has not kept them up-to-date? Of course, your answer would be "None of the above." You want a surgeon with up-to-date knowledge and skills who is cognizant of how your body functions (i.e., its anatomy and physiology), is very technically dexterous, and has a good bedside manner. This clearly indicates that it makes little sense to distinguish domains of learning for professional competencies. Many complex surgical skills simply cannot be performed without in-depth knowledge of the structure and working of the human body, because this allows for the necessary flexibility in behavior. Many skills cannot be performed in an acceptable fashion if they do not exhibit particular attitudes. And so forth. Holistic design models for complex learning therefore aim at the integration of declarative learning, procedural learning (including perceptual and psychomotor skills), and affective learning (including the predisposition to keeping all of these aspects up-to-date, including patient skills). So they facilitate the development of an integrated knowledge base that increases the chance that transfer of learning occurs (Janssen-Noordman et al., 2006).

Fragmentation

Traditional instructional design models make use of *fragmentation*—the act or process of breaking something into small, incomplete or isolated parts—as their basic technique (Van Merriënboer & Dolmans, 2015). Typical of 20th-century instructional design models is that they first analyze a chosen learning domain, then divide it into distinct performance and/or learning objectives (e.g., remembering a fact, applying a procedure, understanding a concept, and so forth), after which different instructional methods are selected for reaching each of the separate objectives (e.g., rote learning, skills labs, problem solving, respectively). In the training blueprint or lesson plan for that domain, the objectives are dealt with one at a time. For complex skills, each objective corresponds with one subskill or constituent skill, and the sequencing of the objectives naturally results in a part-task sequence. Thus, the learner is taught only one or a very limited number of constituent skills at the same time. New constituent skills are gradually added, and it is not until the end of the instruction—if at all—that the learner has the opportunity to practice the whole complex skill.

Back in the 1960s, Briggs and Naylor (1962; Naylor & Briggs, 1963) reported that this approach is only suitable if little coordination of constituent skills is required and if each of the separate constituent skills is difficult for the learners to acquire. The problem with this fragmented approach is that most complex skills or professional competencies are characterized by numerous interactions between the different aspects of task performance, with very high demands on their coordination. In the past half-century, overwhelming evidence has been obtained showing that breaking a complex domain or task down into a set of distinct elements or objectives, then teaching or training each of those objectives without taking their interactions and required coordination into account, does not work because learners ultimately are not capable of integrating and coordinating the separate elements in transfer situations (e.g., Gagné & Merrill, 1990; Lim, Reiser, & Olina, 2009; Spector & Anderson, 2000). To facilitate transfer of learning, holistic design models focus on reaching highly integrated sets of objectives and, especially, the coordinated attainment of those objectives in real-life task performance.

The Transfer Paradox

In addition to compartmentalization and fragmentation, the use of a non-integrated list of specific learning objectives as the basis for instructional design has a third undesired effect. Logically, the designer will select instructional methods that minimize the number of practice items required to learn or master something, the time-on-task spent doing this, and the learners' investment of effort made to reach those objectives; that is, they strive for efficiency. Designing and producing practice items costs time and money, both of which are often scarce. In addition, the learner does not have unlimited time or motivation to study (the learner, as are almost all of us, is a *homo economicus*; one who strives to minimize costs and optimize profits). Take the situation that learners must learn to diagnose three different types of errors (e1, e2, e3) in a complex technical system, such as a chemical factory. If a minimum of three practice items is required to learn to diagnose each error, one may first ask the learners to diagnose error 1, then error 2, and finally error 3. This leads to the following training blueprint:

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

Although this 'blocked' practice schedule will be most efficient for reaching the three objectives, minimizing the required time-on-task and learners' investment of effort, it also yields low transfer of learning. The reason for this is that the chosen instructional method invites learners 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 performances that go beyond the given objectives. If a designer is aiming at transfer, and the objective is that learners can correctly diagnose as many errors as possible in a technical system, then it is far better to train them 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 'random' practice schedule (also called 'interleaving'; Birnbaum et al., 2013) is less efficient than the former one for reaching the three isolated objectives 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 long run it yields much higher transfer of learning!

The reason for this increase of transfer is that a random schedule invites learners to compare and contrast the different errors with each other and thus construct knowledge that is general and abstract rather than entirely bound to the three concrete, specific errors. This allows learners to better 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 reaching integrated objectives and increasing transfer of learning—is known as the *transfer paradox* (Helsdingen, van Gog, & van Merriënboer, 2011a, 2011b; Van Merriënboer, de Croock, & Jelsma, 1997). A holistic design approach takes the transfer paradox into account and is always directed toward more general objectives that go beyond a limited list of highly specific objectives. The differentiation between different types of learning processes should ensure that learners who are confronted with new problems not only have specific knowledge to perform the familiar aspects of those problems but, above all, have the necessary general and abstract knowledge to deal with the unfamiliar aspects of those problems.

To recapitulate, traditional design models usually follow an atomistic approach and, as a result of this, are not very successful in preventing compartmentalization and fragmentation or dealing with the transfer paradox. A holistic approach, in contrast, offers alternative ways for dealing with 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 learners can actually learn from them (Achtenhagen, 2001). In this view, instruction should begin with a simplified but 'whole' model of reality, which is then conveyed to the learners according to sound pedagogical principles. The Ten Steps offers a broad range of instructional methods to deal with complexity without losing sight of whole, real-life tasks.

1.3 Four Components and Ten Steps

The Ten Steps is a practical, modified, and—as strange as it may sound—simplified version of the 4C/ID model (four-component instructional design; Van Merriënboer, 1997; Van Merriënboer, Clark, & de Croock, 2002; Van Merriënboer, Jelsma, & Paas, 1992). Previous descriptions of this model had an analytic-descriptive nature, emphasizing the cognitive-psychological basis of the model and the relationships between design components and learning processes. The Ten Steps, in contrast, is mainly prescriptive and aims to provide a version of the model that is practicable for teachers, domain experts involved in training design, and instructional designers. The focus of this book is on design rather than on learning processes. But for interested readers, some of the chapters include text boxes in which the psychological foundations for particular design principles are briefly explained.

The Ten Steps can be seen as a model of instructional design specifically directed toward programs of vocational and professional education (both at the secondary and higher education level), profession-oriented university programs (e.g., medicine, business administration, law), and competency-based training programs in business, industry, government, and military organizations. Yet applications of the model are also appearing in general secondary education and even primary education for teaching complex skills in both traditional school subjects (e.g., Melo & Miranda, 2015) and specific skills (e.g., Linden et al., 2013). The model will typically be used to develop training programs of substantial duration—ranging from several weeks to several years. In terms of curriculum design, the model will typically be used to design a—substantial—part of a curriculum for the development of one or more professional competencies or complex skills.

The basic assumption that forms the basis of both 4C/ID and the Ten Steps is that blueprints of educational programs for complex learning can always be described by four basic components, namely: (a) learning tasks, (b) supportive information, (c) procedural information, and (d) part-task practice (see the left-hand column of Table 1.1).

Table 1.1 Four blueprint components of 4C/ID and the Ten Steps.

Blueprint Components of 4C/ID	*Ten Steps to Complex Learning*
Learning Tasks	1. Design Learning Tasks
	2. Design Performance Assessments
	3. Sequence Learning Tasks
Supportive Information	4. Design Supportive Information
	5. Analyze Cognitive Strategies
	6. Analyze Mental Models
Procedural Information	7. Design Procedural Information
	8. Analyze Cognitive Rules
	9. Analyze Prerequisite Information
Part-Task Practice	10. Design Part-Task Practice

The term learning task is used here in a very generic sense: A learning task may refer to a case study that must be studied by the learners, a project that must be carried out, a problem that must be solved, a professional task that must be performed, and so forth. The supportive information helps learners perform nonroutine aspects of learning tasks that often involve problem solving, decision making and reasoning (e.g., information about the teeth, mouth, cheeks, tongue, and jaw helps a student in dentistry with clinical reasoning; Postma & White, 2015, 2016). The procedural information enables learners to perform the routine aspects of learning tasks, that is, those aspects of the learning task that are always performed in the same way (e.g., how-to instructions for measuring blood pressure help a medical student with conducting physical examinations). Finally, part-task practice pertains to additional practice of routine aspects in order to help learners develop a very high level of automaticity of these aspects and so improve their whole-task performance (e.g., practicing cardiopulmonary resuscitation (CPR) helps a nurse to be better prepared for dealing with emergency situations).

As indicated in the right-hand column of Table 1.1, the four blueprint components directly correspond with four design steps: the design of learning tasks (Step 1), the design of supportive information (Step 4), the design of procedural information (Step 7), and the design of part-task practice (Step 10). The other six steps are auxiliary to these design steps and are only performed when necessary. In Step 2, performance assessments are designed based on objectives and standards for acceptable performance. Step 3 organizes learning tasks in simple-to-complex levels, ensuring that learners work on tasks that are simple (i.e., not complex) in the beginning and then smoothly increase in complexity. Steps 5 and 6 may be necessary for in-depth analysis of the supportive information that would be helpful for learning to carry out the nonroutine aspects of learning tasks. Steps 8 and 9 may be necessary for in-depth analysis of the procedural information needed for performing routine aspects of learning tasks.

It should be noted that real-life design projects are never a straightforward progression from Step 1 to Step 10. New results and decisions will often require the designer to reconsider previous steps, causing iterations in the design process. One may design a few learning tasks, in a process of rapid prototyping, before designing the complete educational program. In addition, particular steps may be superfluous for particular design projects. As a result, zigzagging (see Section 3.2) between the Ten Steps is common. Then, it is the trick of the trade to keep a good overview of all—intermediate—design and analysis products as well as their relations to the ultimate training blueprint. Computer-based tools will be very helpful to carry out larger design projects, as they facilitate the systematic development of an educational blueprint and help designers to keep the required overview of the whole project—even when they zigzag between different steps (Van Merriënboer & Martens, 2002).

The remainder of this book describes the Ten Steps in 16 chapters. Chapters 2 and 3 provide an introduction to the four blueprint components and the ten steps, respectively. Chapters 4 to 13 make up the main part of this book. Each chapter contains a detailed explanation of one of the ten steps. Chapters 14 and 15 describe, in order, how domain-general skills can be taught in educational programs designed with the Ten Steps and how programmatic assessment can be applied in those programs. Chapter 16 discusses future directions in the field of complex learning.

Four Blueprint Components

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Step 1

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Step 4

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Step 7

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Step 10

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