6. Rendezvous with a Quantum of Learning

Effect Metaphors, Extended Design Experiments and Omnivariate Learning Instances

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Abstract: This chapter is about central ideas about how research on the bridge between cognitive psychology and theories of learning and instruction can be conducted in general and what methodological and logical traps may come with this special endeavor. These conclusions can be made on the basis of decades of consistent and complementary research on mental model theory and on model based learning and instruction. The chapter begins with a presentation and discussion of design experiments and extended design experiments from the tradition of experimental research and their relations to practical feasibility and to different traditions and paradigms from the philosophy of science. Then, common and new metaphors for the interpretation of effects for the empirical levels of the methodological assumptions are introduced and discussed against the backdrop of applied theory of learning and instruction.

Keywords: Learning and instruction; design experiments; mental model theory; learning instances; effect metaphors; research methodology; philosophy of science.

Introduction

The theory of mental models (Johnson-Laird, 1983; Seel, 1991) is the basis for a generalized theory of model centered learning and instruction (cf. Seel, 2003). Findings from mental model theory can help with this deductive process. However, the assumptions for MCL&I are (and have to be) investigated separately with specified research questions concerning the embedded processes of learning and instruction. Both theories are linked and have been investigated for a long
plex and well-investigated internal (model coherent) assumptions which bring about consistent hypotheses leading to data which do not falsify the assumptions. In this chapter I would like to share some central ideas about how research on the bridge between cognitive psychology and theories of learning and instruction can be conducted in general and what methodological and logical traps may come with this special endeavor. The ideas which I introduce are based on the problems and solutions from our research on mental models and model centered learning and instruction as well as on the methodologically sound traditions within these fields. The solutions presented in this chapter are thus completely applicable to the theory of mental models and to MCL&I. I have kept the statements and conclusions as general as possible in order to ease the transfer to other domains and theories, which will in turn also have referring fields (e.g., in cognitive science) and theories of learning and instruction.

**Basic Definitions**

In this paragraph I will give some basic and very short definitions of terms as I use them in this text. It is too incomplete to serve as a general glossary. For a more detailed overview see Kuipers (2007).

- **Axiom**: A self-evident assumption which can not be proven or demonstrated but which is considered to be true for the time being. Axioms are always needed for theory building. One of the goals of good theory building is to specify the axioms which are needed, to keep their number low and their content as basic as possible.

- **Theorem**: Anything which necessarily follows from a set of axioms and/or other theorems when strict logic (deduction) is applied. Simple theorems can be derived from a small set of axioms. Complex theorems may consist of numerous combinations of axioms and theorems. Theorems have to be formally provable.

- **Assumption**: A consideration about something that may be true on the basis of what we already know from existing axioms and theorems (induction). An assumption is like a theorem and has to be either basic, simple and necessary to be considered an axiom or to be tested in the real world by hypotheses.

- **Theory**: A self-contained set of axioms, theorems, and strictly bound assumptions all belonging to a defined subject domain. The goal of a theory is to systematically and unambiguously explain a simple or complex, abstract or concrete phenomenon or sets of such phenomena in the world.