Adequacy in Process Modeling: A Review of Measures and a Proposed Research Agenda – Position Paper –

Jan Recker[1] and Jan Mendling[2]

[1] Queensland University of Technology,
126 Margaret Street, Brisbane QLD 4000, Australia
j.recker@qut.edu.au
[2] Vienna University of Economics and Business Administration,
Augasse 2-6, 1090 Vienna, Austria
jan.mendling@wu-wien.ac.at

Abstract. Adequacy of process design is closely connected to the notion of process model adequacy, which in turn is a surrogate for model quality. Quality of modeling is an important field of research in which, however, a comprehensive and generally acknowledged understanding is still outstanding. Notions of "model", "adequacy" and "quality" often remain vague and focus on single aspects such as "syntax" or "semantics" rather than a comprehensive perspective. In this paper we review existing measures and proposals for process model quality as a surrogate for modeling adequacy. Forthcoming from this review we argue that it is foremost the question of modeling pragmatics that is of pertinence when trying to ascertain the adequacy of process modeling. We illustrate how pragmatic concerns mediate traditional conceptions of model quality. The paper ends with a proposed research agenda in the area of process model quality that stipulates an adequacy perspective with a closer focus on the socio-organizational context in which process modeling occurs.

1 Introduction

According to the ISO/IEC 9126 Software Product Quality Model [1] *adequacy* refers to a special quality aspect of software products that relates to the suitability of its functionality. It is measured by the number of functions that are suitable for performing the specified tasks divided by the number of function evaluated. However, for business process modeling this definition is not directly applicable since functions are usually regarded as black boxes in process models. Furthermore, adequacy in process modeling does not necessarily related to system design adequacy but more to adequacy of the real-world process. The objective of this paper is to discuss the notion of adequacy in the domain of process modeling. In order to arrive at a comprehensive understanding of this notion, it would appear conducive to approach 'adequacy' from the usual scenarios for business process modeling as a starting point:

In their essence, process models serve two main purposes [2]. First, intuitive business process models are used for scoping the project, and capturing and discussing business requirements and process improvement initiatives with subject matter experts and relevant stakeholders. This is basically a *communication* task. A prominent example of a business modeling technique used for such purposes is the Event-driven Process Chain (EPC) [3]. Second, business process models may also be used for process automation, which requires their conversion into executable workflow specifications. This is basically a *specification* task. Techniques used for depicting process models for this purpose have higher requirements in terms of precision. Examples include Petri nets [4] or the Business Process Execution Language for Web Services (BPEL) [5].

This distinction is of relevance when discussing the notion of adequacy in process modeling. Many scholarly papers neglect the differences between the use of process models for graphically describing business processes and for formally specifying executable workflows [2]. However, in practice, this difference is highly relevant as the purpose of process modeling determines the requirements towards a process model and thus ultimately to its adequacy. The two introduced main purposes of process modeling each postulate distinct requirements (see Table 1).

Table 1. Purposes of process modeling and corresponding adequacy requirements [2]

Describing business processes	**Specifying workflows**
Provide a basis for communication	Serve as input to information systems
Must be understandable	Must be machine-readable
Should be intuitive	Should be unambiguous
Should leave room for interpretation	Should not contain any uncertainties

Accordingly, and not surprisingly, it is often witnessed in process modeling practice that individuals from different backgrounds perform these different process modeling tasks (e.g., business analysts versus workflow analysts). These individuals possess quite divergent skills and knowledge, a fact that has been discussed in IS research under the notion of domain knowledge. Related studies have found that domain knowledge determines the way of thinking, approaching and using means, such as developing and using graphical models, for problem solving and other tasks [6]. Given the observable connection between the tasks for which process modeling is being applied and the matching (or non-matching) skills and knowledge of the involved stakeholders, it is surprising to see that this area has so far attracted so little attention in process modeling-related research let alone in a discussion of process model quality and/or adequacy.

To be more concise, obviously, any of the existing theories of adequacy would be expected to provide some (but not all) explanations for the following two observations: First, workflow analysts with background knowledge on formal methods tend to prefer Petri nets as a modeling language for specifying executable workflow processes. Second, business analysts more frequently use techniques such as EPCs for describing a business domain. The resulting challenge is to identify and conceptualize a notion of adequacy that embraces enough explanatory power to consider *all* related aspects that potentially display relevance to process modeling. In Section 2, we elaborate on the aforementioned observations from the perspective of three existing approaches to quality of models. We identify shortcomings that serve us as a motivation for considering additional aspects in Section 3. Section 4 concludes the paper and gives an outlook on future research topics related to adequacy.

2 A Review of Proposed "Adequacy" Notions

In this section we challenge established literature on process modeling "adequacy', "goodness", "quality" and related terms with the observations that we described above. We do not wish to provide a comprehensive overview of all work done in these areas and instead focus on illustrative examples for different types of research. In particular we discuss adequacy related to representational capabilities, to semiotics, and to formal correctness criteria.

2.1 Representational Capabilities as a Surrogate of Adequacy

An increasingly popular evaluation framework for process modeling has become known as the method of representational analysis [7]. Wand and Weber [8-10] suggest that ontology may help in devising conceptual structures on which process modelers can base their representations of real-world domains. They adopted an ontology into a model of representation (the BWW representation model) that specifies a set of essential ontological constructs that process modeling techniques need to provide representations for. Based on this set of ontological constructs, representation theory proposes that the use of the representation model facilitates an evaluation of process modeling techniques as to their representational capabilities. Two main principles are theorized for process modeling techniques to be able to provide 'good' representations of real-world domains:

- a process model should be *complete*, *viz*., it should not exhibit a deficit of representations that are needed to articulate all relevant facets of phenomena that a user seeks to have represented. Wand and Weber [9] have labeled this principle *ontological completeness*, and
- a process model should also be *clear*, *viz*., it should provide representations for all relevant facets of phenomena in such a way that the meaning of these representations can unambiguously be interpreted. Wand and Weber [9] have labeled this principle *ontological clarity*.

In literature, there is an established track record of studies of process modeling techniques with the help of the BWW representation model (summarized in [7]). While these studies suggest that representational analysis is quite useful in identifying issues in the use of process modeling techniques for providing faithful representations of real-world domains, they bear little explanatory power when considering the two observations of Section 1. Instead, according to the work of Wand and Weber, the modeling technique with the better clarity and completeness should always be preferred. While such proposition may or may not be theoretically sound, it certainly does not apply to all observable forms of process modeling practice and hence is only limited in being an *explanatory theory*:

Obviously, a process model that is not complete in light of a representational analysis might still be satisfactory if it turns a blind eye to those real-world aspects that do not serve the purpose for which the process model was created in the first place. For instance, if a modeler does not have a need to graphically articulate system decompositions in a model then, certainly, she would not be concerned with whether the process modeling language of choice actually provides representation forms for system decompositions (which would potentially result in an incomplete model) or whether they would be several representation forms available (which would potentially decrease the clarity of the model). For instance, it was found that for some process modeling purposes (such as devising executable workflow specifications), users deliberately reduce the ontological clarity of the process model in order to be able to specify implementation aspects in a model that for themselves are not articulating any real-world aspect but are nevertheless required by workflow engines for system governance and model deployment reasons [11].

2.2 A Semiotic Quality Framework for Process Modeling

Lindland *et al*. [12] developed a general and generic understanding of conceptual model quality, which has, amongst other areas, also been used in discussions on process model quality (e.g., [13]). The framework is based on linguistic and semiotic concepts (such as syntax, semantics and pragmatics) that enable the assertion of quality at different levels. Lindland *et al.*'s [12, p. 44] framework for quality in conceptual modeling uses these levels to distinguish three aspects of model quality:

- *Syntax* relates the model to the modeling language by describing relations among language constructs without considering their meaning.
- *Semantics* relates the model to the domain by considering not only syntax, but also relations among statements and their meaning.
- *Pragmatics* relates the model to audience participation by considering not only syntax and semantics, but also how the audience (anyone involved in modeling) will interpret them.

While this framework specifies (on an abstract level) a pragmatic dimension of quality in process modeling, this notion prevalently addresses information delivery concerns such as the degree to which a model is understood by its audience and the degree to which a model corresponds to its audience interpretation. Yet, regarding our observations in Section 1, the framework gives at least some idea of an explanation. Assuming that the audience of a workflow model and a domain business process model would be different, it seems reasonable that the pragmatic value of the model might be different if one or the other language is used. Still, this aspect is not directly made explicit in the framework let alone sufficiently conceptualized and operationalized. Therefore, it appears to be appropriate to consider further dimensions of adequacy that would take into explicit consideration the purposes of process modeling.

2.3 Correctness criteria for process models

Several notions and correctness criteria have been proposed for process models. Among them, *soundness* is an important and prominent correctness criterion for business process models introduced by van der Aalst in [14]. The original soundness property is defined for a Workflow net, a Petri net with one source and one sink, and requires that (i) for every state reachable from the source, there exists a firing sequence to the sink (option to complete); (ii) the state with a token in the sink is the only state reachable from the initial state with at least one token in it (proper completion); and (iii) there are no dead transitions [14]. Furthermore, van der Aalst shows that soundness of a Workflow net is equivalent to *liveness* and *boundedness* of the corresponding short-circuited Petri net. Therefore, several liveness and boundedness analysis techniques are directly applicable for the verification of soundness. Also, variants have been developed for the principle of soundness, such as, for instance, relaxed soundness [15] or lazy soundness [16].

Beyond the soundness property, *structuredness* (or well-structuredness) is also discussed as a correctness criterion. In essence, a structured process can be constructed by nesting simple building blocks like split and join of the same connector type. Structuredness of a process model guarantees soundness if the model is live (see e.g., [17]). Some process modeling languages (like BPEL) enforce the definition of a structured model by means of syntactical restrictions in order to provide correctness by design. Yet, structuredness as a correctness criterion has been criticized for being too strict (see e.g., [17]) since some sound process models are discarded right from the start. Furthermore, nesting of structured blocks does neither meet the way people comprehend processes nor does every process fit easily into this scheme. Therefore, structuredness should rather be regarded as a general guideline from which it can be deviated if necessary.

Again, these correctness definitions do not provide a direct answer on questions related to adequacy in general. One line of argumentation could be that languages that allow one to reason about soundness or structuredness could be preferable to others. As a consequence, we obtain a general recommendation that Petri nets should be preferable (e.g., [18]), which in turn at least partially contradicts the observations of Section 1. In contrast, it seems more likely that the correctness notions themselves are subject to adequacy considerations. In the following section, we will sketch what some input factors for such adequacy considerations could be.

3 Towards a Comprehensive Perspective on Process Model Adequacy

3.1 Pragmatism as a Useful Perspective on Process Modeling Adequacy?

Our review showed that there is a noted lack of comprehensive discussions on pragmatic and purpose-oriented measures and dimensions in existing literature on the adequacy, goodness or quality of process modeling and related phenomena. In this section we refer to the philosophical origins of pragmatism in order to explore whether this basis offers a framework on which to countervail these deficiencies and ultimately arrive at a holistic perspective.

Pragmatism suggests that the worth of a proposition, theory or model is to be judged by the consequences of accepting it [19]. Basically, the tenet of pragmatism is that any picture, theory or model is good or true or valuable if and only if it is *useful* – in the sense of helping people to fulfill a given need. Pragmatists consequently do not search for universal truths but instead argue that all construction of knowledge (such as an understanding of whether a process model is adequate), i.e., the association of perceptual input to cognitive concepts, occurs before the background of our historically and socially situated pre-understanding of the context. In particular, pragmatism offers a criterion of adequacy spread across an epistemological ("is this model credible and reliable?") and a normative ("does this model help us in our actions?") dimension. The tenet of pragmatism has been reflected in some previous work on conceptual model quality, for instance in the notion of feasibility in the quality framework of Lindland *et al*. [12], which defines a 'satisfactory' threshold for quality aspects.

Speaking of process modeling, pragmatism is concerned with the compliance of the model to the aims and purposes for which the model was created. In this understanding, the pragmatic dimension is not solely concerned with pure information delivery concerns (whether different stakeholders sufficiently understand the model [12]) but also whether the model, as a graphical statement, enables its interpretants to make use of it for fulfilling their need. That is, the pragmatic dimension transcends pure information delivery concerns such as the ease of retrieving desired information about the process from the process model or the suitability of the presentation form to the comprehension capabilities of different stakeholders. The pragmatic dimension is instead concerned with assessing the value of the process model for helping its interpretants to better cope with their problems of, for example, introducing process-aligned organizational structures or solving process improvement tasks. In order to arrive at such objective, it is necessary to form mutual agreements about the horizon of meaning of the process model amongst model designers and users. As the pragmatic judgment is subject to individual norms, ethics, values and needs, appropriate means for evaluation call for empirical research strategies rather than theoretical ones.

Interestingly, examples for such research are indeed identifiable in modeling domains other than process modeling. Taking the example of conceptual data modeling research, several researchers have turned to the exploration of different modeling forms and styles and the impact on problem solving tasks (e.g., devising data structures or query formulation [6, 20]). Surprisingly, the domain of process modeling has not yet been thoroughly approached from this perspective and thus, examples for investigations into pragmatic aspects of modeling quality are scarce at best (one of the few examples includes [21]). We see potential and first evidence that some of the successful research streams from related conceptual modeling domains could be adopted to the area of process modeling to extend the current body of knowledge.

3.2 Implications for Theorizing Process Model Adequacy

Pragmatism offers a way of developing an understanding of why certain notions of process model adequacy appear to hold only for a limited number of but not all modeling scenarios. It informs us that we have to take into consideration the overall aim of the process modeling exercise and the situational background before which the modeling occurs. This situational context is first and foremost coined by the abilities and characteristics of the modeling individual. Clearly, it is the modeler who imposes on the process modeling procedure and outcomes her trademark in terms of skills, expertise, opinions and beliefs about how the overarching process modeling objective can best be achieved. In recapitulation, we put forward three arguments:

1. Process modeling can serve many purposes and is used in a variety of contexts. Singling out the distinction between business- and IT-oriented purposes alone (and there are many more, activity-based costing, process improvement, reference modeling, simulation, knowledge management to name just a few) indicates how different the *requirements* towards a process model may be. Accordingly, it is quite presumptuous to believe that one and the same process model (or technique) can be of the same help for all of these purposes.
2. Process modeling practice (and our review of literature) strongly suggests that the different *capabilities* of process modeling technique serve different process modeling tasks and different users to different extents. In this context, previous studies have found that existing process modeling techniques exhibit quite significantly different capabilities and shortcomings, for instance, in the expression of workflow patterns [22] or in their representation fidelity [11].
3. Similarly (although not being primary subject in this paper's discussion), previous research has shown that modelers differ sometimes quite significantly in their skills and *abilities*, for instance, with respect to their cognitive skills [23] or their background domain knowledge [6]. Clearly, the extent to which users of a process modeling technique bring to bear different levels of background knowledge of, for instance, IT domains, affects the way process models are created with a technique and accordingly, whether or not the resulting model is considered adequate or not.

Forthcoming from these observations we argue that it is not so much the fact that some techniques may have "better" inherent capabilities for process modeling or match some correctness or adequacy criteria better than others but rather the extent to which the characteristics of a process modeling technique match skills and tasks that determine whether or not the process modeling outcome can be considered adequate. We hence propose to consider the ternary relation *user abilities - technique capabilities - task requirements* as a general framework for discussing adequacy in process modeling.

The ternary relation *user abilities - technique capabilities - task requirements* presents a strong theoretical framework for the notion of adequacy. Input to each of these facets can hereby be obtained from related work. As described in Section 2, a number of researchers have established indicators for differences between process modeling techniques that could be used as indicators for technique characteristics. The introduced two basic purposes of process modeling present a modeler with different task requirements pertaining to her process modeling activities (see Table 1). Other research has investigated differences in modeler abilities such as domain knowledge [6] or training background [24], to name just a few factors that could potentially serves as input to the concept of user abilities.

4 Conclusions

There are arguably observable merits stemming from a closer focus on modeling pragmatics in the discussion of process modeling adequacy. First and foremost, the incorporation of social and pragmatic considerations into the discussion of process modeling facilitates an appreciation of the organizational and situational context in which modeling occurs. By focusing aspects of process modeling adequacy that transcend traditional syntactic and/or semantic concerns it is made possible to ultimately produce modeling outcomes that are not only of interest to, and perceivable by, relevant stakeholders but moreover helpful in solving real-world modeling problems rather than building 'correct' models that are more or less useless for solving organizational problems.

Our work serves as a reference for further research on at least two premises: first, it underlines a pragmatic-oriented methodology of business process modeling that provides strong explanatory and explorative power for understanding modeling adequacy. Second, our considerations provide an initial understanding of process model adequacy. As such, they can serve as a basis for deriving applicable, relevant and theoretically sound dimensions and measures of adequacy.

References

1. ISO/IEC: Information Technology - Software product evaluation - Quality Characteristics and Guidelines for their Use. ISO/IEC International Standard 9126. (1991)
2. Dehnert, J., van der Aalst, W.M.P.: Bridging The Gap Between Business Models And Workflow Specifications. International Journal of Cooperative Information Systems 13 (2004) 289-332
3. Keller, G., Nüttgens, M., Scheer, A.-W.: Semantische Prozessmodellierung auf der Grundlage "Ereignisgesteuerter Prozessketten (EPK)". Working Paper 89. Institut für Wirtschaftsinformatik, Universität Saarbrücken (in German), Saarbrücken, Germany (1992)
4. Petri, C.A.: Fundamentals of a Theory of Asynchronous Information Flow. In: Popplewell, C.M. (ed.): IFIP Congress 62: Information Processing. North-Holland, Munich, Germany (1962) 386-390
5. Andrews, T., Curbera, F., Dholakia, H., Goland, Y., Klein, J., Leymann, F., Liu, K., Roller, D., Smith, D., Thatte, S., Trickovic, I., Weerawarana, S.: Business Process Execution Language for Web Services. Version 1.1. BEA Systems, International Business Machines Corporation, Microsoft Corporation, SAP AG and Siebel Systems (2003), available at: http://xml.coverpages.org/BPELv11-May052003Final.pdf

6. Khatri, V., Vessey, I., V. Ramesh, P.C., Sung-Jin, P.: Understanding Conceptual Schemas: Exploring the Role of Application and IS Domain Knowledge. Information Systems Research 17 (2006) 81-99
7. Rosemann, M., Green, P., Indulska, M., Recker, J.: Using Ontology for the Representational Analysis of Process Modeling Techniques. International Journal of Business Process Integration and Management (forthcoming) in press
8. Wand, Y., Weber, R.: On the Deep Structure of Information Systems. Information Systems Journal 5 (1995) 203-223
9. Wand, Y., Weber, R.: On the Ontological Expressiveness of Information Systems Analysis and Design Grammars. Journal of Information Systems 3 (1993) 217-237
10. Wand, Y., Weber, R.: An Ontological Model of an Information System. IEEE Transactions on Software Engineering 16 (1990) 1282-1292
11. Recker, J., Rosemann, M., Indulska, M., Green, P.: Business Process Modeling: A Maturing Discipline? BPM Center Report BPM-06-20. BPMcenter.org (2006)
12. Lindland, O.I., Sindre, G., Solvberg, A.: Understanding Quality in Conceptual Modeling. IEEE Software 11 (1994) 42-49
13. Krogstie, J., Sindre, G., Jørgensen, H.D.: Process Models Representing Knowledge for Action: a Revised Quality Framework. European Journal of Information Systems 15 (2006) 91-102
14. van der Aalst, W.M.P.: Verification of Workflow Nets. In: Azéma, P., Balbo, G. (eds.): Application and Theory of Petri Nets - ICATPN 1997. Lecture Notes in Computer Science, Vol. 1248. Springer, Toulouse, France (1997) 407-426
15. Dehnert, J., Rittgen, P.: Relaxed Soundness of Business Processes. In: Dittrich, K.R., Geppert, A., Norrie, M.C. (eds.): Proceedings of the Advanced Information Systems Engineering - CAiSE 2001. Lecture Notes In Computer Science, Vol. 2068. Springer, Interlaken, Switzerland (2001) 151-170
16. Puhlmann, F., Weske, M.: Investigations on Soundness Regarding Lazy Activities. In: Dustdar, S., Fiadeiro, J.L., Sheth, A.P. (eds.): Business Process Management - BPM 2006. Lecture Notes in Computer Science, Vol. 4102. Springer, Vienna, Austria (2006) 145-160
17. Dehnert, J., Zimmermann, A.: On the Suitability of Correctness Criteria for Business Process Models. In: van der Aalst, W.M.P., Benatallah, B., Casati, F., Curbera, F. (eds.): Proceedings of the 3rd International Conference on Business Process Management. Lecture Notes in Computer Science, Vol. 3649. Springer, Nancy, France (2005) 386-391
18. van der Aalst, W.M.P.: Three Good Reasons for Using a Petri-net-based Workflow Management System. In: Wakayama, T., Kannapan, S., Khoong, C.M., Navathe, S.B., Yates, J. (eds.): Information and Process Integration in Enterprises: Rethinking Documents. The Kluwer International Series in Engineering and Computer Science, Vol. 428. Kluwer Academic Publishers, Boston, Massachusetts (1998) 161-182
19. Wicks, A.C., Freeman, R.E.: Organization Studies and the New Pragmatism: Positivism, Anti-positivism, and the Search for Ethics. Organization Science 9 (1998) 123-140
20. Bowen, P.L., O'Farrell, R.A., Rohde, F.: Analysis of Competing Data Structures: Does Ontological Clarity Produce Better End User Query Performance. Journal of the Association for Information Systems 7 (2006) 514-544
21. Danesh, A., Kock, N.: An Experimental Study of Two Process Representation Approaches and their Impact on Perceived Modeling Quality and Redesign Success. Business Process Management Journal 11 (2005) 724-735
22. van der Aalst, W.M.P., ter Hofstede, A.H.M., Kiepuszewski, B., Barros, A.P.: Workflow Patterns. Distributed and Parallel Databases 14 (2003) 5-51
23. Vessey, I., Conger, S.A.: Requirements Specification: Learning Object, Process, and Data Methodologies. Communications of the ACM 37 (1994) 102-113
24. Iivari, J.: Why are CASE Tools not Used? Communications of the ACM 39 (1996) 94-103