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Discussion on the Article "On Ontological Foundations of Conceptual Modelling" by Boris Wyssusek

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Abstract. In this debate paper we follow up on the argumentation given by Boris Wyssusek, who criticizes the use of the BWW-ontology as a foundation of conceptual modelling. In addition, we mention some other possible foundations for conceptual modelling. We have over many years looked at the area of semiotics, given our social constructivistic view of modelling, and we give a brief overview of how semiotics relates to the ontological approach. Finally, we describe some of our practical experiences with the semiotic approach for evaluating modelling languages in an industrial setting.

1 Introduction

As highlighted by Wyssusek, the Bunge-Wand-Weber (BWW) ontology has received increasing interest as a theoretical foundation for conceptual modelling languages, particularly in the last years. I first came into contact with the BWW ontology in 1989, when Wand's (1989) paper was part of the curriculum of a course I attended as a student. We had the pleasure of having Yair Wand visiting us in Trondheim around this time, giving a guest lecture. Although I found the framework intellectually intriguing, I was from the start somewhat sceptical about it and remember asking some linguistically oriented

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questions (such as how to deal with Venus being called both the morning star and the evening star, the modelling of unicorns etc). I was never quite satisfied with the answers.

Some years later, I realized that the major problem from my point of view was Bunge's ontological stance, i.e. his commitment to dialectical materialism. Not subscribing to the latter view, but rather to one of social constructivism, I find it difficult to put very much weight on results from evaluations being done from the perspective of dialectical materialism. In the light of reading Wyssusek, it is interesting to see that neither Wand nor Weber openly subscribe to dialectical materialism. Nor, in fact, does any user of BWW that I can remember.

I will mention two arguments for a social constructivist perspective on information systems. First, within the IS field, and especially in the design research tradition (Hevner et al. 2004), we focus more on what can be efficiently done in an organizational setting and less on what can be regarded as *true* in a material sense. Second, whereas ontology is concerned with concrete objects, modelling is focused on concepts, which are not concrete (although they might be given concrete forms).

Even with this outlook I do however acknowledge that the BWW-framework has its merits and can be pragmatically useful in certain cases. For instance, I myself have used parts of the terminology for defining a vocabulary of the IS-field (Krogstie and Sølvberg 2003), but obviously without giving the terms any ontological significance. I will return to this below.

2 An Approach Based on Semiotics

Wyssusek only briefly mentions alternative approaches towards a theoretical foundation of conceptual modelling. Popular source disciplines in addition to ontology are cognitive psychology and cognitive science (e.g., Siau 2003; Evermann 2005), semiotics (e.g., Stamper 1997), and linguistics (e.g., Goldkuhl and Lyytinen 1982).

Wyssusek states that conceptual modelling should be practiced with the awareness of its object being socially and linguistically constituted. We have for a number of years worked on the SEQUAL framework for understanding different aspects of quality for conceptual models, based on semiotic theory. Below we present an informal account of the main aspects of this thinking, and indicate how it relates to a theoretical foundation for modelling methods. A more formal presentation is given in (Krogstie and Sølvberg 2003).

The SEQUAL framework:

- is closely linked to linguistic and semiotic theory. Given that semiotics is related to how humans are communicating using signs, and the marks we make in modelling are signs made to communicate meaning, we have found this a natural starting point. In particular, the core of the framework including the discussion on syntax, semantics, and pragmatics (see below) is parallel to the use of these terms in the semiotic theory of Morris (1946). It is further based on the use of semiotic theory within the information systems field by Stamper (1997).
- is based on a constructivistic world-view, recognizing that models are usually created as part of a dialogue between the participants that are involved in modelling and whose knowledge of the modelling domain changes as modelling takes place. Even a socially constructed world, however, benefits from being modelled (Dahlbom 1991) for participants to be able to understand and potentially reconstruct it.
- distinguishes between quality goals and means to achieve these goals. Language quality goals are one type of means, but means can also be related to modelling process, techniques, and tools. Language quality is the area where the kind of theoretical foundations we are talking about here is most relevant.

Quality of models is looked upon on several levels (parallel to the semiotic ladder proposed by Stamper (1997)):

- Physical quality: The basic quality goals on the physical level are related to the persistence and availability of the conceptual model for the model's audience.
- Empirical quality deals with predicable error frequencies when a model is read or written by different users, coding (e.g. shapes of boxes) and HCI-ergonomics for documentation and modelling-tools.
- Syntactic quality is the correspondence between the model and the rules of the language in which the model is written.
- Semantic quality is the correspondence between the model and the domain of modelling. Note that the domains we are normally dealing with in information systems development have been socially constructed and are more or less intersubjectively agreed upon. Parts of the domain (e.g. the laws for doing business in a country) are constructed outside the control of the organization and can for practical purposes, be looked upon as objectively given.
- Perceived semantic quality is the correspondence between the audience interpretation of a model and his or her current knowledge of the domain, and is what can actually be checked at quality control (validation).

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- Pragmatic quality is focusing on the correspondence between the model and the audience's interpretation of it, on the learning that takes place as part of modelling and on the wider organizational effect of modelling. We differentiate between social pragmatic quality (to what extent people understand and use the models) and technical pragmatic quality (to what extent tools can be made to understand and utilize the models).
- The goal defined for social quality is agreement among audience members' interpretations.
- The organizational quality of the model relates to how well statements in the model directly or indirectly contribute to fulfilling the goals of modelling (organizational goal validity). High organizational quality also requires that all the goals of modelling are addressed through the model (organizational goal completeness).

The layers can be divided into two groups in order to reveal the technical vs. the social aspects. Physics, empirics, and syntactics comprise an area where technical and formal methods are adequate. However, the higher quality levels cannot be explored using these methods unmodified. This indicates that one has to include human judgment when evaluating quality on the higher semiotic levels. Accordingly, an approach which builds on a foundation outside human judgment cannot address all the relevant aspects of modelling.

Language quality looks upon the appropriateness of the modelling language in use for achieving the above quality types. There are two types of criteria:

- Criteria for the underlying (conceptual) basis of the language (i.e., what is typically represented in the meta-model of the language).
- Criteria for the external (visual) representation of the language (i.e., the notation and the concrete syntax of the language).

Six main forms of language quality are identified, with aspects relating both to the meta-model and the notation:

- *Domain Appropriateness*. This deals with how suitable a language is for use within different domains. If there are no statements in the domain that cannot be expressed in the language, then the language has good domain appropriateness. In addition, you should not be able to express statements that are not in the domain. One approach to evaluating domain appropriateness is to look at how the modelling perspectives found useful for the relevant modelling tasks are covered. Another approach is obviously to base an evaluation on an ontological theory (e.g., Wand and Weber 1993), but a choice of BWW needs to be

properly motivated from case to case. Given the social construction of the domain, there is no a priori, objectively given best way of representing the knowledge of all domains.

- *Participant Language Knowledge Appropriateness*. It is a goal here that the participants know the language, or are able to easily learn it.
- *Knowledge Externalizability Appropriateness*. This deals with the participants' ability to express all relevant knowledge using the modelling language.
- *Comprehensibility Appropriateness*. The audience should be able to understand as much as possible of the language. Detailed criteria here lean specifically on areas such as graph aesthetics and information visualization, basing their thinking on results from cognitive psychology (Ware 2000).
- *Technical Actor Interpretation Appropriateness*. It is important for the use of technical actors (tools) that the language is suitable for automatic reasoning. This can be achieved if the language is formally defined (formal syntax, and potentially formal semantics) and reasoning is efficient and practical to use.
- *Organizational Appropriateness*. This area relates the language to standards and other specific needs due to the organizational context of modelling.

More than 70 specific criteria of language quality within these 6 areas can be identified (Østbø 2000). When using SEQUAL to do a language evaluation, we should have the following in mind:

- It is possible to make good models in a poor modelling language.
- It is possible to make poor models in a comparatively good modelling language.
- You will always find some deficiencies in any language and tool support. On the other hand, it is useful to know the weak spots to avoid the related potential problems. Such deficiencies should, in general, be addressed with the use of an appropriate modelling technique and an overall methodology.

Over the last five years, we have used SEQUAL for evaluating a number of modelling approaches, both theoretically (Carlsen et al. 1997; Krogstie 2003) and for practical evaluation for organizations in the position of choosing between different modelling languages (Krogstie and Arnesen 2004; Nysetvold and Krogstie 2006).

A typical approach for a practical evaluation is the one used in (Nysetvold and Krogstie 2006) in which a company had specified the need for a new

enterprise modelling language. The various criteria of language quality were all evaluated for their importance to the case organisation. This resulted in a list of around 40 relevant criteria. Thus some criteria of language quality are typically found to not be relevant in specific cases. In one area, domain appropriateness, one typically identifies more criteria than in the general framework. Also organizational appropriateness is typically specialized. A short-list of relevant languages was identified by us and the case organization in cooperation. The chosen languages were then evaluated on a 0–3 scale according to the selected criteria. In this process, all languages were used for the modelling of several real cases from the organizational domain using a modelling tool that could accommodate all the selected languages. By showing the resulting models and evaluation results to persons in the company, we got feedback and corrections both on the models and our grading. The models were also used specifically to judge the participant language knowledge appropriateness.

3 Concluding Remarks

When evaluating a modelling approach using BWW, one is focusing solely on the domain appropriateness of the language relative to some idealized domain. As indicated above, using BWW (or another ontology) is one of several ways of devising more concrete criteria for this area. One main aspect of domain appropriateness, that the language can be used to express anything in the domain, is similar to the BWW criterion that there are no construct deficits (Wand and Weber 1993). Another main aspect of domain appropriateness, that you should not be able to express things that are not in the domain, is similar to the BWW criterion that there should be no construct excess (Wand and Weber 1993). Another approach to specialising domain appropriateness is to base the evaluation on well-defined criteria within the specific area of modelling. In (Nysetvold and Krogstie 2006) we used the work on workflow patterns (van der Aalst et al. 2003) to find some of the criteria.

Relative to the area termed comprehensibility appropriateness in SEQUAL, we can recognize the other two main quality criteria from BWW (Krogstie and Sølvberg 2003):

- The concepts of the language should be easily distinguishable from each other, vs. “construct redundancy” (Wand and Weber 1993).
- The concepts of the language should not be used to represent several concepts, vs. “construct overload” (Wand and Weber 1993).

In the area of comprehensibility appropriateness, we have also included a large number of potential criteria taken from fields such as cognitive psychology, graph aesthetics, and HCI.

BWW gives detailed generic guidelines for the language meta-model, and workflow patterns give specific guidelines. In SEQUAL, we have additional support for discussing aspects related to the notation. We have also included more context-specific criteria, which have to be specialized relatively to the people involved and the organizational setting.

The cases in (Nysetvold and Krogstie 2006) and in (Krogstie and Arnesen 2004) illustrate how our generic framework, in order to be useful, must be specialized to a specific organization and type of modelling, resulting in different ranking of modelling languages due to different goals.

One can find weaknesses also in our approach. For instance, it can be argued that the actual valuation is somewhat simplistic (flat grades on a 0–3 scale that are summarized). This said, we should not forget that language quality properties are never more than means for supporting the model quality. Evaluating modelling languages on the generic language quality criteria of expressiveness and comprehension is not enough. The language quality goals should be linked to model quality goals to more easily adapt the generic framework to the task at hand.

The overall theoretical foundation of SEQUAL can of course also be questioned. There are a large number of semiotic theories. We have primarily built on the application of a particular type of sign semiotics. Other researchers have claimed that models should rather be looked upon as texts than as collections of signs, and that a better avenue is to build on one of the many approaches to text semiotics (see Nöth 1990 for an introduction).

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