Epilogue

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In the foreword to this *Handbook* by Prof. Youqun Ren, the notion of a revolution in schooling predicted by Alfred Bork in 1987 is discussed. In spite of the remarkable progress in technology in the intervening years, the promised revolution has not occurred and does not yet appear imminent. There were overly optimistic advocates of educational technology, failure to follow through on the policy level with promising innovations, and other reasons for failing to radically transform learning and instruction. Prof. Ren cites four realizations that need to be considered in addressing the challenge of transforming learning and instruction with technology: (1) technological improvement does not directly translate into improved learning; (2) the same technology may perform differently in different contexts; (3) the continuing development of technologies exacerbates the shortage of teachers and instructional designers who can make effective use of those technologies; and (4) technological, pedagogical, and content knowledge on the part of teachers and designers is more important than ever.

Many chapters in this *Handbook* address these four points and the associated challenges, as suggested in the Foreword. Researchers are urged to conduct research in the area of educational communications and technology that will make real and lasting differences in educational practice around the globe. One way of framing how to go forward is to build on connections between theory and practice—specifically on bridging learning theories and technology-enhanced learning environments, as suggested in Prof. Joost Lowyck's first chapter in this *Handbook*.

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Prof. Lowyck began Chap. 1 with the same interest in improving learning and instruction that Prof. Ren discussed; Lowyck also regards the emphasis on systematically and systemically improving learning as fundamental to the educational technology enterprise. Lowyck critically examined the history of efforts to bridge learning theory and technology-enhanced learning environments and developed five observations that we wish to take up in the remainder of this epilogue: (1) changes in society and educational practice influence the selection and use of learning theories and supportive technologies; (2) learning theories and associated technologies exist within a vague and not so well articulated conceptual framework; (3) learning theories and educational technologies are connected to how people process information and acquire expertise; (4) control in learning situations has shifted from system/teacher control to learner and shared/distributed control; and (5) learning theories and findings have been transformed into a fuzzy array of principles and applications that seldom contribute to the science of education and a close connection between theory and practice. We briefly continue the discussion that Prof. Lowyck began in Chap. 1 in the following sections.

Change and a Conceptual Framework (Spector)

While all five of Lowyck's observations are interrelated, the first two are linked quite closely. Significant changes have occurred in society and educational practice in recent years and these will surely continue, although the major shifts to in both society and practice appear to be linked with increasing emphasis on issues centering around empowerment—empowerment of disadvantaged segments of society and empowerment of individual learners. The latter has led to a somewhat vague conceptual framework guiding the development of instructional systems and learning environments. Perhaps the most clearly articulated conceptual framework for learning and instruction, and one that has theoretical foundations and empirical support, and that cuts across

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instructional design and the learning sciences is cognitive apprenticeship (Collins, Brown, & Newman, 1989). One could argue that most of the successful learning environments developed since then have been a variation of cognitive apprenticeship. Many other conceptual frameworks published since cognitive apprenticeship appeared acknowledge direct links to that early conceptual framework (see, for example, Milrad, Spector, & Davidsen, 2003; Seel, 2003).

The extent to which cognitive apprenticeship has been embraced by the instructional design and learning sciences communities is a topic worth investigating. If that framework is as widely adopted in one form or another, then it might become an explicit bridge across the troubled waters that separate various instructional and learning theorists and practitioners. However, the tendency toward developing apparently new theories, frameworks, and models needs to be addressed. The not-invented-here syndrome that Lowyck identified may account for much of the apparent and arbitrary separation of researchers and practitioners working to improve learning and instruction.

Presumably a shared goal is to develop a body of cumulative knowledge and refined theories, frameworks, and models to inform the planning, implementation, activation, evaluation, and management of learning and instructional systems. We want to do this so as to improve learning and instruction. However, the research to support this goal and overarching aim needs to be conducted in a variety of contexts, some of which involve actual classrooms, some of which involve design and development teams, some of which involve targeted studies of micro-interventions and so on. Carrying out one kind of study within such a wide array of possibilities should be acknowledged by others as contributing to a common set of research objectives aimed at better understanding learning so as to improve learning and instruction. All too often, there is a tendency to believe that the one niche one happens to be currently pursuing is more important than any of the other niches in which one might conduct a study and make a contribution.

Finally, whatever conceptual frameworks evolve in the future, it is likely that there will be some vagueness and openness. Learning is not a monolithic process or discrete activity that can be captured by a few variables that generalize across all possible scenarios and situations. Learning is complex. Learning is something that occurs naturally but also something that can occur with effort or even against one's own intentions. Some people used to say that a good teacher can *cause* learning to happen. The current mantra appears to be that a good teacher is one who can *allow* learning to happen. While each of these views has links to a theoretical framework (the former being linked to behaviorism and the latter being linked to socio-constructivism), neither seems fully satisfying. While learning is inherently complex, teaching is, as a result, even more complex, given the variety of learners and learning tasks involved. It seems, then, that there is much yet to be done to elaborate meaningful and compelling frameworks to guide the development of learning environments and instructional systems.

Information Processing and Knowledge Acquisition (Bishop)

Among the observations Prof. Lowyck made regarding what occurs at the intersection of learning theory and educational technology, he posited that learning theories and technology are connected by our foundational understandings of information processing and knowledge acquisition. Lowyck argued that, as our underlying epistemologies have shifted from objectivism to constructivism, so too have our views on how learners acquire, organize, and synthesize information as well as our perspectives on what tools and strategies will best optimize those processes. To demonstrate these connections, this section of Lowyck's chapter traced the evolution of thinking in the field about knowledge acquisition and the concomitant instructional technology developments from behaviorism through early cognitive theory and into constructivism and socio-constructivist theory. The merit of any instructional technology, Lowyck concluded at the end of this section, is defined by that tool's link with our understandings of underlying cognitive processes.

Clearly our perspectives on the nature of cognitive processes have had a profound effect on the design, development, integration, and implementation of technology for learning over the years (for a complete review, see Richey, Klein, & Tracey, 2011). In fact, many of the chapters in this *Handbook* reflect this connection between learning theory and instructional technology by opening with an introductory section that identifies some educational need with the intent of demonstrating how the proposed technology (whether mechanical/electronic or the application of scientific principles and theoretical knowledge) will support learners' cognitive processing in one way or another. However, while it appears this has at least been nominally true, in practical application the strength of the connection between instructional technologies and current understandings about knowledge acquisition within the sociocultural constructivist perspective may be more tenuous than we would like to think.

As Lowyck noted, technologies embedded in a sociocultural constructivist perspective must provide the interactive, adaptive tools learners need in order to have their own voice in the *instructional conversation*. But the instant an instructional designer makes his first decision within this learning context about the problem for study, the examples and/or artifacts to be used, the look and feel of the interface, the delivery platform, the nature of feedback to be offered, or even the way in which the learner physically interacts with the technology, he imposes something of his own understanding, culture, and general sense of the way things are into the learning environment—and, to some degree, circumvents the learner's own knowledge construction processes. As Wilson (2005) contended, "the capturing, packaging, and presentation of expertise is more than a technical matter—it says something about how we see knowledge, whether in embodied or transcendent terms" (p. 13).

Obviously a communication source (in this case the instructional designer) must encode messages in *some* way in order for them to be sent over a channel to the receiver (the learner); this is an inevitability of human communication that cannot be avoided. However, as Subramony (2004) argued we are too often "ignorant of the hidden assumptions and strong cultural values that accompany our work, and are consequently failing to take on the social responsibility of making this self-evident to our audience and clients" (p. 21, citing a personal communication with Schwen, 2003). Technologies built around our understandings of knowledge acquisition within a socio-constructivist framework require that we become more aware of these "moral dimensions" of instructional interactions and begin findings ways to evaluate our designs more systematically around these issues (Thomas, Mitchell, & Joseph, 2002). Osguthorpe, Osguthorpe, Jacob, and Davies (2003) concluded that, until we become more critical of the way we conduct and view our designs in relation to those who will use our products, we will continue to inadequately address the instructional needs of certain segments of the intended audience for our work.

At the same time there has also been growing recognition that—in addition to cognitive processes—emotions play a critical role in human learning as well (Pekrun, 2011; see all the chapters by Kim and Pekrun herein). It is increasingly clear that emotion or *affect* impacts knowledge acquisition in terms of the overall climate of the learning environment itself (how welcomed and safe the learner feels within the learning context), the learner's predispositions about the content under study (how interested and confident the learner feels going into the learning task), and the dynamic affective states the learner undergoes throughout the experience (failure/success, boredom/engagement, frustration, and the like). Graesser and D'Mello (2011) observed, "in fact, the inextricable link between affect and cognition is sufficiently compelling that some claim the scientific distinction between emotion and cognition to be artificial, arbitrary, and of limited value" (p. 12; see also Bickhard, 2003). Still others have suggested that this shift in our thinking about knowledge acquisition requires an even more fundamental shift in the very outcomes we are hoping to achieve as well. Goodyear (2011) argued

> In scoping the field of learning, technology, and affect, it would be a great mistake to focus on taken-for-granted but obsolescent educational goals and processes. Optimizing instruction for nineteenth-century outcomes is not the direction in which we should be heading (p. 244).

In light of these next steps in the evolution of our thinking about knowledge acquisition and the ways in which learning theory and instructional technologies are connected by this understanding, Wilson (2005) has suggested we take a broader view of instructional design research that extends our "pillars of practice" beyond individual cognition/behavior and social/cultural learning to include the "often neglected aspects of design, particularly the moral and value layers of meaning, and the aesthetic side of our work" (p. 15). While some of the chapters in this *Handbook* edition help to further frame this discussion, we are only just beginning to scratch the surface of the direct implications that values and affect should have on our thinking about the design, use, and evaluation of instructional technologies within a socio-constructivist paradigm. Let's hope that, between now and the 5th edition of the *Handbook*, there will be much more to discuss in these areas of inquiry.

Control Within Learning Environments (Merrill)

In Chap. 1 Lowyck summarizes the developments on control within learning environments with the following important conclusion: "The advent of cognitive and (socio-) constructivist approaches shifted the focus from program control to learner and shared control." He then qualifies this development with the following statements: "Learner support in technology rich environments is crucial for learning. … The expectation that open-ended learning environments in and of themselves would result in learning is questionable." These qualifications suggest that some form of direct instruction and guidance is necessary if learning from learner-centered in open learning environments is to be effective.

Several chapters in this *Handbook* address the issue of control in more learner-centered learning environments, as the following examples indicate. Brand-Gruwel, Kester, Kickken, and Kirschner reinforce Lowyck's observation that learners who are self-directed with knowledge about the structure of the domain may benefit, whereas those who lack these characteristics have difficulty learning from open-learning environments. Their chapter discusses approaches for helping learners acquire the necessary self-direction to profit from more open learning environments. Herrington, Reeves, and Oliver emphasize that learning is better in the context of real-world problems. Goodyear, Jones, and Thompson review many approaches for promoting learner collaboration and critique. Seel emphasizes the need for learning environments to promote the learner's development of appropriate mental models.

In spite of the research efforts reported in this *Handbook*, much instruction in training and education still relies on some form of tutorial instructional design in which an instructional system provides a considerable amount of direct instruction and significant guidance in solving problems. For more than three decades and again in 2010 the most widely used textbook for instructional design, which describes the design of primarily direct instruction, is *The Systematic Design of Instruction* by Dick, Carey, and Carey (2009) (see Johnson, Xue, Mackal, & Reiser, 2012). When an organization is faced with the need to enable their trainees to acquire specific skills, it is far more likely to rely on direct instruction than on any of the forms of learner-centered approaches described in the chapters of this *Handbook*.

Van Merriënboer and Kirschner's *Ten Steps to Complex Learning* (2012) and Merrill's *First Principles of Instruction* (2012) suggest a middle ground approach that integrates the best of problem-based learning, learner collaboration, and tutorial instruction. van Merriënboer and Kirschner (2012) suggest a systematic, four-component approach to instructional design that also attempts to integrate a problem-centered approach with more direct instruction. They suggest four training blueprints: (a) [whole] learning tasks, (b) supporting information, (c) procedural information, and (d) part-task practice. Learning is in the context of an easy-to-difficult sequence of authentic, real-world, whole tasks. Supportive information helps learners acquire the problem-solving skills for performing the tasks and relate this information to what they already know. Procedural information helps learners perform the task and is gradually faded as learners gain experience with the task. Part-task practice enables learners to automate routine aspects of task performance. The authors also describe how self-directed learning activities can be incorporated into their four-component approach.

Merrill's *First Principles of Instruction* (2012) suggests that effective instruction consists of four instructional phases: (a) activation, (b) demonstration, (c) application, and (d) integration. This model further suggests that effective instruction is problem-centered; that is, learners best acquire problem-solving skills in the context of a progression of real-world problems. *First Principles* suggests a problem-centered approach that first demonstrates the solution for an instance of a problem to be solved or a task to be completed. This approach then provides demonstration and guided application for the component skills required for the solution of the problem or the completion of the task in the context of a progression of increasingly complex instances of the problem or task. It concludes with learners engaged in solving additional instances of the problem or completing additional instances of the task.

Merrill and Gilbert (2008) suggest that peer interaction is best in the context of solving real-world problems or completing real-world tasks. They suggest that peer sharing of related experience is most appropriate for activation of previously acquired mental models that are appropriate for acquiring the desired problem-solving skills; peer discussion is appropriate during demonstration of problem solving; peer collaboration is appropriate during application of component skills to the solution of a problem; and, peer critique is appropriate for integration of the problem-solving skills into the repertoire of the learner. The *First Principles* approach integrates these forms of peer interaction into the problem progression instructional sequence by: (a) providing a peer sharing activation experience prior to demonstrating a solution of the problem; (b) providing opportunity for peer discussion during the demonstration of one or more instances of the problem; (c) engaging learners in problem-solving collaboration during the application of component skills to the solution of problems in the sequence; and (d) involving learners in peer critique of the problem-solving efforts of their fellow learners. *First Principles* promotes model building by helping learners activate an existing mental model or providing a structural framework that can be used to develop an appropriate mental model; *First Principles* provides guided demonstration and practice in the context of a progression of real-world problems; and, *First Principles* integrates peer collaboration and critique into the instructional sequence.

Merrill (2012) and van Merriënboer and Kirschner (2012) represent two attempts to combine problem-centered, learner-centered, and guided direct instruction into an integrated approach. It is hoped that before the next *Handbook of Research* is published that there will be more work on integrating the various approaches described in this edition into instructional design models that capitalize on the strengths of the different approaches described herein.

A Fuzzy Array of Principles and Applications (Elen)

Lowyck in Chap. 1 uses the following metaphor to describe the evolution of the theoretical nature of our field: "the former theories resemble rivers flowing in a riverbed while the latter show a delta structure where the river spreads out in a fan shape into many channels." While not everybody may totally agree with the metaphor nor the interpretation Lowyck provides of it, the metaphor clearly illustrates that in our current reflections multiple perspectives, complexity, and diversity are fully acknowledged. Different chapters in this *Handbook* clearly illustrate this: there is no methodological preference, the (contextual functionality and value) of qualitative and quantitative methods is recognized; the importance of more domain-specific considerations with respect to instructional strategies is fully recognized, and with new technologies, tools, or toys "new" lines of research are opened. While valuable in its own right this whole movement also results in a very dispersed field open to all types of evolutions and perspectives, characterized by diversity and—luckily—mutual respect. The backside of this evolution might be that we end up with a large set of small nuclei all working very hard on their tiny little problem, with their very particular technology, from their very idiosyncratic perspective. The danger does not seem to reside in the recognition of complexity and diversity; rather, it seems to reside in the absence of critical discussion between these nuclei, the absence of challenging questions about why new meanings are given to solid terms, what the relevance is of investigating a well-known principle simply because a "new" technology is on the market. The danger may reside in too much disengaged respect and not enough engaged criticism. Organizations like AECT (Association for Educational Communications and Technology), initiatives like this *Handbook*, and the Springer series entitled "Explorations in the Learning Sciences, Instructional Systems and Performance Technologies" (edited by J. M. Spector and S. P. Lajoie) may help to counter these dangers.

While Lowyck may sound a bit pessimistic, different contributions in the Handbook also reveal that attempts are being made to overcome the problems and to work towards a new basic understanding, theoretically sound and empirically at least verifiable. Work of Merrill on the first principles (2001, 2012), of Jonassen on different types of problem solving (2011), of Hannafin and colleagues on open learning environments (Hannafin, Land, & Oliver, 1999), and of van Merriënboer and Kirschner on a complex learning design model are simple examples. In all these cases efforts are being made to identify interrelated, theoretically sound principles for which empirical evidence can also be provided. It is to be acknowledged that all these kinds of efforts remain at a more general level and hence to some extent abstract. But getting to a theory that is at the same time applicable in a wide variety of settings, considers a complex amalgam of variables, while also being very detailed and concrete is impossible. That is simply not what a theory is about. Any general instructional theory will need to be translated to a specific context, and will be usable and testable only after operationalization.

The development of solid instructional theories is a challenge for the years to come. It will require reconciliation of perspectives, basic agreements on what the goal of an instructional theory should be, on how different instructional goals can be described, on what learner characteristics are relevant, on how differentiation in context gets understood. All of this requires that we understand very well that a learning theory is not an instructional theory, nor is an instructional theory a learning theory, as repeatedly argued by Mayer (2010), Reigeluth (1983), and others.

We expect that at least two emerging approaches will challenge both current learning theories and current instructional theories and hence also their interrelationships. The first challenge will come from evolutions in neuro-psychogological and neuro-pedagogical research. Our understanding of the functioning of the brain will question our current conceptualizations and help us to derive learning principles that are even more closely linked to the way we think and learn. The second evolution relates to increasing possibilities to document what learners actually learn while learning and studying. The need to rely on what learners think they have done, how much mental effort learners report to have engaged in is gradually diminishing. We will be better able to acknowledge that learning and talking about learning are two behaviors that each require to be explained in their own right. Let's hope that these new evolutions challenge us enough to open up our nuclei and start discussing about really important and relevant instructional principles.

Concluding Remarks

This *Handbook* has taken 3 years to develop. It may take a dedicated educational technology researcher another 3 years to work through all of the knowledge represented and referred to in these pages. About the time that task is completed, the next edition of this *Handbook* may be available. Just as the task of conducting research and development to improve learning and instruction is never-ending, the task of understanding that body of knowledge and then applying it to improve learning and performance is never-ending. It is our hope that this *Handbook* makes a meaningful contribution to such efforts.

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