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# Toward a Taxonomy of Modeling Difficulties: A Multimodal Study on Individual Modeling Processes (Extended Abstract)<sup>1</sup>

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**Abstract:** Combining complementary modes of observation of modelers' modeling processes, we study modeling difficulties encountered by modelers while performing a data modeling task. Using the notion of cognitive breakdowns, we identify and confirm five types of modeling difficulties relating to different aspects of data modeling by analyzing audiovisual protocols of the modelers' modeling processes, recordings of modelers' interactions with the employed modeling software tool and survey data of modelers about their own perceptions of modeling difficulties they encountered. The identified types of modeling difficulties motivate a taxonomic theory of modeling difficulties intended to inform design science research on modeling assistance for modelers at different stages of their learning and mastering of conceptual modeling.

**Keywords:** Conceptual data modeling; Modeling difficulty; Cognitive breakdown

## 1 Introduction

Conceptual modeling as an activity involves an intricate array of complex cognitive processes and performed actions including goal setting, abstracting, conceptualizing, associating, contextualizing, interpreting and sense-making, judging and evaluating, anticipating and envisioning, visualizing, and, in group settings, communicating, discussing and agreeing. Prior research suggests that data modelers at all stages of mastering conceptual data modeling face specific difficulties but surprisingly little is known about the reasoning of modelers with respect to the modeling difficulties they encounter, which difficulties they encounter, and how to mitigate or even overcome these difficulties by tailored modeling assistance. The multimodal study presented in [RS19] integrates complementary modes of observation of modeling processes to identify modeling difficulties eight beginning modelers face while performing a data modeling task using a modeling software tool. We use the concept of cognitive breakdowns [NS72] to identify modeling difficulties in verbal (think aloud) protocols and complement difficulty identification by visually inspecting recordings of modeler-tool interactions as well as video recordings of individuals' modeling processes. We then complement difficulty identification by surveying these individuals about performing the modeling and about the difficulties they perceived.

<sup>1</sup> The work summarized in this extended abstract is published as [RS19].

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## 2 Findings and Discussion

Our analysis leads us to identify five types of modeling difficulties the beginning modelers face while performing the data modeling task, relating to different aspects of constructing conceptual data models, i.e., entity types, relationship types, attributes, and cardinalities. Our findings suggest that the majority of difficulties encountered by the participants relates to modeling relationship types with modelers especially facing difficulties with regard to developing sensible identifiers for relationship types.

The findings presented in [RS19] serve as a starting point for developing a more elaborate taxonomy of modeling difficulties over the course of multiple studies, in the sense of a classification or taxonomic theory (following, e.g., [Gr06]). The taxonomy, in turn, is intended to serve as theoretical foundation for design science research on developing tailored tool assistance for modelers at different stages of their learning and mastering of conceptual modeling. A number of further studies is needed to deepen our understanding of distinct modeling difficulties, the modelers' corresponding reasoning, presumed causes for encountered difficulties and remedies for mitigating their occurrences. In a recent comparison with findings we obtained from studying eight modeling processes of experienced modelers [RSP20], we find considerable overlaps in modeling difficulties experienced and non-experienced data modelers encounter, i.e., a majority of difficulties relating to modeling relationship types, especially to developing identifiers for relationship types, besides clear differences in difficulties related to determining cardinalities and fostering model integrity.

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