Conceptual Modelling and Humanities

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Abstract: Humanities are becoming a hyping field of intensive research for computer researchers. It seems that conceptual models may be the basis for development of appropriate solutions of digitalisation problems in social sciences. At the same time, humanities and social sciences can fertilise conceptual modelling. The notion of conceptual models becomes enriched. The approaches to modelling in social sciences thus result in a deeper understanding of modelling. The main aim of this paper is to learn from social sciences for conceptual modelling and to fertilise the field of conceptual modelling.

1 The Value of Conceptual Modelling

1.1 Computer science is IT system-oriented

Computer system development is a complex process and needs abstraction, separation of concerns, approaches for handling complexity and mature support for communication within development teams. Models are one of the main artefacts for abstraction and complexity reduction. Computer science uses more than 50 different kinds of modelling languages and modelling approaches. Models have thus been a means for system construction for a long time. Models are widely used as an universal instrument whenever humans are involved and an understanding of computer properties is essential. They are enhanced by commonly accepted concepts and thus become conceptual models. The main deployment scenario for models and conceptual models is still system construction (with description, prescription, and coding sub-scenarios) although other scenarios became popular, e.g. documentation, communication, negotiation, conceptualisation, and learning.

1.2 Learning from Digital Hunanities

Digital humanities is becoming a hyping buzzword nowadays due to digitalisation and due to over-applying computer technology. We have been engaged in a number of projects, e.g.

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[1, 2, 4, 6, 9]. We step back now and reconsider the challenges to conceptual modelling in these projects and generalize the experience we have gained in these projects. Let us first present a number of observations:

Observation (1): *The concept spaces used in social sciences underpins the conceptual model. Conceptions are systems of concepts. The concept space is typically structured complex and is used with multiple viewpoints.*

Observation (2): *Conceptualisation has to be co-considered at various abstraction levels at the same time, e.g. at the micro-, meso-, and macro-level.*

Observation (3): *The mould[3] (and methodology) determines model handling and the utilisation scenarios in which a model functions by playing roles. Models incorporate their function.*

Observation (4): *The model consists of a surface (or normal) sub-model and of deep (implicit, supplanted) sub-models which represent the disciplinary assumptions, the background, and the context. The deep models are the intrinsic components of the model. Conceptualisation might be four-dimensional: sign, social embedding, context, and meaning spaces.*

Observation (5): *Models benefit and suffer from the art of omission. Social and cultural embeddings are considered to be obvious and are thus omitted.*

Observation (6): *Models can be materialised and thus might have a material obstinacy due to the chosen material.*

Observation (7): *Conceptual models have to carry at the same time a manifold of understandings and a manifold of domain-situation models.*

1.3 The storyline

These observations and lessons are useful for conceptual modelling in our area. They are mostly not explicitly observed in computer science. They are however implicitly used. Think, for instance, on conceptual database models. We often use a conceptual schema that describes the structure of the entire database system and use additionally a number of conceptual views that describe the viewpoints of users. Therefore, we explain now how conceptual modelling can learn from successful approaches in social sciences. The learning process will enhance the added value of conceptual modelling.

[3] The mould is a hollow form or matrix or simply frame for giving things (such as models) a particular shape. In production, moulds are used as a shaped cavity for forming fluid or plastic things.

2 Learning from Humanities for Conceptual Modelling

According to [5, 10, 13] we define the model notion as follows:

> "*A* **model** *is a well-formed, adequate, and dependable instrument that represents origins and that functions in utilisation scenarios.*"
>
> *"Its criteria of well-formedness, adequacy, and dependability must be commonly accepted by its community of practice (CoP) within some context and correspond to the functions that a model fulfills in utilisation scenarios."*

Well-formedness is often considered as a specific modelling language requirement. The criteria for adequacy are analogy (as a generalisation of the mapping property that forms a tight kind of analogy), being focused (as a generalisation of truncation or abstraction), and satisfying the purpose (as a generalisation of classical pragmatics properties).
The model has another constituents that are often taken for granted. The model is based on a background, represents origins, is accepted by a community of practice, and follows the accepted context. The model thus becomes *dependable*, i.e. it is justified or viable and has a sufficient quality. *Justification* includes empirical corroboration, rational coherence, falsifiability (in our area often treated as validation or verification), and relative stability. The instrument is *sufficient* by its *quality* characterisation for internal quality, external quality and quality in use. Sufficiency is typically combined with some assurance evaluation (tolerance, modality, confidence, and restrictions).

2.1 The notion of conceptual model

A notion of conceptual model might be a slim, light, or concise one depending on the level of detail we need in model utilisation. We will use in the sequel one notion, i.e. the concise notion and refer for slim and light versions to [12, 14].

Concise version:
Conceptual Model $\sqsupseteq$ **(Model** $\bigoplus$ **Concept(ion)s)** $\bowtie$ **Enabler** [7]:

> A conceptual model is a model that is enhanced by concept(ion)s from a concept(ion) space, is formulated in a language that allows well-structured formulations, is based on mental/perception/situation models with their embedded concept(ion)s, and is oriented on a mould and on deep models that are commonly accepted.

The mould and the deep models form the matrix of a model [11]. We notice that a conceptual model typically consists of a model suite in social sciences. Each of the models in a model suite reflects some viewpoint or aspect.

2.2 The added value of conceptual modelling

Models do not have to be conceptual models. Conceptual models do not have to be based on an ontology. The main purpose of conception as a system of concept or of a concept(ion) space is the integration of interpretation pattern that ease the communication, understanding, delivery of a model in dependence on the model functions. The concept(ion) space, the mould of model utilisation, and the explicit knowledge of the social determination provide a means for the correct and sufficiently precise interpretation of the model elements.

2.3 The four dimensions of conceptual modelling

The consideration of the strategic, tactical, and operational sides of modelling and of conceptual modelling drives us to consider the four dimensions in Figure 1. These dimensions

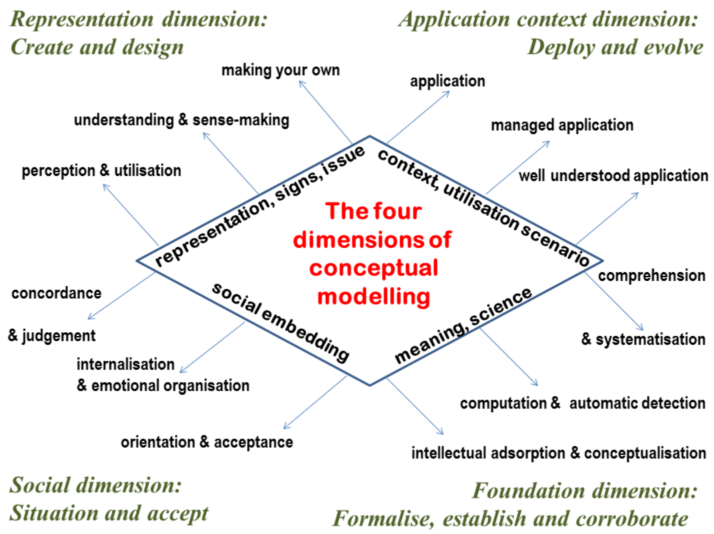

Fig. 1: The representation, application context, foundation, and social dimension of conceptual modelling

cover the application areas in [15] and especially those in humanities. Information systems typically consider the representation dimension and only one of the branches of the foundation dimension. Computer engineering especially considers the application context

dimension.
Prescriptive conceptual models that are used as the blueprint for system realisation also consider this dimension. The social embedding is typical for social sciences. The foundation dimension has additional aspects in social sciences since corroboration, comprehension and systematisation are far more complex. Conceptualisation is based on complex concept and conception spaces.

2.4 Handling forgetful mappings to IT and DBMS technology

In is often claimed that conceptual database or data models are mainly descriptive ones. Description is, however, only one of the functions that a conceptual data model has in a system development scenario. Other typical scenarios are documentation, prescription, communication, negotiation, and explanation. These scenarios are also observed for humanities.
In system construction we transform the conceptual data model to corresponding realisation models. This transformation also changes the semantics from rich semantics of conceptual models to lexical semantics which is based on the lexical interpretation of the words used in realisation models according to the meaning in the given application area. It is thus forgetful. The reestablishment of the conceptualisation must thus be handled by a reference to the conceptual model what also means to use a tight bundling of all models in the case of system maintenance (e.g. evolution and migration) and integration. The social dimension and the foundation dimension get also lost during transformation.

2.5 Sophisticated conceptual models are model suites

Based on the observations, we should consider a conceptual model as a model suite, i.e. a coherent collection of explicitly associated models. The associations are explicitly stated, enhanced by explicit maintenance schemata, and supported by tracers for the establishment of coherence [8]. Each model in the model suite has its orientation and its functions in utilisation scenarios. The association schema among the models allows to consider the model suite as a complex but holistic model.
Model suites in most sciences and engineering incorporate some conceptual models. This situation is not different for social sciences. For instance, the CRC 1266 [1, 2] uses as a complex model of transformation a model suite consisting of models for socio-economic formation (cluster B-E), for socio-environmental components of change (cluster F), and for natural science investigation (cluster G). The interplay of these models allows to suppose hypotheses and to draw conclusions. Most models are already conceptual ones. They use, however, different conception spaces. The association among these models is handled by interlinkage groups within the CRC.

2.6 Models as mediating instruments instead of middle-range theories

Middle-range theories [2] are essentially model suites. They are used for an integrating consideration of quantitative sources and theory conceptions. Quantitative sources are used for derivation of quantitative concepts. The theory offer underpins these concepts. Qualitative theory-oriented research uses theoretical concept(ion)s. These concepts are supported by supporting sources which are often generated before and might use the current quantitative sources. A theory integrates these concepts. We use typically several theories, e.g. for plausibility check, for investigation, explanation, knowledge experience propagation, and discovery scenarios. In a proxy-based research we start with proxy sources that might be underpinned by proxy concepts. This research results in a theory request that can be satisfied by a theory offer.
This approach often results in a gap between qualitative and quantitative research. Models can be used to render the theory offer. At the same time, models may also render a qualitative theory. The rendering procedures are typically different. A model suite can now be constructed by models for theoretical concepts from one side and by models for quantitative concepts from the other side. In this case, we use models for the quantitative theory offers and for the qualitative theories. This approach is depicted in Figure 2.

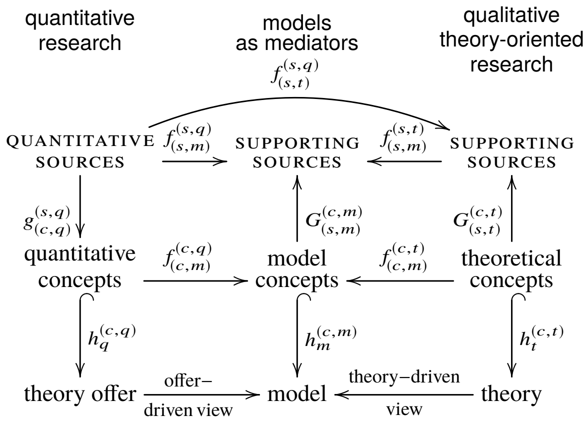

Fig. 2: Models as integrating and mediating instrument for conceptualisation, investigation, explanation, knowledge experience propagation, and discovery

This approach has already used for the investigation in the CRC 1266 [2]. In a similar form we can consider now conceptual models for other application cases.

3 Concluding: Conceptual Modelling Inspired by Humanities

Conceptual modelling is a widely used practice in many science and engineering disciplines. The current practice used for database conceptualisation can be enhanced by a number of insights that we observed in social science research.

- The concept(ion) space is often far more complex structured than finally represented and used for a singleton conceptual model. We should consider conceptual models that orient on different aspects and different levels.
- The context dimension should not be neglected for conceptual models.
- The social dimension and the foundation dimension are equally important as the representation dimension.
- Models and especially conceptual models consist of a number of models and thus form a model suite.

We got now additionally a number of special necessities for conceptual modelling without which conceptual models are of low quality, not justified, and also not adequate.

Deep models: Models consist of normal sub-models and deep sub-models. The first ones are given in an extrinsic and explicit form. The later ones are often concealed.

Model mould: The second element of the matrix of modelling is the mould. We know a number of canonic approaches that guide the modelling process, the modelling outcome, and the capacity of the finally developed model.

Concept-biased modelling: Conceptual models are typically deeply biased by the concepts in a given domain. Concepts such as “village”, “settlement” and “center” are essentially representing the same understanding but are used in very different contexts. The same applies to database models, e.g. the concepts of “Person” or “Address” depend on geographic, law etc. assumptions.

Functions of models as the guiding principle: The utilisation scenarios determine the functions that a model has in such scenarios. The model is an instrument in these scenarios. Whether it is a proper and fit-to-use instrument depends on the function the model has (and thus on the purpose and the goal).

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Remark

We thank the reviewers for their remarks, suggestions, and critics. The paper is based on our previous papers on models, e.g. on the generalisation of approaches used in design science research [3]. The compendium [15] presents model notions and modelling used in agriculture, archaeology, arts, biology, chemistry, computer science, economics, electrotechnics, environmental sciences, farming, geosciences, historical sciences, languages, mathematics, medicine, ocean sciences, pedagogical science, philosophy, physics, political sciences, sociology, and sports at Kiel university. It is based on a decade of Tuesday-evening-open-end discussions on models and modelling in sciences. We selected only four of our collaboration projects from humanities research and discussed some of the modelling lessons.

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[4] http://www.sfb1266.uni-kiel.de/en/
[5] http://www.dfg.de/en/index.jsp