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Editors

The Psychology of Digital Learning

Constructing, Exchanging, and Acquiring Knowledge with Digital Media

Springer

Introduction

Today, hundreds of thousands of students enroll in Internet-based courses (Massively Open Online Courses—MOOCs); digital tablets and multimedia textbooks have found their way into the classroom; people do not only routinely look up information on Wikipedia but also feed their own knowledge into online networks; and learners interact with digital content not only via screen, keyboard, and mouse but have begun to access and actively transform information via immersive displays and bodily activities such as gesture or touch. Putting all these trends together, constructing, exchanging, and acquiring knowledge has undergone a fundamental transformation in the past three decades.

Fifteen years ago, the field of digitally enhanced learning was in the midst of this transformation: Multimedia applications, intelligent tutorial systems, email, and web browsers had already been around for several years. Apple had at this time just introduced the iPod, Marc Prensky coined the term "Digital Natives," Richard Mayer published his influential book on "Multimedia Learning," and eLearning was a trendy buzzword. However, there were neither smartphones, YouTube, Wikipedia, or Facebook, nor a systematic monitoring of these developments for education (the first Horizon report of the New Media Consortium was issued in 2004).

Yet, from 1990 to 2000 the introduction of digital technologies into classrooms, universities, and informal learning settings had gained momentum, and as early as 2001, there was a growing need for both theoretical models and basic empirical research on the implications of digital technologies on processes and outcomes of learning. Thus, many questions arose: Will advanced digital presentation technologies, such as animations or simulations, help learners to better understand the principles of dynamic systems and events? Will self-guided interactive control enable learners to adapt a learning environment to their cognitive needs, or will it introduce an additional cognitive burden that distracts students from the content to be learned? Will nonlinear content allow for more flexible mental representations, or will it confuse users, making them become lost in hyperspace? How do small groups solve knowledge-related tasks, and how can each member be made aware of intragroup differences and commonalities of knowledge? How can large online communities be utilized for knowledge construction and knowledge exchange?

It quickly became clear that the answers to these and related questions could not be given on the basis of purely technological or educational considerations, but also required a psychological stance, firmly grounded in current cognitive models of the underlying structures and mechanisms of human information processing and learning. Thus, it does not come as a surprise that it was an acknowledged expert from the field of basic experimental research in psychology who met the challenge of linking modes and technologies of digital learning to models and paradigms of experimental psychology.

Friedrich W. Hesse had studied psychology in Marburg and Düsseldorf, had received his PhD in Aachen, and completed his habilitation in Göttingen before he was appointed a full professor at the University of Tübingen and became head of a research group at the Deutsches Institut für Fernstudienforschung (DIFF). He was well recognized for his expertise in human problem solving and in the interplay of cognition and emotion. Soon after his move to the DIFF, he realized the necessity of what later would be termed as use-inspired basic research, namely, empirically investigating and explaining phenomena of learning with digital media "in the wild" by applying theories and methods from basic cognitive research. In the course of closing the DIFF in 2000, he envisioned the idea of a research institute exclusively devoted to addressing knowledge processes with digital media by means of a fruitful fusion of basic and applied perspectives. It was exactly the right time for bringing this vision into being, and in the following months, Friedrich Hesse devoted all his energy and expertise to convince the relevant stakeholders of the importance of this endeavor for both the scientific community and society. Armed with strong arguments brought forward by his passionate personality, he succeeded to receive the necessary institutional and financial support, and finally in 2001, the Leibniz Institut für Wissensmedien (IWM) was inaugurated with Friedrich Hesse as its founding director.

Luckily, from its beginning the IWM was part of the Leibniz Gemeinschaft, a network of 91 scientific institutes that all pursue the philosophy of "theoria cum praxis," thus bridging basic and applied perspectives by doing research that is both excellent in scientific terms and at the same time of high relevance for important issues currently being dealt with in our society. The IWM fits perfectly well into this program, and in the last fifteen years, Friedrich Hesse has continued his pioneering work both within the IWM and also on the level of the Leibniz Gemeinschaft as a whole. One prominent example of his innovative impulses was the first virtual Ph.D. program of the German Research Foundation (DFG), where insights from the IWM's research were applied to the scientific community itself by making heavy use of the opportunities provided by modern digital media for scientific research and exchange. Another tremendously influential initiative by Friedrich Hesse was the first German science campus, a close collaboration between the IWM and the University of Tübingen, again bringing forward the idea that scientific research at its best will be an interdisciplinary combination of basic and applied perspectives.

Against this background, the aim of this book is to provide an overview of the state of the art of psychological research on learning and knowledge exchange with digital media, based on the comprehensive research program that was realized at the

IWM during the past decade. At the same time, it honors the enormous impact that Friedrich W. Hesse, the founder and current director of the institute, has had on this field. These two goals go together well because, since its foundation in 2001, the IWM has become one of leading institutes for research on processes of knowledge acquisition, knowledge exchange, and knowledge communication using innovative technologies.

Research at the IWM has covered a dramatic rise of new tools and technologies that have fundamentally reshaped teaching, learning, and knowledge exchange from the perspective of human information processing. Eight different labs cover a broad spectrum of topics, ranging from questions of appropriate strategies for searching the internet, optimal conditions for mental integration of multimedia presentations, the neural correlates of learning, determinants of active contribution of pieces of knowledge to online forums, facilitating conditions and tools for knowledge management to the motivations for knowledge sharing in organizational contexts, the role of social networks, and tie strength in receiving informational benefits. Hence, the book provides an easily accessible overview of the main theoretical approaches and empirical results that have been accumulated at the IWM over the past years.

In essence, learning, knowledge construction, and knowledge exchange with digital media are conceptualized as an interplay between the information processing structures of the users and the enabling and enhancing capabilities of a certain digital technology, with the goal of comprehending or exchanging a particular content or piece of knowledge. Human information processing is used in a broad sense, comprising not only perception and attention, working memory and long-term memory together with processes of metacognition, information selection, activation of prior knowledge, elaboration, and social cognition, but also seeing learners as social agents, who actively participate in knowledge construction, communication, exchange, and collaborative problem solving. Also, with reference to digital technology, emphasis is put on its generic attributes such as nonlinearity, multimedia, visibility, persistence, editability, or association, instead of narrowly focusing on specific, quickly outdated implementations.

In accordance with the institute's lab structure, the present book charts the field of learning with digital media in ten chapters. The first four chapters deal with the role of different presentation formats of digital content—texts, numbers, visualizations—and their interplay for knowledge processes. In Chap. 1, Katharina Scheiter, Anne Schüler, and Alexander Eitel review the empirical findings from studies that have been conducted in Katharina Scheiter's lab regarding knowledge acquisition via combinations of verbal and pictorial representations. In particular, both the cognitive underpinnings of learning with multiple types of representation formats and effectiveness of instructional interventions fostering cognitive integration of text and pictures are discussed. Based on Korbinian Moeller's research program and his lab, Chap. 2, written by Ursula Fischer, Elise Klein, Tanja Dackermann, and Korbinian Moeller, focuses on the acquisition of numerical skills by use of computer-supported embodied numerical trainings and their underlying neuro-cognitive mechanisms. In Chap. 3, the main focus is on the role of realistic pictures in digital learning environments. Based on findings of Stephan Schwan's lab, differences and

commonalities between perception and mental processing of realistic pictures in comparison to real-world information are described. In Chap. 4, the first block of chapters closes with an overview of research results from Peter Gerjets' lab about new developments in learning with hypermedia environments that are structured in a nonlinear manner. Here, learners are required to evaluate and integrate multiple sources of information, often accessed via novel interaction formats, including gesture or touch.

The second block of chapters is devoted to processes of knowledge production, knowledge exchange, and knowledge processing within networked groups. Chapter 5, written by Annika Scholl, Florian Landkammer, and Kai Sassenberg, summarizes a research program in Kai Sassenberg's lab about the impact of a great variety of characteristics of social relations on information exchange in context of computer-mediated communication. Information exchange is conceptualized as a socially motivated process in which certain social constellations elicit group- or self-serving motives that influence how information is shared and received. In Chap. 6, Jürgen Buder outlines a conceptual framework of knowledge exchange in small groups of learners, integrating dimensions of context, input, process, and output on the basis of the lab's empirical research on group awareness tools. Based on a large set of empirical studies in their lab, Ulrike Cress and Joachim Kimmerle have developed a complementary cognitive-systemic framework of the interplay of individual learning and collective knowledge construction, described in detail in Chap. 7. In Chap. 8, Carmen Zahn discusses the notion of "design-based learning" as a powerful approach for fostering a learner's comprehension of a given topic. She reports on the findings of five experimental studies on how dyads make use of advanced video tools for collaboratively solving design problems. In Chap. 9, Sonja Utz and Ana Levordashka show how social media users derive professional informational benefits from online networks such as Facebook, LinkedIn, or Twitter, depending on platform usage, networking behavior, and network composition. They report on a large-scale longitudinal study currently underway in Sonja Utz's lab.

Finally, in his afterword, the long-standing chairman of the institute's scientific board, Hans Spada, closes the book giving a knowledgeable view from outside and thoughtfully reflecting on the IWM's scientific and institutional history of the past 15 years.

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Contents