Conceptual Model Evaluation. Towards more Paradigmatic Rigor

Jan Recker[1]

[1] Centre for Information Technology Innovation
Queensland University of Technology
126 Margaret Street, Brisbane QLD 4000, Australia
j.recker@qut.edu.au

Abstract. Information Systems (IS) research has so far been primarily concerned with the development of new modeling languages, techniques, and methods. Also, evaluation approaches have been developed in order to assess the appropriateness of a modeling approach in a given context. Both modeling and evaluation approaches, however, lack epistemological rigor, leading to problems regarding the applicability of a certain modeling language in a given context on the one hand, and regarding the feasibility of certain evaluation approaches towards certain modeling questions on the other hand. We therefore argue for a philosophical-paradigmatic discussion of evaluation methods for conceptual modeling languages in order to assess their applicability in given modeling contexts and present our research in progress towards a framework for paradigmatic discussion on model evaluation.

Keywords. Philosophy, modeling methods, information modeling, research evaluation

1 Introduction

The importance of information systems (IS) for successful businesses is widely recognized [1]. Their implementation is preceded by their development through design methodologies which utilize information models to specify IS on a conceptual level. Such conceptual models have been successfully employed throughout IS theory and practice. This has led, however, to the proliferation of an enormous amount of available modeling approaches. The "flooding" of the IS discipline with a multiplicity of conceptual modeling approaches consequently leads to an immanent need for comparing and evaluating existing modeling methods in order to determine which approach is most appropriate for a given modeling task. While evaluation approaches for conceptual modeling languages do exist, e.g. [2, 3], they differ substantially in perspective and approach. Thus, the question remains, which evaluation approach is most suitable for finding an appropriate answer in a given situation. An objective of this research is to develop an approach to compare different evaluation approaches for conceptual models in order to explicate their applicability and appropriateness for different modeling questions.

Approaching this research question from a theoretical perspective motivates the idea of transferring insights gained from philosophy towards the problem domain, i.e. conceptual modeling and model evaluation.

While there is plenty academic discussion on philosophical foundations of the IS discipline, e.g. [4], and of conceptual modeling [5, 6], the field of evaluative research lacks a thorough paradigmatic discussion. Thus, we address the research question as to what consequences certain philosophical viewpoints reveal to the evaluation of IS research artifacts. The significance of this research question becomes visible in the are of conceptual models: Since these denote abstract representations of a modeler's perception of "some" reality, the assessment of model quality not only depends on epistemological and ontological assumptions underlying the artifact development (modeling), but also the artifact validation (evaluation), e.g. the question how truth can be obtained through models.

Addressing this research question, the remainder of this paper is structured as follows: The next section presents an academic discussion of concepts central to this research, i.e. research philosophy, conceptual modeling, and research evaluation. Section 3 presents an assessment framework for discussing paradigmatic implications of evaluation approaches. The feasibility of the framework is demonstrated by applying it to the well-know Bunge-Wand-Weber evaluation approach for conceptual models. Section 4 closes this paper by presenting conclusions and future topics of research.

2 Background and Related Work

2.1 Philosophy in IS Research

The IS discipline has shifted into a field of numerous theoretical and conceptual foundations [7, 8]. This is at least partly due to the interdisciplinary context of the discipline, integrating research paradigms from different fields [6-8]. Furthermore, methodological pluralism as a multi-method research approach is currently intensively debated in academia, e.g. [9]. This tapestry of diversity in IS research leads to an urge for publishing underlying philosophical-paradigmatic assumptions of research work so that fellow researchers and other readers fully comprehend the research approach and the perspective taken by the researcher. Furthermore, an evaluative criticism of research work is not possible without understanding the perception of science underlying the research to be evaluated. While the debate on philosophy in IS research may or may not be seen as essential (for the denial of a link between philosophy and IS see e.g. [10]), the engagement in philosophy cannot be avoided since a "good part of the answer to the question "why philosophy?" is that the alternative to philosophy is not no philosophy but bad philosophy. The 'unphilosophical' person has an unconscious philosophy, which they apply in their practice – whether of science or politics or daily life." [11], p. 17.

While it is not the purpose of this research to fully investigate all parts of philosophy, it is nevertheless essential to delineate specific philosophical terms of interest,

especially those that form research paradigms common in the IS discipline. Generally, a paradigm is understood as a specific way of thinking about problems based on a set of achievements that are acknowledged as a foundation of further research practice [12]. It therefore denotes a constellation of fundamental beliefs, values, and techniques. A number of paradigmatic frameworks have been used in the analysis of information systems research. Predominant have been, the work of BURRELL and MORGAN [13], WOOD-HARPER [14], KLEIN and LYYTINEN [15] and IIVARI [16]. In this paper, we analyze research paradigms based on two inter-dependent dimensions, a distinctive reality view (ontological aspect) and a distinctive perspective upon the nature of knowledge (epistemological aspect). These two aspects form the "Weltanschauung" on which evaluative research is here discussed. As for the following aspects, for illustration purposes we present dichotomous positions while bearing in mind that the paradigms as such are permeable – their so-called "transition zones". Ergo, the distinctions drawn here must not be used uncritically but rather as a guide.

The ontological aspect refers to the question whether the object of cognition exists beyond subjective imagination and perception [17]. Ergo, a researcher has to position himself in terms of the assumption "existence of an objective reality". For simplicity reasons, we only differentiate two contrary positions:

- (ontological) realism: There is an objective reality existent independently from subjective cognition, i.e., independent from thought and speech.
- (ontological) idealism: There is no objective reality existent, it is dependant on subjective perception, cognition, and language.

The epistemological aspect refers to the question whether an objective recognition of things is possible beyond subjective perception. Again, for simplicity reasons, we differentiate two basic positions:

- (epistemological) realism: Objective cognition of an independent reality is possible for cognitive subjects.
- (epistemological) constructivism: Perception of a reality is always subjective ("private"), thus dependant on the cognitive subject.

Considering these epistemological and ontological positions, we can identify and distinguish the following popular research paradigms in the field of Information Systems:

- In terms of *positivism*, the world is objectively and in principle real and can objectively be perceived without subjective biases [18].
- In terms of *interpretivism*, the world is objectively real; however, the cognition process is subject dependant. Reality perception is thus susceptible to a (predominantly linguistic) (re-) construction of the cognition of reality [18].
- In terms of *radical constructivism*, the world is subject to subjective cognition. Cognition independent from a subject is impossible and it consequently only refers to a subjectively perceived reality [19].

As indicated in [20], positivism (still) dominates IS research with interpretivism being the only real alternative so far. Thus, the paradigmatic discussion of IS evaluation research in our paper mainly focuses on these two paradigms.

However, to extend the discussion of philosophical paradigms in the IS field, several researchers have just recently argued for the need of post-approaches in the IS discipline [16, 21]. As an example, we included the paradigm of radical constructivism [19] above. However, we are aware that there exist other post-approaches, such as critical realism, critical socialism etc. on which we do not elaborate here.

2.2 Conceptual Models in IS Development

Over the last decades, conceptual models have been employed to facilitate, systemize, and aid the process of information system engineering. Conceptual models describe object systems (e.g. an information system) of some domain in semantic terms, using an abstract yet formalized language [22]. Purposes served by conceptual models in the context of IS development include communicating between developers and users, thereby bridging the misunderstanding gap between requirements analysis and implementation specification. Further purposes of conceptual models include: helping analysts to understand a domain, providing input to the design process, and documenting the requirements for future reference [22].

During the seventies and eighties, most research effort was spent on developing new modeling techniques, e.g. the ERM notation [23]. The nineties provided yet another boost to this trend, for example through the development of the object-orientation paradigm in software engineering, the evolvement of enterprise resource planning (ERP) systems, or the utilization of conceptual models in organization theory. Thus, it is not unsurprising that conceptual models have been proposed as the core of the IS discipline [5, 24].

The quality of conceptual models is believed to have an enormous impact on to related IT and IS artifacts, as conceptual models used in the requirements specification phase of a system development process determine the acceptability and usability of the product to be built [25]. As the cost of fixing errors grows exponentially as an elapsed time to discovery [26], the importance of an adequate problem and domain representation through conceptual models is recognized. Conceptual models may reveal errors such as faulty requirements specification in an early stage of system development.

The area of conceptual modeling is, however, coined by a juxtaposition of different terms and concepts. In order to clarify the object of investigation, conceptual modeling, a thorough demarcation of IS development terms is presented in the following:

Following the perception of science as a problem solving activity [27], a modeling method is understood as a structural approach to systematically conduct the essential steps of modeling activities during the system development process [28]. A (modeling) method as such is problem type-specific, i.e. it is designed for a certain task (here: modeling), which is defined in operational terms within the modeling technique ascertaining how to perform the activities necessary for problem solving. A modeling technique is differentiated in to a language and a procedural aspect, with the language aspect providing semantic constructs for describing the domain of interest, and with the procedural aspect defining how to use the language constructs provided in order

to build a semantically and syntactically correct model [29]. Similar to these elaborations, WAND and WEBER [22] differentiate between a conceptual modeling grammar (language aspect) and a conceptual modeling method (procedural aspect) within a specific domain context.

2.3 IS Evaluation Research

Scientific research is based upon the idea of progress; hence it must comprise approaches for differentiating between competing alternatives. Thus, evaluation must be seen as a core substantive element of IS research. The importance of rigorous evaluative research can be stated as follows: "No problem-solving process can be considered complete until evaluation has been carried out. It is the evaluation which helps us to measure the effectiveness of the problem-solving process and the problem solver in the 'problem situation' – unless this element is considered there is no way of establishing that the 'problems' have been successfully resolved" [30], p. 108.

Evaluation is defined as the systematic study of a research artifact (here: modeling methods) to determine its usefulness, effect, or impact [31]. IS Evaluation methods in the area of conceptual information modeling can be classified in empirical and non-empirical approaches and further distinguished as illustrated in Table 1.

Table 1. Overview of model evaluation methods (adapted and modified from [32])

Non-empirical evaluation methods	Empirical evaluation methods
Feature comparison: Modeling methods are compared by modeling the same domain with different methods and investigate how the various methods represent the same problem, based on a checklist of features (e.g. [33]).	*Survey*: This technique refers to the use of questionnaires to gather human attitudes, opinions, and impressions on modeling methods (e.g. [34]).
Meta modeling: This technique uses meta models of methods as an analysis basis. It is attempted to evaluate methods by structurally investigating analogies and dissimilarities of their meta models (e.g. [35]).	*Laboratory experiment*: In a laboratory experiment, independent variables, such as different modeling methods, are manipulated in order to measure the effect on dependent variables like accuracy or time costs of modeling (e.g. [36]).
Metrics approach: This technique aims at comparing methods based on a predefined set of method metrics. Metric values are compared to reference values which address complexity and appropriateness of a method (e.g. [37]).	*Field experiment*: Researchers perform the investigation in concrete business organizations while trying to maintain control over the most significant independent variables. Examples in the field of IS modeling were not identified.
Paradigmatic analysis: This technique refers to the analysis of	*Case study*: This technique focuses the systematic

underlying assumptions of methods, e. g., the view of IS development intention, the view on language functions, the definition of IS etc. (e.g. [21]). *Contingency identification*: This technique aims at identifying the contingencies of the project in which a modeling method is utilized (e.g. [39]). *Ontological evaluation*: This technique maps modeling language constructs to the constructs provided by an ontology to assess the modeling language's capability to represent reality (e.g. [3]). *Approaches based on cognitive psychology*: This technique investigates the impact of cognitive psychology theories on the statements that can be obtained from the use of modeling methods (e.g. [41]).	observation of a particular group or subject that utilizes the investigated modeling method. The investigation is conducted without intervening (e.g. [38]). *Action research*: Action research is the application and testing of ideas developed in an academic environment in real world situations under participation of the researching individuals (e.g. [40]).

3 A Philosophical-Paradigmatic Discussion of Model Evaluation

3.1 Constructing the assessment framework

As different philosophical viewpoints determine and impact an artifact construction process, the same can be said about evaluation design. Different world views of researchers designing evaluation approaches serve the basis for evaluation, e.g. by coining the understanding of model purpose and model quality. These philosophical understandings are not subject to evaluation themselves due to the paradigmatic incommensurability problem connected [42]. However, a discussion of these assumptions aids explicating the approach and thus increasing the understanding for what kind of evaluative statements can be derived by applying a certain evaluation approach in a given context.

Here, a framework is presented to aid the discussion of evaluation approaches for conceptual models. As discussed above, paradigmatic positions have significant impact not only on the development and embodiment of modeling methods but furthermore on the perception of models, on the question how truth (in the form of models) can be obtained, and on the results generally achievable through evaluation. In order to explicate and evaluate these paradigmatic underpinnings of model evaluation approaches, we construct the following framework:

Firstly, we identify the underpinning paradigm of the evaluation approach under consideration, for instance one of the three philosophical paradigms introduced, namely positivism, interpretivism, or radical constructivism. Secondly, these paradigms form the theoretical basis for model evaluation and are concretized in the following aspects of the framework:

- Model perception: This point refers to paradigmatic consequences on the perception of the terms "model" and "modeling". For instance, interpretivists may favor a construction-oriented model perception that incorporates modeling subject and modeling purpose as important term defining factors while positivists may argue for a pure representation-oriented model perception. For radical constructivists, models denote more of a tool by which it can be expressed how the world is experienced [43].
- Evaluation perception: This point refers to paradigmatic consequences on the evaluation methodology, i.e. as to how evaluation can be conducted. E.g., positivists may judge modeling language sufficiency by comparing it against a taxonomy of reality constructs in an ontology. Positivist evaluation methodologies are coined by the correspondence theory of truth [44] while radical constructivists favor the concept of "viability" of a model [19], i.e. the functional fitness of a model towards its subjective purpose [45]. Interpretivists rather argue for consensus-oriented approaches towards model evaluation [2], based on the consensus theory of truth [46].
- Quality perception: This point refers to paradigmatic consequences on the perception of quality. E. g., for positivists, the quality of a model is determined through its compliance to reality, whereas for interpretivists, the perception of quality is subject and purpose oriented and needs to be agreed on in an accordant community. Thus, a model is deemed of high quality, if a group of experts (or users) agree on this statement. The quality of a model in a radical constructivist view is determined through its usefulness in the experimental world of the researching subject.

3.2 Applying the assessment framework

In order to demonstrate the feasibility of the discussion framework, it is applied to a common evaluation approach, namely the evaluation of modeling language through the BWW ontology [3, 47, 48].

In short, WAND and WEBER applied an ontology (a set of constructs and terms sufficient for describing reality) developed by BUNGE [17] to the field of conceptual modeling. The BWW ontology serves as a reference point in evaluation, specifying reality constructs that a conceptual modeling language should be able to depict. The evaluation is conducted by mapping language constructs against ontology constructs and thereby assessing ontological completeness and ontological deficiency within the modeling language [47].

Applying our framework to the BWW approach, the following results have been obtained, as illustrated in Table 2.

Table 2. Paradigmatic discussion of the BWW evaluation approach

Criterion	Criterion value
Research paradigm	WAND and WEBER take a both ontological and epistemological realistic position as they are followers of a positivist research approach, believing that the world is made up of things that "really exist in the world" [49], p. 34. WEBER claims to refrain from realism and furthermore argues that the question of objective or subjective perception of reality (the epistemological aspect) does not matter for the development of an ontological foundation for the IS discipline ([49], pp. 174 ff.). However, the idea of ontological analyses based on BUNGE'S ontology can only make sense if one adheres to BUNGE'S philosophical belief [50].
Model perception	The universe of discourse (UoD) comprises immutable objects and object structures that exist as empirical entities. Consequently, models of the UoD exist independently from any observer's perception [4], and thus denote a descriptive representation of the UoD. The model perception is more that of a reproduction than that of a (re-) construction. A conceptual model is, in this perception, understood as an objective perspective through which observers can perceive unbiased reality.
Evaluation perception	Following a positivist research approach, the evaluation of models and conceptual modeling languages refers to an investigation of how well model represent reality. The ontology hereby serves as a reference point for evaluation. Following the correspondence theory of truth, the BWW ontology is understood as a fact statement that is assumed to be objectively true. Evaluation in the BWW approach following this perception refers to a structural analysis of analogies and dissimilarities between conceptual modeling language constructs and ontology constructs, thereby determining statements in the model under observation which do or do not correspond to the "true" statements of the BWW ontology.
Quality perception	For positivists, the quality of a model is determined through its compliance to reality. The quality of a model is expressed through its degree of ontological completeness and ontological clarity. This quality perception does not include any reference to purpose, developer, or addressee of the artifact and it is solely based on semantics and syntax, leaving out domain-specific or pragmatic quality aspects.

3.3 Discussing the findings: Some Implications

Concluding from these elaborations, ontological evaluation through the BWW models is at least to a certain degree restricted to research contexts adhering to the same paradigm. This can be explained by the paradigm incommensurability thesis stating that researchers must commit themselves to a single chosen paradigm and proscribing a multi-paradigm research approach [9]. In the field of evaluation research, we believe this single-paradigm commitment must be stressed even further, as certain dichotomies exist between multiple paradigms, e.g. opposing positions representing

alternatively competing "truths" about the world. Consequently, a shift of paradigms during model development and model evaluation would resist reconciliation or synthesis.

Regarding the BWW approach, from an interpretivist or radical constructivist viewpoint, the approach is insufficient. Accordingly, models developed or utilized in research contexts that favor for different research values and norms cannot deliberately rely on the evaluation results obtained through the BWW approach. This finding is problematic in several ways:

First, classical positivism is widely believed to be defunct yet is still often applied in IS research [51]; even WAND and WEBER apply some critical self-reflection to their approach [49, 52]. Regarding evaluation practice, a positivist approach raises the question how we can be prove that the reference system of evaluation – the BWW ontology – itself is suitable for expressing "true" objects and relationships in "the" world. Since this question cannot be answered, we must state that the BWW ontology is as good for evaluation as any other theoretical reference system.

Second, WEBER claims that the foundational role of ontology in the IS field is not necessarily bound to a certain paradigm. But if it were the case that paradigmatic presuppositions had no bearing on the evaluation of models, why do WAND and WEBER bother with an ontological foundation of modeling at all? While we are aware that the dichotomous distinction between research paradigms introduced here is rather illustrative than impenetrable we nevertheless argue that the usage of BUNGE'S ontology can only make sense in compliance to BUNGE'S philosophy. This is opposed to WEBER'S point of view as he argues that the difference between positivism and interpretivism [18] is somehow meaningless to IS research.

Regarding some implications for the BWW approach it may be considerable to abandon its positivist foundations and move towards a post-positivist understanding of the BWW ontology. E.g. GRUBER'S perception of an ontology as a "formal explicit specification of a shared conceptualization" ([53], p. 199) stresses the belief that knowledge and thus ontology is language-bound. WYSSUSEK [50] argues concordingly that understanding the BWW ontology as one language-specific conceptualization of some reality may thereby serve researchers well as a reference basis for evaluation – in case a research group, or even better, the whole IS community – applies a compatible shared understanding to the ontology.

4 Conclusions and Outlook

This work demonstrated that evaluation is markedly problematic due to the complex nature of both the object of investigation and evaluation itself. As both aspects are subject to individual paradigmatic viewpoints, these assumptions need to be thoroughly explicated in order to fully comprehend the research context. This paper presented a basic discussion framework that can be used to provide more paradigmatic rigor in evaluation research by explicating philosophical assumptions that underlie evaluation approaches. Exemplarily, the application of the framework to the BWW approach revealed that the positivist paradigm underlying the BWW approach restricts its applicability to research artifacts that comply with this paradigm.

Concluding from this research, we want to raise awareness for more foundational rigor in IS research. Paradigmatic assumptions not only determine artifact creation but also artifact evaluation. Thus, researchers have to maneuver carefully through existent methods both for artifact development and validation to select appropriate, i.e. paradigm-compliant approaches within their research context. The framework presented in this paper can be used as a guideline towards this selection.

Future research work includes the extension of the framework to incorporate further philosophical aspects as well as to identify and differentiate further research paradigms. We will further prove its feasibility by applying it to paradigmatically different evaluation approaches, such as the consensus-oriented discursive evaluation approach by FRANK [2]. Furthermore, we will endeavor the discussion of post-approaches in evaluation research, e.g. critical realist or radical constructivist evaluation approaches.

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