
Title: A view of schema theory

Author: Sandra P. Marshall


Review by

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Sandra P. Marshall has written a solid and interesting book, but one whose scope and aspirations are curiously out of balance. As the title suggests, Marshall aspires to build a theory of schemas and their use in problem solving. In chapter 2 she tells us that such a theory would include four types of knowledge; identification knowledge, elaboration knowledge, planning knowledge, and execution knowledge.

Identification knowledge enables pattern recognition. By itself identification knowledge does not constitute a schema, simply a concept. “Elaboration knowledge enables an individual to create a mental model about the current problem” p. 40. Although used frequently throughout the book, the term “mental model” is never defined. However, there seems to be a fairly direct correspondence between Marshall’s identification and elaboration knowledge and Van Lehn’s (1989) abstract schemas and instantiated schemas. If in Van Lehn’s sense, a schema is thought of as a list of attribute-value information, then an abstract schema with its default values roughly corresponds to Marshall’s identification knowledge. A schema is instantiated by replacing its placeholder values with the particulars of a given instance. For example, a physician’s “measles schema” is instantiated with details from a particular patient, with a particular set of symptoms,

at a particular level of severity, etc. The knowledge used to instantiate a schema corresponds approximately to Marshall’s elaboration knowledge.

Marshall’s unique and controversial contribution lies in making planning knowledge and execution knowledge part of her definition of schema so that a schema contains both declarative and procedural knowledge. However, it is never quite clear what we are to make of this combination. Is Marshall proposing that schema theory become the basis of a cognitive architecture? Is it intended as a possible rival to, e.g., ACT-R (Anderson, 1993) or Soar (Newell, 1990)? This seems not to be the case. Can Marshall’s schema theory be mapped onto existing cognitive architectures or to the general information processing approach to cognition? This is not clear either. Although she voices some objections (pp. 180-183) to the adequacy of existing theories to account for her theoretical mechanisms, her alternatives are not well-specified.

Perhaps some of these issues with aspirations can be resolved by looking at the book’s scope. The focus of the book is on what to teach, how to teach it, and how to test it. More specifically, the book examines the teaching of arithmetic word problems.

From an examination of the literature and original empirical research, Marshall has discovered 5 types of arithmetic word problems: change situation, group, compare, restate, and vary. For each word problem type she specifies identification knowledge, elaboration knowledge, planning knowledge, and execution knowledge.

Her contribution here is important. Marshall has discovered a new way of classifying and solving arithmetic word problems that provides a coherent approach to this topic. The bulk of her empirical work shows that adults can learn the five categories and the four types of schema
knowledge for each. Once learned, these categories and schema knowledge can be used to classify and solve word problems.

**Section by section**

Although the above is a quick summary of the theoretical and research thrust of the book, no review would be complete without a brief section by section review of the author’s presentation. Section I, Fundamentals, begins with a dizzying 2000+ year review of schema theory. This reviewer would have appreciated fewer Greeks and more moderns. Chapter 2 is an equally brief overview of cognitive theory and an introduction to the four types of knowledge required by Marshall’s schema theory. Chapter 3 introduces us to the five types of arithmetic word problems and their corresponding schema knowledge.

From the teacher-practitioner perspective, section II is the heart of the book. Chapter 4 is a too brief overview of various approaches to instruction that touches selectively on various theories and approaches while avoiding the major controversies. Chapter 5 provides an introduction to her two computer environments for teaching and solving arithmetic word problems. This chapter contains a very interesting and worthwhile discussion of the human-computer interaction considerations that went into carefully crafting these instructional environments.

Section III reviews the empirical work that shows that college students be taught to use the five categories to classify arithmetic word problems. Beyond classification, the protocol data provide evidence that, following training, students can use the four types of schema knowledge to solve word problems and that the computer environments Marshall designed facilitated these processes. A major complaint is the scarcity of detailed examples and information regarding the
detailed analysis of the protocol data. Although this lack may not be felt by all readers, a
monograph is clearly the place to get “down into the data.” Readers not interested these details
can be directed around such sections. As protocol analysis is hard work, lengthy, and often hard
to publish in traditional journals, it is regrettable that the author passed up an opportunity to
make a stronger case for her process arguments by presenting more of her analyses.

Section IV contains a discussion of how student knowledge is currently assessed and,
according to Marshall’s schema theory, should be assessed. Section V ends the book with 4
chapters that provide an overview of the computational models that were built and used, and a
summary chapter on schema theory. The comment I made in Section III regarding protocol
analysis also applies here. Although Marshall provides an excellent overview of her
computational models, the lack of detail is disappointing.

Summary

Schemas in problem solving is an interesting book that was easy to read but that provided a
much too light-weight treatment of many complex topics. It does not contain the detailed
examples, in-depth appendices, and analyses that might be expected of a research monograph, nor
does it contain the in-depth survey, review, and integration of the current literature that might be
expected in the proposal of a new theoretical paradigm. This raises the issue of “who is the target
audience” for this book? In her preface, the author tells us that instructional designers are the
target audience for the chapters on instruction and assessment, whereas, cognitive modelers are the
audience for the sections on learning and modeling. As one who has done both instructional
design and cognitive modeling, I disagree. I believe that active instructional designers and cognitive
modelers will find their appetites whetted by this book but will be disappointed when the main

course never appears. In contrast, the book is a perfect introduction to cognitive theory, cognitive modeling, and the information processing approach to learning and instruction. As such, it would be an interesting addition to the graduate curriculum in research-oriented Schools of Education and in upper-division undergraduate seminars in psychology.

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References