Section VII

Emerging Technologies

M.J. Bishop and Jan Elen

While instructional technologists must avoid the temptation to allow any technology to drive pedagogical decision making, there is little question emerging technologies bring along with them new opportunities and affordances upon which we can capitalize (for a complete review, see Clark, 2001). The purpose of this section of the Handbook, therefore, is to present research on new technologies, especially with regard to their potential impact on learning and teaching.

Given that the technologies presented in this section are quite new, in many cases the reader will discover that the research presented in these chapters will be somewhat limited. When that is true, chapter authors have indicated where questions remain about those specific technologies with regard to their application to teaching and learning and have provided insights into how one might conduct research in those areas. It is important to note that one apparent theme across many of these authors' research methodology recommendations is the movement away from randomized controlled trials in sterile lab-based settings toward the use of mixed-methods design research conducted in realistic, applied environments. While studies conducted in naturalistic settings are often expensive, conceptually difficult to conduct, and sometimes less "productive" in terms of theoretical insights, many of the authors in this section argue that this is the best approach to truly understanding how emerging technologies might help to optimize learning from the environments we design.

The first four chapters in this section are grouped together because their focus is largely on new hardware devices that promise to broaden our perspectives on instructional technologies beyond computer-based delivery with which learners interact via traditional mouse- and keyboard-based input in hopes of some digital or paper-based output. For example, recent developments in desktop manufacturing technologies allow one to design 2D and 3D objects on the computer screen, and then "print" them out on a fabrication device as tangible products. While these systems have only recently become affordable for schools to purchase, Glen Bull, Jennifer Chiu, Robert Berry, Hod Lipson, and Charles Xie argue that they hold great promise for enhancing pedagogical approaches to science, technology, engineering, and mathematics (STEM) topics. Their chapter discusses these possibilities and points readers to the many fruitful avenues of research to be done in this area, particularly those aimed at helping teachers understand how to capitalize on these technologies to optimize learning.

Next, Michael Evans and Jochen Rick explore recent developments in interactive surfaces (tablets, tabletops, whiteboards) and spaces (smart rooms) with which learners manipulate digital information directly with their fingers, feet, and other body movements as opposed to traditional mouse-and-keyboard-mediated interactions. The authors argue that these "natural interfaces"—many with multiple access points for groups of learners to collaborate—provide unique opportunities for designers to support colocated collaborative and more kinesthetic learning experiences. The authors discuss the technology development projects under way, review the existing empirical research to date, and point to the additional work needed to advance educational practice in this area.

The next chapter explores "smart toys," which Kursat Cagiltay, Nuri Kara, and Cansu Cigdem Aydin define as toys that facilitate two-way interactions between the child and toy in order to carry out purposeful tasks. The authors suggest that, because these toys can potentially have significant effects on children's cognitive development, they should be designed and developed from a strong foundation in developmental theory. This chapter, therefore, explores the relationships between smart toys and children's developmental stages.

In the last of the hardware-specific chapters in this section, Ann-Louise Davidson and Saul Carliner explore e-books and their affordances within learning contexts.

M.J. Bishop, Ed.D. (✉)
Lehigh University, Bethlehem, PA, USA
e-mail: mj.bishop@lehigh.edu

J. Elen
KU Leuven, Leuven, Belgium

Granted, e-books are not necessarily hardware specific—the authors suggest that any device that can open e-book file formats in some sort of "reader" application might be considered an e-book. However, the proliferation of e-book-specific devices like the Kindle and Nook muddies the existing research in this area and continues to make it difficult for educators to know what direction to take when considering adoption in school-based settings. In this chapter, the authors help to clarify where the technology currently stands, discuss the issues, and suggest areas for future research.

The remainder of this section moves away from hardware-specific technologies in order to explore applications that are more or less device independent. For example, the next two chapters explore the opportunities that virtual worlds and augmented reality technologies present for contextualizing learning. First, Lisa Dawley and Chris Dede review recent developments and design considerations for creating virtual worlds and immersive simulations intended to enhance learners' engagement and situate learning. Then Matt Dunleavy and Chris Dede continue the discussion by focusing on the use of augmented realities, which enable participants to interact with digital information embedded within the physical environment. The authors suggest ways these technologies can be used to scaffold authentic inquiry, active observation, peer coaching, reciprocal teaching, and legitimate peripheral participation among groups of learners.

Next, Yu-Chang Hsu, Yu-Hui Ching, and Barbara Grabowski review Web 2.0 communication tools and technologies and explore their affordances for instructional contexts from a "learning through collaboration" lens. While their review uncovers many promising classroom-based practices for Web 2.0 applications such as blogs, wikis, collaborative documents, social networking, video sharing, and the like, the authors also identify many unexplored opportunities and challenges to be addressed in terms of both research and practice. They suggest further that until we understand more about how these technologies can enhance learning experiences, we will not realize the real potential of Web 2.0 applications for instruction.

According to George Veletsianos and Gregory Russell, "pedagogical agents" are "anthropomorphous virtual characters employed in online learning environments to serve various instructional goals." Pedagogical agents have been touted by proponents as being adaptable and versatile while also capable of providing realistic simulations, addressing learners' sociocultural needs, improving motivation, and enhancing learning. However, the authors note from their review of the recent research on pedagogical agents that empirical support for the claims made about the utility of these technologies has been somewhat mixed. They recommend further work on the sociocultural aspects of pedagogical agent use and, like others in this section, suggest mixed method studies in naturalistic settings.

Sabine Graf and Kinshuk's chapter on adaptive learning technologies focuses on environments that "intelligently" adjust to learners' needs based on their learning styles, cognitive abilities, affective states, and the learning context/situation. The authors discuss methods by which these adaptive environments become "aware" of the learners' needs, note the myriad ways in which adaptive technologies are being used across a variety of platforms, and identify areas of future research.

According to David Wiley, TJ Bliss, and Mary McEwen, open educational resources (OERs) are "educational materials either licensed under and open copyright license or in the public domain." Their chapter reviews research in this area around how OERs are produced and shared, as well as the benefits of OERs for learning contexts. The authors note that, while significant obstacles regarding OERs remain unresolved, including definitional issues, this is a promising area of research that needs further exploration.

The final two chapters in this section both explore visual representations, but from different sides of the same coin. Joris Klerkx, Katrien Verbert, and Erik Duval's chapter discusses the ways visualizations that are *generated for the learner* can be used to help them find and understand educational resources, collaborate with others, and reflect on their progress within a learning environment. In contrast, Ton de Jong's chapter explores emerging technologies available to create visualizations *generated by the learner* to organize, analyze, and synthesize information while problem solving. Both chapters explore the variety of affordances that different representational formats offer for learning and synthesize the recent research in these areas.

Like other sections in this *Handbook*, this section is by no means an exhaustive look at all emerging technologies likely to impact teaching and learning in the near future. Notably missing from this review, for example, are mobile technologies, cloud computing, and personal learning environments. In most cases, the paucity of research in these areas precluded the inclusion of these topics at this time. While many of these technologies are discussed less directly elsewhere in this volume, a more complete review of the emerging research in these areas will have to wait for future editions of the *Handbook*.

Reference

* Clark, R. E. (Ed.). (2001). *Learning from media*: *Arguments*, *analysis*, *and evidence*. Greenwich, CT: Information Age Publishing.

* An asterisk next to a reference entry throughout this Handbook indicates a reference that the author(s) considers to be central to the topic.