

IN ORDER TO LEARN

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In Order to Learn:
How the Sequence of Topics Influences Learning
Edited by Frank E. Ritter, Josef Nerb,
Erno Lehtinen, and Timothy M. O'Shea

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To our Families, Who Help us Learn

Foreword

David Wood

How can we explain our species' remarkable capacity to disseminate and propagate intellectual discoveries through generations and over time? For me, this is the most fundamental theoretical question that underpins and integrates the chapters offered in this volume. Deep divisions separate those theorists who have sought explanations in a selective, self-constructive, and self-evaluative learning process from theoretical positions that look to processes of spontaneous or intentional teaching as mediators of learning and rediscovery. Each of the two general positions is occupied by competing, special theories. These theories, in company with yet other approaches—ones that seek more integrated explanatory accounts of interactions between processes of learning and teaching—make for the complex conceptual and methodological landscape that this book explores.

The book's focus on the study of order effects in learning continues and advances a major methodological strategy for exploring this fundamental issue. Crudely, to the extent that the order and sequence of

experience is crucial for learning and rediscovery (and to the extent that learners are unable to impose such ordering on their own learning environment), one is tempted to seek explanations in terms of an implicit or explicit pedagogy. Conversely, where order is irrelevant or of little account (or where learners are able to structure and evaluate their own environment to help optimize the learning process), one might take more seriously those theories that stress self-construction and autodidactics. Alternatively, of course, one might prefer to turn to learning theories that explain why sequential order is unimportant in the first place.

Added to the theoretical promise of research into order effects are potential educational applications afforded by a deeper understanding of sequential constraints on curriculum design. The book also contributes to this tradition with, for example, critical evaluations of and challenges to supposed "principles" of curricula organization found in contemporary educational settings.

Many chapters, the editors warn us, raise more questions than they answer. Some also generate empirical findings that either are less decisive or clear-cut than expected or seem impossible to reconcile with the hypotheses tested and theories advanced. Others generate unambiguous but intriguing and even counterintuitive outcomes that are worthy of future replication and extension into new learning contexts.

To give a flavor of these latter cases, I was struck by findings that, for me, gave rise to the following questions:

- How, when, and under what conditions is it possible for learners to learn from their own errors when they seem to lack the knowledge about how to be right?
- How can we explain a finding that implies that learning improves when learners impose their own order on the tasks to be learned—even when they change the order away from one found to benefit learning?
- How, why, and under what conditions can feedback to a learner that is actually based on a misconceived explanation of the phenomena they are attempting to understand enhance their learning more so than feedback based on a robust understanding of the phenomena?
- How should we conceptualize the nature of the relations between the processes underpinning original acts of discovery (such as the construction of a new and powerful theory) and those involved in subsequent learning (rediscovery?) by others about what has been discovered?
- Instructional support often seems to enhance learning best when it is contingent on learner problem solving, minimalist in content and offered in response to learner error or help request. This seems to apply not only to learning specific skills but also to learning strategies for regulating one's own learning. What kind of theory of learning can explain why learning should be enhanced by such attributes of instructional support?

- The idea that order effects might be optimized by sequences of tasks or assignments that become progressively harder has intuitive appeal. Under what conditions of learning might the idea prove false . . . and why?
- Why might the timing and spacing of learning activity that optimizes rapid learning be far from optimum in promoting the most enduring memorization of what has been learned?

I have drawn these questions from findings reported in this volume. These findings, when taken in company with other highlights found in the chapters that follow, do not exactly lend support to any one major theoretical position: In this sense, as the editors caution us, they spawn more questions than answers.

One has to ask whether and where the everyday connotations of natural language might mislead us to expect theoretical coherence across contexts that, though bound together under everyday uses of the verb “to learn” or “to discover,” rest on quite different psychological processes, processes that might best be investigated using different empirical approaches. This book addresses such issues as an explicit part of its agenda and its rationale. The editors tell us that the volume has a self-conscious tutorial function. The inclusion of

- chapters that guide readers through the theoretical and empirical landscape
- efforts by the authors of each chapter to articulate questions, projects, or issues designed to support further thought and learning
- cross-referencing across chapters on key points

offer evidence of the authors' efforts toward these objectives. The result is a book that manages to explore the state of the art without trivializing the complexity of the challenges involved, one that also offers support to its intended readers as they try to meet the demands of such challenges.

Preface

The order in which material, for acquiring both facts and skills, is presented or explored by a learner can strongly influence what is learned, how fast performance increases, and sometimes even whether the material is learned at all. This book proposes that these effects are more pervasive and important than we have previously believed. The chapters explore the foundational topics in this area at the intersection of psychology, of machine learning, of AI and cognitive modeling, and of instructional design. We included some case studies and numerous questions that should lead to further research projects and provide stimulation and encouragement for professionals working in areas such as education. In some ways, the chapters raise more questions than they answer.

This book will interest experimental psychology types, educational design folks, and machine learning aficionados, as well as cognitive scientists in general. The audience also includes graduates and practitioners of computer science (particularly AI and machine

learning), psychology and cognitive science, and educational technology who are interested in order and learning. Readers may be potential researchers or informed consumers of future computing or instructional design products that support human learning or deploy machine learning techniques. This book is intended for those who are seriously interested in these issues and have some training or a strong interest in one of these fields.

Each chapter is self-contained and relatively short. They are directly accessible to at least one of the three types of readers that the book is designed for and should be useful for the others. We worked with the authors to help the book chapters integrate more like a textbook and to appear less like an edited conference collection. Many argue a surprising point of view on the importance or irrelevance of ordering or sequencing for instructional design domains and about human skill or machine learning mechanisms. Each chapter ends with clear conclusions, including

generalizations, suggestions for action, and projects of various sizes. The book is also designed to be a source book for people at the early stages of their PhD work.

Collaborative learning: Cognitive and computational approaches. Edited by P. Dillenbourg. 1998. New York: Pergamon.

HISTORY OF THE BOOK

This book arose out of a task force created as part of the Learning in Humans and Machines (LHM) project. Hans Spada was the leader of this European Science Foundation (ESF) initiative.

The research program was organized by means of five task forces on the following themes:

- representation changes in learning (Task Force 1, Kayser)
- learning with multiple goals and representations (Task Force 2, van Someren)
- learning strategies to cope with sequencing effects (Task Force 3, O'Shea and then Lehtinen)
- situated learning and transfer (Task Force 4, Bliss)
- collaborative learning (Task Force 5, Dillenbourg)

This book was discussed at several general meetings of the task force, including the first one in Milton Keynes, where Tim O'Shea put forward the idea of a highly edited, accessible book to serve as an introduction to order effects in learning. Over time, chapters were added by members of other task forces and by other prominent thinkers on learning. Thus, this book joins the other books produced by the other LHM task forces, including:

Learning in humans and machines: Towards an interdisciplinary learning science. Edited by P. Reimann and H. Spada. 1996. New York: Pergamon

Modelling changes in understanding. Edited by D. Kayser, and S. Vosniadou. 1999. New York: Pergamon.

Learning with multiple representations. Edited by M. W. van Someren, P. Reimann, H. P. A. Boshuizen, and T. de Jong. 1998. New York: Pergamon.

Learning sites: Social and technological resources for learning. Edited by J. Bliss, R. Säljö, and P. Light. 1999. New York: Pergamon.

PROGRAM STRUCTURE: THE TASK FORCES

Authors

The initial set of chapter authors were selected by the steering committee of the LHM special program to be members of a task force on the effects of task order on learning in humans and machines. Our task force's charge was to explore how the order in which learning tasks are performed affects the final outcome of learning. We were also to determine how each of the three areas of (a) psychology, (b) machine learning and cognitive modeling, and (c) instructional design can be fruitfully combined to understand and use order effects in learning tasks. Thus, cross-disciplinary results are common in the chapters. We invited members of other ESF task forces and other authors as appropriate who have a strong point of view on ordering and learning.

Other Acknowledgments

We would like to thank the members of the initial task force who were not able to provide chapters but who contributed to our thinking and the design of the book: Eileen Scanlon, Nicolas Szilas, and Teresa del Soldato. Kurt VanLehn, Stellen Ohlsson, and Pat Langley supplied invaluable council on editing books, and Wally Feurzeig and Oliver Selfridge provided crucial support at the end of this process. Katharina Scheiter nudged us when we needed encouragement. Ying Guo offered valuable editorial assistance. We would also like to thank our senior editors, Tim O'Shea and Erno Lehtinen, for the guidance they gave us, as well as our editor at Oxford, Catharine Carlin, who was very supportive as we pulled this project together. We recommend her highly. Anonymous reviewers provided useful feedback on our book at the proposal stage, and Carlin helped us interpret and incorporate their suggestions. The graduate students in an advanced seminar on learning at Penn State (Mark Cohen, Joshua Gross, Sue Kase, Jong Kim, Andrew Reifers, and Bill Stevenson) made

numerous useful suggestions on the first reading of the book as a whole. Final preparation of this book was performed with help from kind colleagues at TU/Chemnitz and Tufts when Ritter was on a gratefully received sabbatical from Penn State. Finally, thanks to our families and friends who supported us in this endeavor. In particular, we would like to thank Josef Krems and Pat Langley for advice and comments and Nicole, Colleen, Robert, Paul, and David. Finally, *Alles in Ordnung!*

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