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International Handbook of Metacognition and Learning Technologies

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International Handbook of Metacognition and Learning Technologies

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Preface

This is the first international handbook on the topic of metacognition and learning technologies. We are proud to have been invited by Springer to coedit such an important two-volume international handbook. The handbook represents the best cutting-edge interdisciplinary research from leading scholars across the globe. The ubiquity and widespread use of learning technologies across various settings (e.g., classrooms, informal settings, and research laboratories) necessitate a theoretically guided and empirical basis for their use for learning and instruction. It has become clear in recent years that learners' self-regulatory and metacognitive processes are a key influence on their learning outcomes with computer-based learning environments. A deep understanding of the relations between self-regulation, metacognition, the design of learning environment, and learning outcomes is therefore highly desirable from both a scientific and a practical perspective. This fundamental requirement has led dozens of interdisciplinary researchers to focus on understanding, measuring, supporting, and fostering metacognition and self-regulated learning in individual and collaborative groups. As such, the timely publication of this handbook is critical since it is the first to document the most influential interdisciplinary research on the topic from researchers in the fields of educational psychology, learning sciences, computing sciences, artificial intelligence (AI), cognitive psychology, human–computer interaction (HCI), educational technology, educational data mining, engineering, mathematics education, science education, teacher education, and literacy.

We hope that the handbook will be viewed as a standard of scholarship for conceptual, theoretical, empirical, and applied research in the several areas related to learning technologies and metacognition. This handbook is targeted as a resource; as such it should appeal to a broad interdisciplinary audience, including researchers, professors, graduate and upper-level undergraduate students, instructional designers, curriculum developers, teachers, and anyone else interested in learning about learning technologies and metacognition. Our handbook can be used as the primary textbook for a graduate-level course in metacognition and learning technologies. It can also be used as a supplement for graduate courses on cognition, metacognition, learning, learning sciences, theories of learning and instruction, human–computer interaction, artificial intelligence (AI) in education, educational technology, and measuring complex cognitive, metacognitive, motivational, and affective processes prior to, during, and following learning and problem solving.

The *International Handbook of Metacognition and Learning Technologies* has 46 chapters thematically structured across seven sections: Models and Components of Metacognition, Assessing and Modeling Metacognitive Knowledge and Skills, Scaffolding Metacognition and Learning with Hypermedia and Hypertext, Intelligent Tutoring Systems and Tutorial Dialogue Systems, Multi-Agent Systems to Measure and Foster Metacognition and Self-Regulated Learning, Individual and Collaborative Learning in Classroom Settings, and Motivation and Affect: Key Processes in Metacognition and Self-Regulated Learning. Each section contains a varying number of chapters, ranging from four to nine, written by leading scholars in each topic area. The difference in the number of chapters across each section is representative of the focus of research in the area of metacognition and learning technologies. For example, there are nine chapters in the section on scaffolding metacognition and learning with hypermedia and hypertext because this area has traditionally been a dominant area of research. By contrast, there are only five chapters in the motivation and affect section because this area of research has been emerging more recently; it is our opinion that it stands to contribute immensely to our understanding of the role of metacognition and learning technologies.

Our greatest challenge was assembling the finest collection of contributors to the handbook. We as editors are extremely impressed with the quality and diversity of the chapters that are collected in this handbook. It is our profound hope that the readers of this handbook will find the chapters as stimulating and gratifying as we found them when assembling the handbook. Happy reading! Please don't forget to monitor as you read.

Montreal, QC, Canada — Roger Azevedo
Pittsburg, PA, USA — Vincent Aleven

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Susan Bull leads the Artificial Intelligence in Education research in the School of Electronic, Electrical and Computer Engineering, at the University of Birmingham, UK. Much of this work is in the area of Open Learner Models and aims to help promote metacognitive activities in learning, including self-reflection, monitoring, and planning. The work also considers skills related to collaborative learning and peer help. This work focuses on both the more traditional, as well as emerging social and other new technologies, and applies not only to learners but also to professors and lecturers, teachers, parents, and other stakeholders in the education process.

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Halszka Jarodzka holds a Master of Science in Psychology (2007) and a Ph.D. (2011) from Tuebingen University, Germany. Her Ph.D. thesis focused on characteristics and training of visual expertise in biological and medical domains, and during her Ph.D. research she worked at the eye-tracking laboratory at Lund University (Sweden), the medical department of Aarhus University (Denmark), and the Center for Learning Sciences and Technologies (the Netherlands). In July 2010 she joined the Open University of the Netherlands as an Assistant Professor, where she pursues her investigations of visual expertise and her research interest in methodological aspects of eye-tracking.

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Ton de Jong is Professor of Educational Psychology at the University of Twente, the Netherlands. He specializes in inquiry learning (mainly in science learning) supported by technology. He was project manager of several EC projects and several national projects, including the ZAP project, in which interactive simulations for psychology were developed. ZAPs are sold worldwide. For ZAP and SimQuest he has won a number of international prizes. He published over 100 journal articles and book chapters and is on the editorial board of 7 ISI journals. In 2006 he published a paper in *Science* on inquiry learning with computer simulations.

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David A. Joyner is a doctoral student at the Georgia Institute of Technology. He works in the Design and Intelligence Laboratory in the School of Interactive Computing investigating ways in which to teach and facilitate model-based reasoning and scientific inquiry in middle-school classrooms. His forthcoming Ph.D. proposal will propose an environment and software tutor for interactively teaching students these skills.

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Hermann Koerndle is Professor of Psychology of Learning and Instruction at Dresden University of Technology, Germany. He has an extensive background in both cognitive psychology and man–machine interaction. Hermann Koerndle received his Ph.D. at Oldenburg University, worked at Regensburg University in the field of applied psychology, then at the Technical University of Aachen in the field of man–machine interaction. Since October 1993 he is at Dresden University where he is currently engaged in (a) research on the factors in and effects of technology-enhanced interactive learning tasks, and (b) research on open-ended authoring tools in various instructional contexts.

Bracha Kramarski is an Associate Professor and the head of the Mathematical Training department in Bar-Ilan University. Her research deals with metacognition and SRL in mathematics education and teachers' professional education with advanced technology environments. She developed in her Ph.D. an innovative method called IMPROVE for learning mathematics, based on metacognitive and SRL principles, cooperative learning, and feedback-corrective theories. Her research is published in prestigious journals. Recently she was invited by the OECD to write a paper on the impact of mathematics education on twenty-first century skills based on the IMPROVE research. Prof. Kramarski was the principal investigator and research director for PISA 2000, 2006 in Israel.

Susanne P. Lajoie received her Doctorate from Stanford University in 1986. She is a Canadian Research Chair in Advanced Technologies for Learning in Authentic Settings (ATLAS) and directs the ATLAS group at McGill University. She is a Fellow of the American Psychological Association as well as an Inaugural Fellow of the American Educational Research Association. Dr. Lajoie uses a cognitive approach to identify learning trajec-

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Marcia C. Linn is a Professor at the Graduate School of Education, University of California, Berkeley. She is a member of the National Academy of Education, and a Fellow of American Association for the Advancement of Science (AAAS), American Psychological Association, and Association for Psychological Science. She was elected President of the International Society of the Learning Sciences, Chair of the AAAS Education Section, and member of the AAAS Board. She received the National Association for Research in Science Teaching Award for Lifelong Distinguished Contributions to Science Education and the Council of Scientific Society Presidents first award for Excellence in Educational Research.

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Rose Luckin has a Bachelor's degree in Computer Science and Artificial Intelligence and a Ph.D. in Cognitive Science, both from University of Sussex. She is Professor of Learner Centered Design at the London Knowledge Lab. Her research explores how to scaffold learning across multiple technologies, locations, subjects, and times. Luckin has taught in a range of sectors, including schools, and Further and Higher Education. In her book "Re-designing Learning Contexts," (Routledge, 2010), Luckin explores the meaning of *Context*, it's relationship to learning, and the manner in which we can develop technology rich contextualized learning activities that meet each learners needs.

Valentina Lupi earned her degree in Languages at the University of Genoa (Italy) in 1995, then (1996–2000) studied Linguistic and Theatre Translation at the Sophia-Antipolis University in Nice (France), and later earned a Ph.D. in "Languages, Cultures, and ICT" at the University of Genoa (2006–2008). She is currently a French teacher in a junior high school. She has been teaching in the teacher training school of the University of Genoa and collaborates with researchers of the University of Genoa and of the Institute for Educational Technology of CNR. Her current research focuses on the mediation of ICT to learn foreign languages, applying task-based activities to trigger creativity.

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Daniel C. Moos is an Assistant Professor in the Education Department at Gustavus Adolphus College, St. Peter, Minnesota (USA). His research broadly considers the relationship between cognitive, metacognitive and motivational processes in learning. Most recently, he has focused on the role of metacognitive calibration and its effect on motivation in learning with emerging technology. His research also extends to teacher preparation and the relationship between self-regulated learning and instructional practices.

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Laura Naismith is a doctoral student in the Department of Educational and Counseling Psychology at McGill University in Montreal, Canada and a member of the ATLAS laboratory. Her dissertation examines the influence of emotion on medical students' attention to feedback in a computer-based learning environment. Previously, she worked with subject specialists in the Centre for Learning, Innovation and Collaboration (CLIC) at the University of Birmingham in the UK to develop a needs-driven research program in Educational Technology with funding from Microsoft UK Ltd. Naismith trained as a systems design engineer at the University of Waterloo in Canada.

Susanne Narciss is a Professor at the Department of Psychology of Learning and Instruction at Dresden University of Technology. She received her Ph.D.

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Timothy J. Nokes-Malach is an Assistant Professor of Psychology and a Research Scientist at the Learning Research and Development Center at the University of Pittsburgh. He received his Ph.D. from the University of Illinois at Chicago and postdoctoral training at the Beckman Institute at the University of Illinois at Urbana-Champaign. His research focuses on human learning, problem solving, knowledge transfer, and most recently on the effects of motivation and social interaction on those processes. His work has been supported with grants from the Pittsburgh Science of Learning Center, the National Science Foundation, and the Department of Education's Institute of Education Sciences.

Maria Opfermann is an Assistant Professor at the Department of Instructional Psychology at the University of Duisburg-Essen, Germany. She has a background in Educational Psychology with a focus on Instructional Psychology and received her Ph.D. in 2008 with her thesis focusing on the role of instructional design and individual learner characteristics in multimedia and hypermedia learning. In line with this, her main research interests focus on learning with multimedia and the role of cognitive load and its measurement. In addition, current studies focus on different ways of instructional support to foster self-regulated learning with multimedia.

Marily Oppezzo received her doctoral training in the School of Education of Stanford University. She also earned a Master's degree in Nutritional Science and is a Registered Dietitian. Her Ph.D. thesis demonstrated that simply taking a walk outdoors doubles highly structured creativity compared to several control conditions, including being pushed in a wheel chair outdoors or walking on a treadmill. Her recent studies investigate the most effective strategies for empowering people to motivate themselves to maintain difficult behavior changes that include academic and health-related goals.

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Eric Poitras is currently completing the requirements of a doctoral degree in Educational Psychology with specialization in the Learning Sciences at McGill University. He obtained his B.A. at the University of Moncton, NB, and his M.A. at McGill University under the supervision of Dr. Susanne Lajoie and is a member of the ATLAS laboratory. His research aims to evaluate the design of a metacognitive tool called the MetaHistoReasoning tool in terms of enhancing learning through historical inquiry.

Antje Proske is a research assistant at the department of Psychology of Learning and Instruction at Dresden University of Technology. She received her Ph.D. in Psychology (2006) on the development and evaluation of interactive training tasks in academic writing. She was actively involved in several joint projects of the German funding program "New Media in Education" dealing with the question of how to support efficient Web-based learning in various instructional contexts (http://www.studierplatz2000.tu-dresden.de). Her current research interests include the development and experimental investigation of computer-based scaffolding for academic writing and self-regulated learning, as well as the construction of interactive learning tasks.

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John Ranellucci received a B.A. in psychology from Concordia University, a M.Ed. in Educational Psychology at McGill, and is currently a doctorate candidate at McGill and is a member of the ATLAS laboratory. His research interests focus on motivation, emotion, and self-regulated learning.

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Falko Rheinberg was born 1945. He received his Master's degree in psychology in 1972, followed by a doctoral degree in Philosophy in 1977. He completed his Habilitation at the University of Bochum, Germany in 1983, where he held the position of Assistant Professor between 1972 and 1983. During this time, he conducted research on how teachers' achievement evaluation has an effect on students' motivation to learn (Reference Norm Orientation). From 1983 to 1994, he was a Professor of Educational Psychology at the University of Heidelberg, Germany. His research focused on motivational training in schools and organizations. Between 1994 and 2007, he held the position of Professor of Psychology at the University of Potsdam, Germany, where he was Chair of Psychology of Motivation, Emotion, and Action. He investigated motivational effects on learning activities, incentives of purpose and action, risk motivation, and flow experience. He retired in 2007.

Ido Roll is a Science Teaching and Learning Fellow at the Carl Wieman Science Education Initiative at the University of British Columbia and a researcher in the Pittsburgh Science of Learning Center. His research focuses on helping students become more capable, curious, and innovative learners. Roll is particularly interested in understanding, promoting, and assessing self-regulation and inquiry learning skills in the context of authentic environments, often using educational technologies. He has published numerous papers in the fields of Education and the Learning Sciences, Cognitive Science, Artificial Intelligence, and Human–Computer Interaction. His work has received several best-paper awards in peer-reviewed conferences.

Jonathan P. Rowe is a doctoral candidate in the department of Computer Science at North Carolina State University. His research focuses on intelligent tutoring systems, user modeling, and interactive narrative in game-based learning environments. He received the M.S. degree in Computer Science from North Carolina State University and the B.S. degree in Computer Science from Lafayette College. He served as a co-organizer for the Fourth Workshop on Intelligent Narrative Technologies. His research has been recognized with Best Paper Awards at the Seventh International Artificial Intelligence and