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HOW GOOD IS BPMN REALLY?
INSIGHTS FROM THEORY AND PRACTICE

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Abstract

The increased interest in a more disciplined approach for Business Process Management has motivated many organizations to make significant investments in process modelling initiatives. This, in turn, has triggered significant related research. One outcome of this development is the Business Process Modeling Notation (BPMN), which has been proposed as the new process modelling industry standard. BPMN has become over the last two years a popular process modelling technique. This paper represents the first contribution towards a theoretically sound and empirically validated analysis of BPMN. Based on an established process, we conducted a representational analysis of BPMN using a representation model based on the Bunge ontology. In addition to the theoretical identification of possible shortcomings of BPMN, we conducted a comprehensive series of interviews with BPMN users in order to seek empirical evidence for our propositions. Through this study, we identified a number of critical issues related to the practice of modelling with BPMN in contemporary process management initiatives, for example, the capture of business rules and the specification of the Lane and the Pool constructs.

Keywords: Process Modelling, Representational Analysis, BWW model, BPMN, Ontology

1 INTRODUCTION

Business Process Management (BPM) has been ranked as a top business priority and building business process capabilities is seen as a major challenge for senior executives within the coming years (Gartner Group 2005). BPM is a structured, coherent and consistent way of understanding, documenting, modelling, analyzing, simulating, executing and continuously changing end-to-end business processes and all involved resources in light of their contribution to business performance. Overall, an increasing demand for a more disciplined approach towards Business Process Management can be observed, which motivates many organizations to make substantial investments in BPM-related initiatives. This in turn has triggered significant related academic and commercial work aiming towards advanced business process management solutions.

One prominent example in this context is the increased popularity of business process modelling. A wide range of process modelling approaches has been proposed over time, ranging from simple flowcharts to advanced variants of Petri nets with high expressive power. One of the most recent proposals for yet another process modelling language is the Business Process Modeling Notation (BPMN), version 1.0 of which was proposed in May 2004 and adopted by OMG for standardization purposes in February 2006. The conformity with emerging Web Services standards, its reasonably intuitive notation and the promise of becoming an official process modelling industry standard, have boosted the popularity of BPMN. In fact, the official BPMN web site (www.bpmn.org) already lists more than 30 vendors of process tools that support BPMN. The attention that BPMN is receiving, however, until now has not been balanced by a critical analysis of its actual and perceived capabilities.

The research presented in this paper uses the principles of *representational analysis* for an investigation into the *potential* and *perceived* shortcomings of BPMN. In particular, it uses a model of representation proposed by Wand and Weber (1995) that was originally derived from an ontology defined by Bunge (1977), the so-called BWW representation model. Over the last decade the BWW model has been applied to several leading conceptual modelling techniques. The maturity of this theory and the opportunity for further comparative analyses of our findings with related representational evaluations motivated the selection of this model. The *aim of this paper* is to provide a deeper understanding of the potential and actual issues of the emerging process modelling standard, BPMN. Besides its theoretical contribution, *i.e.*, the formal analysis of BPMN, this paper has high practical impact for vendors of tools and training programs related to BPMN. Furthermore, the results of this study are beneficial for organizations currently selecting process modelling languages. This is the first paper that uses a sound theoretical base, *i.e.*, the BWW model, in conjunction with an empirical study, in order to evaluate comprehensively the emerging standard for business process modeling. The two *research questions* of this paper are:

- What are the *representational shortcomings* of BPMN in light of the Bunge-Wand-Weber model?
- Which of these theoretically identified shortcomings is perceived as an *actual shortcoming* by BPMN users?

We proceed as follows. The next section provides a brief overview of the background of our research, including an introduction to BPMN and the BWW representation model, as well as related work in the area of evaluating process modelling techniques. Section 3 summarizes the outcomes of our representational analysis of BPMN and presents nine propositions derived from the analysis. In section 4, we discuss the findings of a series of BPMN user interviews for each of the nine propositions. The fifth and final section summarizes the contributions of this paper, the limitations of the presented research and our intended future research directions.

2 BACKGROUND AND RELATED WORK

2.1 The Business Process Modeling Notation

The Business Process Modeling Notation (BPMI.org & OMG 2006) is a recently proposed process modelling technique, the development of which has been based on the revision of other notations including UML, IDEF, ebXML, RosettaNet, LOVeM and Event-driven Process Chains. The development of BPMN stemmed from the demand for a graphical notation that complements the BPEL4WS standard for executable business processes. Although this gives BPMN a technical focus, it has been the intention of the BPMN designers to develop a modelling technique that can be applied for typical business modelling activities as well. The specification document differentiates the BPMN constructs into a set of core graphical elements and an extended specialized set. For the purpose of this research we investigated both sets. The complete BPMN specification defines thirty-eight distinct language constructs plus attributes, grouped into four basic categories of elements, *viz.*, *Flow Objects*, *Connecting Objects*, *Swimlanes* and *Artefacts*. *Flow Objects*, such as events, activities and gateways, are the most basic elements used to create Business Process Diagrams (BPDs). *Connecting Objects* are used to inter-connect *Flow Objects* through different types of arrows. *Swimlanes* are used to group activities into separate categories for different functional capabilities or responsibilities (*e.g.*, different roles or organizational departments). *Artefacts* may be added to a diagram where deemed appropriate in order to display further related information such as processed data or other comments.

2.2 The BWW representation model

In the process of requirements engineering for Information Systems Analysis and Design, various stakeholders are confronted with the need to represent the requirements in a conceptual form. Often, however, they do not possess an underlying conceptual structure on which to base such models (Floyd 1986). This deficit motivated research for a theoretical foundation for conceptual modelling. A promising theory emerged from the observation that, in their essence, computerized Information Systems are representations of real world systems. Real world systems, in turn, can be explained and described using ontology – the study of the nature of the world and attempt to organize and describe what exists in reality, in terms of the properties of, the structure of, and the interactions between real-world things (Bunge 1977, pp. 3-6). Wand and Weber (1993, 1995) suggest that the theory of ontology can be used to help define and build information systems that contain the necessary representations of real world constructs, including their properties and interactions. Hence, they developed and refined a set of models based on an ontology defined by Bunge (1977) for the evaluation of modelling techniques and the scripts prepared using such techniques. These models are referred to as the BWW models. The BWW *representation model* is one of three theoretical models defined by Wand and Weber (1995) that make up the BWW models. The application of the representation model to Information Systems foundations has been referred to by a number of researchers (Green & Rosemann 2004) and the model is now often referred to as simply “the BWW model”. Its key constructs can be grouped into four clusters: things including properties and types of things; states assumed by things; events and transformations occurring on things; and systems structured around things. For a complete description of the BWW constructs please refer, for example, to (Weber 1997).

Weber (1997) suggests that the BWW representation model can be used to analyze a particular modelling technique so as to make predictions on the modelling strengths and weaknesses of the technique, in particular its capabilities to provide *complete* and *clear* descriptions of the domain being modelled. He clarifies two main evaluation criteria in representational analyses that may be studied according to the BWW model: *Ontological Completeness* is indicated by the degree of *construct deficit*, *i.e.*, the extent to which a modelling technique covers completely the constructs proposed in the BWW representation model. *Ontological Clarity* is indicated by the degrees of *construct overload*, where one language construct covers several BWW constructs, *construct redundancy*, where one

BWW construct maps to several language constructs, and *construct excess*, where language constructs exist that do not map to any BWW construct.

2.3 Related work

Research related to our work can broadly be differentiated into three categories: (1) ontology-based theories for conceptual modelling, (2) evaluation of process modelling techniques, and (3) research on BPMN.

Regarding ontology-based theories for conceptual modelling, the BWW models are just one candidate of a set of proposed conceptual modelling theories that draw on the notion of ontology. For example, we refer to the work of Chisholm (1996) and Guizzardi (2005), whose upper-level ontologies have been built for similar purposes and seem to be equally expressive (Davies *et al.* 2005). These ontologies, however, have not yet achieved the level of dissemination of the BWW models, which reasons our selection for this model as a benchmark.

In the area of evaluation of process modelling techniques, only limited research efforts have been made to compare process modelling techniques based on an established theoretical model. Söderström *et al.* (2002), for example, compare process modelling techniques based on a framework proposing core concepts in the area of process modelling. Yet, similar to other proposals in the field, this work neither is widely distributed in academia or practice, nor does it have an established track record. The BWW representation model, on the other hand, has been used in over twenty-five research projects for the evaluation of different modelling techniques (see (Green & Rosemann 2004) for an overview), including data models, object-oriented models and reference models. It also has a strong track record in the area of process modelling with contributions coming from many international researchers. In this section, we briefly summarize BWW-related studies that involved the analysis of a process modelling technique by means of a representational model.

Keen and Lakos (1996) determined essential features for a process modelling scheme by evaluating six process modelling techniques. Their evaluation was based on the BWW representation model. Among the modelling techniques evaluated were ANSI flowcharts, Data Flow Diagrams and IDEF3. From the analysis, the authors concluded that, in general, the BWW model facilitates the interpretation and comparison of process modelling techniques. Yet, the authors did not empirically verify their findings on the features of process modelling schemes. Green and Rosemann (2000) analyzed the EPC notation with the help of the BWW model. Their findings have been empirically validated through interviews and surveys (Green & Rosemann 2001). Confirmed shortcomings were found in the EPC notation with regard to the representation of real world objects and business rules, and in the thorough demarcation of systems. Green *et al.* (2004) compared different modelling standards for enterprise system interoperability, including BPEL4WS v1.1, BPML v1.0, WSCI v1.0, and ebXML v1.1. The study found that ebXML provides a wider range of language constructs for specification requirements than the other techniques. At the present point in time, this analysis too, has not yet been empirically validated. Overall, most of the research conducted lacks, at the time of writing, empirical verification of the theoretical findings. Overcoming this shortcoming of previous analyses, our foremost research objective was to conduct a comprehensive study on BPMN that included the empirical testing of our findings so we can report comprehensively on *theoretical* as well as *perceived* capabilities of BPMN.

Research relating directly to the evaluation of the Business Process Modeling Notation is still limited as BPMN is a very recent modelling technique. Wahl and Sindre (2005) report on an analytical evaluation of BPMN using the Semiotic Quality Framework (Krogstie & Sølvberg 2003). They conclude that BPMN particularly excels in terms of comprehensibility appropriateness due to its construct specializations and type aggregations, and is well-suited generally for the domain of business process modelling. Interestingly, they also see the need for, and potential of, a representational analysis. Similarly, Nysetvold and Krogstie (2005) compared BPMN to UML Activity Diagrams and EEML in a case study based on the same framework, finding that BPMN achieves the highest score in all categories except for domain appropriateness. Finally, based on the workflow patterns framework (van der Aalst *et al.* 2003), Wohed *et al.* (2005) evaluated BPMN as to its capability to express a series of control flow, data and resource patterns. They found that BPMN supports the majority of the control flow patterns, nearly half of the data patterns and a few resource patterns. The outcomes of their study align with most of our findings, *e.g.*, the lack of means in BPMN for representing states assumed by things or the unclear specification of the constructs Lane and Pool (see Table 1).

3 ON THE REPRESENTATIONAL ANALYSIS OF BPMN

Generally, the focus of representational analyses is on the bi-directional comparison of constructs specified in the underlying theory of representation with the language constructs of the modelling technique, leading to statements about the two situations of ontological completeness and clarity. In order to follow a rigorous approach towards evaluation, we followed an established procedural model (Rosemann & Green & Indulska 2005). Specifically, our analysis was conducted in three steps. First, two researchers separately read the BPMN specification and mapped the BPMN constructs against BWW constructs in order to create individual first analysis drafts. Second, the researchers met to discuss and defend their mapping results. Third, the jointly agreed second draft was discussed and refined in several meetings with the entire research team. By reaching a consensus over the final mapping result we feel that we achieved a maximum of possible objectivity and rigor in this type of research. The final mapping result is manifested in a table that can be found in (Recker *et al.* 2005).

Based on the mapping findings from the representational analysis of BPMN, we derived nine propositions in order to demonstrate how the lack of ontological completeness and clarity can lead to problems with the use of the notation (see Table 1). The first three propositions stem from the notion of construct deficit in BPMN. That is, the lack of a mapping of a BWW construct to a BPMN construct indicates the lack of means for users to describe particular real-world phenomena. Such deficiency drives users to modify existing constructs, employ new constructs, or adopt constructs from other modelling techniques in order to compensate for the deficit. From the perspective of construct redundancy, we identify examples of BWW constructs to which more than one BPMN construct is mapped. Such cases are undesirable as they lead to confusion over which real-world concept can best be represented by a particular language construct. From the perspective of construct excess, we identified the BPMN constructs that appear to have no real-world meaning as per the BWW model. Accordingly, users will get confused when using these constructs and, hence, they will need mechanisms for further clarification. From the perspective of construct overload, we can identify examples of BPMN constructs to which more than one BWW construct has been mapped. Such cases require the user to bring to bear extra-model knowledge in order to understand the capacity in which a given construct is used in a particular scenario.

Construct deficit	
P1	Because there is no representation for *state*, *stable state*, *unstable state*, *conceivable state space*, *state law*, *lawful state space*, *conceivable event space*, and *lawful event space*, state modelling will lack definability and focus. Thus, the depiction of business rules that rely on state and transformation laws will be unclear.
P2	Because there is no representation for *history*, the need for a log of state changes in important entities will not be met. Such a situation can cause significant problems related to recovery and reliability of interacting entities, such as inter-organizational systems.
P3	Because there is no representation for *system structure*, there is no thorough demarcation of the system and the things within the system. This deficiency can lead to difficulties in the use of BPMN for modelling inter-organizational business processes. Also, in large modelling projects, problems can arise regarding how to structure process models into constituent models. Due to the inability to break down the system coherently, the understandability of models captured with BPMN will be undermined.
Construct redundancy	
P4	Because a *thing* can be represented by either a Pool or a Lane, users will have difficulty understanding which of these constructs should be used. Specifically, users will confront problems when modelling organizational entities, *e.g.*, whether to use a Lane or a Pool for representing an organizational department.

P5	Because a *transformation* can be represented by the BPMN constructs Activity, Task, Collapsed Sub-Process, Expanded Sub-Process, Nested Sub-Process, and Transaction, users will get confused as to which construct is to be used when representing a transformation. The BPMN constructs differ in terms of visualization but no significant semantic differentiation can be stated in terms of their use.
P6	Because an *event* can be represented by nine BPMN constructs, *viz.*, Start Event, Intermediate Event, End Event, Message, Timer, Error, Cancel, Compensation, and Terminate, users will encounter confusion regarding the differentiation of these constructs.
Construct excess	
P7	Because the BPMN constructs Link, Off-Page-Connector, Association Flow, Text Annotation, Group, Activity Looping, Multiple Instances, Normal Flow, Event (super type), and Gateway (including all Gateway Types) appear to have no real-world meaning, their use will cause understandability problems. Users will have to bring to bear extra model knowledge to make sense of these constructs. Specifically, BPMN provides certain constructs (such as Event, Gateway, Normal Flow) that are further specialized in the notation and thus appear to be unnecessary from the perspective of the BWW representation model.
Construct overload	
P8	Because the BPMN construct Lane maps to the BWW constructs *thing*, *class*, *kind*, *system*, *subsystem*, *system composition*, *system environment*, *system decomposition*, and *level structure*, users will be required to bring to bear extra model knowledge in order to understand which real-world concept is being modelled by the Lane construct. Consider, for example, a question whether a Lane in a BPMN model represents a specific organizational entity, an application system, or a set of entities such as a group of actors.
P9	Because the BPMN construct Pool maps to the BWW constructs *thing*, *system*, *subsystem*, *system composition*, *system environment*, *system decomposition*, and *level structure*, users will need to have extra model knowledge in order to understand which real-world concept is being modelled by the Pool construct. Specifically, it is unclear whether a Pool stands for a single organizational entity, whether it is part of a super-ordinate entity, or whether it might be external to a modelled system.

Table 1. Propositions derived from the representational analysis of BPMN

4 ON THE PRACTICE OF BPMN

4.1 Research method and interview design

After evaluating BPMN analytically against our selected benchmark, the BWW model, we sought to gain insight into the actual practice of process modelling with BPMN in business organizations. We deemed semi-structured in-depth interviews to be the best available empirical research strategy as they allowed us to gather deep insights into the propositions derived from the analysis. Furthermore, this approach allowed for extensive reasoning and richer feedback from the interviewees, which facilitated discovery of additional issues with the notation that may have remained undiscovered by the representational analysis.

Based on the nine propositions introduced in the previous section, a semi-structured interview protocol was developed[1]. The protocol consists of two main sections – a section that collects demographic information (Section A) and a section composed of questions related to the propositions (Section B). In total, the study had nineteen participants from six Australian organizations and government agencies distributed over four Australian states. The participants ranged in terms of their levels of experience with modelling, and with BPMN. Also, the participants varied in their use of the BPMN specification, with 32% of the interviewees using only the core set of the specification and 68% using an extended or complete set of BPMN constructs.

In response to emerging criticism about methodologies for testing representational propositions with practitioners (Rosemann & Green & Indulska 2005), we sought to establish guidance on how to design

[1] A copy of the interview protocol is available from the authors on request.

appropriate empirical research strategies to complement representational analyses. In particular, we developed classification schemes to consistently and comprehensively classify participant responses to Section B questions. This work is based on, and further extends preliminary elaborations formulated by Davies *et al.* (2004). One classification scheme each for construct deficit, redundancy, excess and overload, was developed for this study. Here, we discuss the classification schemes for construct deficit and construct excess as an indication (see Figure 1).

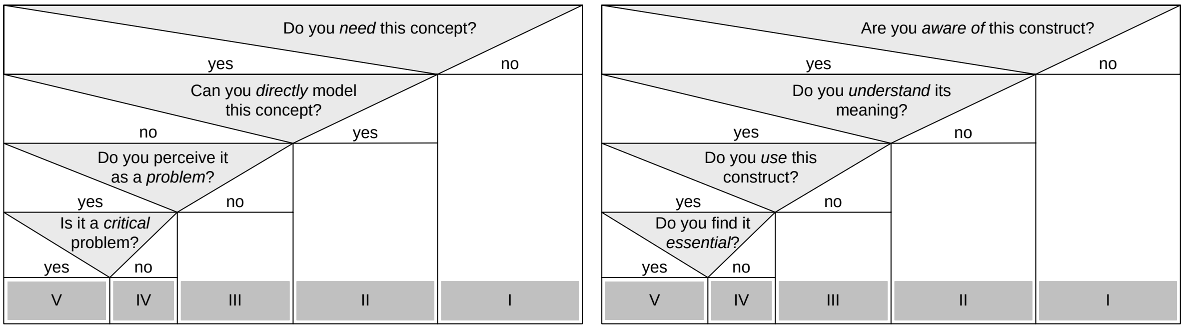

Figure 1. Response classification schemes for testing construct deficit and construct excess

Under the construct deficit classification scheme, the first question asked of the participant is that of need for a particular modelling concept, *e.g.*, "have you ever had the need to graphically represent business rules?". If the response is negative, it is classified as a type I response. If the answer is positive, a further question regarding the ability to model directly the concept is asked, *e.g.*, "can you explicitly graphically represent business rules using BPMN constructs?". This response can be classified as a type II response if the participant can directly model the concept in question. Otherwise, they are asked to indicate if they perceive this inability to be a problem. If not, then a type III response is recorded, otherwise a type IV or V response is recorded, depending on the criticality of the problem. Type V responses can be seen as the strongest form of support for a proposition. In this manner, all responses can easily be classified.

The classification scheme for construct deficit is modified slightly in order to be also comprehensive for categorizing responses about construct redundancy, excess and overload. As an example, the modified classification scheme for construct excess is shown on the right in Figure 1. As construct excess proposes that these additional constructs have no real-world meaning and are not required for modelling, our response classification scheme seeks to capture whether modellers are aware of such a construct (type I); if so, whether they understand its meaning (type II); if so, whether they use this construct for modelling (type III); and if so, then whether they perceive it as an essential part of their modelling activities (types IV and V).

With use of the classification schemes, we are able to summarize the responses in Table 2 where, for each proposition, the number of interviewee responses is given that match a particular response type. Note here that propositions related to construct excess involve a number of constructs (twelve in the case of BPMN); hence, for overview purposes Table 2 gives the average of responses across all identified excess constructs. All responses were grouped into two categories of BPMN modellers: core set users and users who use an extended or complete set of constructs from the specification. In the next subsections, we will discuss in more detail the findings of our empirical investigation.

Deficiency type	*Proposition*	*Participant category (total #)*	*Response type*				
			I	*II*	*III*	*IV*	*V*
Construct deficit	1	Core set users (6)	3	1	1	1	0
		Extended set users (13)	4	2	4	3	0
		Total (19)	7	3	5	4	0
	2	Core set users (6)	5	0	1	0	0
		Extended set users (13)	7	1	4	1	0

		Total (19)	12	1	5	1	0
	3	Core set users (6)	3	0	2	1	0
		Extended set users (13)	4	7	1	0	1
		Total (19)	7	7	3	1	1
Construct redundancy	4	Core set users (6)	2	2	1	0	1
		Extended set users (13)	2	6	4	1	0
		Total (19)	4	8	5	1	1
	5	Core set users (6)	0	5	0	0	1
		Extended set users (13)	0	8	5	0	0
		Total (19)	0	13	5	0	1
	6	Core set users (6)	0	3	1	2	0
		Extended set users (13)	0	11	0	1	1
		Total (19)	0	14	1	3	1
Construct excess (average)	7	Core set users (6)	2.17	0.50	3.83	0.67	4.83
		Extended set users (13)	0.54	0.62	1.85	2.00	7.00
		Total (19)	1.05	0.58	2.47	1.58	6.32
Construct overload	8	Core set users (6)	1	2	3	0	0
		Extended set users (13)	0	6	6	1	0
		Total (19)	1	8	9	1	0
	9	Core set users (6)	4	1	1	0	0
		Extended set users (13)	1	4	4	4	0
		Total (19)	5	5	5	4	0

Table 2. Summary: Responses to proposed deficiencies, by modeller category

4.2 Propositions related to construct deficit

Proposition P1 has moderate support based on participants' comments. Questioning about the need for modelling business rules uncovered that 37% of participants had no need for representing business rules. Some of the reasons given for this were that their BPDs are intended for business people who may not have the experience to read more complicated diagrams, and that the organization wanted to start with simpler diagrams in order to facilitate process understanding. Of the participants who indicated the need for business rule depiction, 75% stated they could not directly model business rules in BPMN. This represents 42% of participants who found workarounds and therefore do not consider this aspect to be a shortcoming, and 33% of participants who consider this inability to directly model business rules to be a minor problem. Some of the workarounds used included narrative descriptions of rules and conditions, using spreadsheets and external tables, and using additional tools that allow users to create hyperlinks to documents, meta-tags and attribute fields.

Proposition P2 has limited overall support. Over 63% of participants have no need to model the history of state changes. Some indicated that there is a need for such modelling but that it has not yet been done in their organization or that they have not yet figured out how to do this. Others commented that such modelling is not required at the higher level and would be more likely to be required for software design. Of the participants that indicated a need for modelling the history of state changes, over 71% indicated that while they had no way of modelling this directly, it did not prove to be a problem. Some workarounds involved simply having multiple activities on the diagram with names that implied state changes of things.

Representing the structure of systems was expected to be one of the weaknesses of BPMN as there is no specific representation for *system structure,* as per the BWW model. Proposition P3 has only insignificant support. Of the nineteen participants, almost 37% indicated no need for capturing system structure. Of the remaining twelve participants, 58% indicated that they are able to model system structure with BPMN directly with the use of pools, lanes, and start/end events. One participant classified the lack of direct modelling capabilities as a minor problem, with another participant classifying it as a major problem.

4.3 Propositions related to construct redundancy

Limited support was found to exist for proposition P4. Results indicated that only 21% of participants had no limitations in modelling things with BPMN, with a further 42% stating that they could directly model the concept. However, notably, over 35% of participants indicated that they had no way to model directly *things* with BPMN. While 71% indicated that this was not a problem, mainly due to the use of tools, one participant each classified it as a major and minor problem, respectively. Some of the more experienced participants who indicated the issue not to be a problem admitted that it would indeed be a problem if they did not have additional tools into which BPMN was incorporated in their organization, *i.e.*, if they were using BPMN in isolation.

Proposition P5 was found to have insignificant support. Over 68% of participants indicated their ability to directly model transformations with no confusion. Of the remaining 32% of participants that could not, only one participant classified this to be a major problem. Interestingly, this participant was a user of the core set of constructs and was the only user in that category to indicate any inability to directly model transformations without confusion. It is also interesting to note that all of the remaining five participants that indicated an inability to directly model transformations without confusion (but did not classify it as a problem) are users of the extended set of BPMN constructs. Some of the workarounds that were used were colour coding of activity symbols to allow differentiation of automated and manual tasks. Also, methodologies and guidelines for process modelling were in place and these included templates, which would reduce any confusion over which BPMN construct to use. One would expect that without these additions the problem would manifest itself more severely.

Very insignificant apparent support was found for proposition P6, with 74% of the interviewees stating that they did not experience any limitations in using BPMN for the modelling of events. In fact, some interviewees stated that the event specializations provided in the specification comprehensively and rigorously allow for the depiction of different events that may impact business operations:

> *"[…] and that's where BPMN is really good, you know, all the options you can think of, no one's said, we could really need another type. You know, you've got the timer event and then you've got a message arriving, all sorts of things."* (interview transcription data)

However, out of the 26% of responses indicating that they are limited in capturing events, 80% categorized this limitation as a problem (minor or major). Our empirical data furthermore suggests that modellers using the core set without event specializations encounter more difficulty in capturing business events. Only 50% of core set users stated that they have no limitations in modelling events, and 67% out of the remaining interviewees classified this issue as a (minor) problem. This finding is contradictory to our theoretical proposition, which predicts that confusion would arise when using the full specification set. Core set users often responded that the limited set of constructs is not explicit enough and needs to be extended to capture comprehensively different events. Other interviewees stated that the usage of the core set forced them to complement their BPMN diagrams with additional documents further refining the events sketched in the model. While this was not perceived to be a major problem due to this workaround, responses nevertheless indicated that the event specializations in BPMN are perceived as a helpful feature.

4.4 Propositions related to construct excess

We predicted in proposition P7 that users would avoid some BPMN constructs in order to limit confusion when interpreting the model. For this proposition, we found varying apparent support. The constructs Off-page connector, Group, and Multiple Instances were classified by over 50% as being 'not in use' (63%, 58%, 63%, respectively). Some of the other proposed excess constructs were rated as essential for process modelling activities (see Table 3). Examples include the constructs Normal flow, Event and Link. The responses indicate that while some constructs (such as Link) may have no real-world semantics, they are nonetheless perceived as important for process modelling as they allow for better demarcation and linking of large-scale process models. The same holds, for instance, for

Text Annotation and Association Flow. From a representational viewpoint, such constructs may be regarded as 'support constructs' that may be helpful for the act of modelling but have no real-world meaning per se. However, in modelling practice, they seem to be very useful for complementing the graphical models with extra information, for instance additional textual descriptions.

Excess construct	Normal Flow	Event (supertype)	Link	Data Object	Association Flow	Text Annotation	Gateway (supertype)	Activity Looping	Off-page connector	Gateway (subtypes)	Multiple Instances	Group
Essential (%)	100	84	79	53	53	53	47	42	37	37	26	21

Table 3. Proposed excess constructs perceived as essential for process modelling

The data obtained does not significantly vary between the two categories of modellers. Amongst core set users, as expected, the extra constructs that are only included in the full specification were mostly rated as being 'not in use'. Also, as expected, support constructs such as Text Annotations were more often perceived as essential (67%) than amongst extended set users (46%). Interestingly, extended set users – although able to use specialized gateway types for modelling decisions and business rules – still rated the unspecialized Gateway supertype construct as more essential than its differentiated subset (62% versus 15%, respectively).

4.5 Propositions related to construct overload

The interview responses clearly indicate ambiguities in the specification of the BPMN Lane and Pool constructs (propositions P8 and P9). While 5% and 26% of the interviewees stated they do not use the Lane and the Pool construct respectively, only 44% and 36% of the interviewed practitioners who make use of Lane and Pool constructs respectively apply them for a single, specified purpose. 56% and 64%, respectively, used these constructs for two or more distinct purposes, with 29% of the interviewees using the Pool construct even for three distinct purposes. The types of purposes used for the Lane construct included, *inter alia*, roles (used by 61% of interviewees), organizational units and business areas (39%), scoping (22%) and grouping (17%). In terms of the Pool construct, purposes included external organizational units and business areas (64%), internal organization (50%), scoping (29%), and grouping (21%).

In summary, in terms of construct overload, our empirical investigation identified apparent support for propositions P8 and P9. Breaking down the responses into the two mentioned categories of modellers reveals that core set users seem to be clearer in their usage of the Pool construct as 50% of the practitioners using the construct (33% overall) apply a single, specified meaning to it, while 67% of extended set users have two or more distinct meanings for the Pool construct. In fact, one interviewee, when asked about the usage of the Pool construct, responded that it was a nice concept but difficult to grasp and the reason they did not use it was to keep the models simple and understandable. In terms of the usage of the Lane construct, the two modeller categories (core and extended set) do not differ much as 40% and 46%, respectively, of the interviewees using a Lane apply a single meaning to it.

5 DISCUSSION & CONCLUSION

This is the first comprehensive analysis of BPMN that incorporates both a theoretical model for evaluation and empirical research to gain insights on the resultant propositions. Our theoretical model predicted nine different propositions regarding limits and shortcomings of BPMN. Our empirical investigation, however, revealed that not all the theoretical predictions will constitute critical problems in process modelling practice (see Table 4).

Not all of our propositions demonstrated apparent support. However, several of the interviewees commented that at this stage of their modelling experience they could only see minor consequences of the weakness for practical use, that is, “a nice feature to have”. It is also important to note that all of the respondents use BPMN in conjunction with other tools (such as System Architect for example) and rely on those tools to supplement their BPMN models, for instance through the annotation of model elements via meta-tags or other attribute fields. The moderating effect of tool support on the perceived criticality of identified representational deficiency aligns with previous studies (Davies & Rosemann & Green 2004, Green & Rosemann 2000), which identified the characteristics of the person who uses the process modelling technique (e.g., self-efficacy) and the purpose of process modelling (*e.g.*, for workflow engineering or compliance management) as primary contextual factors.

Level of support	No or insignificant support	Limited support	Apparent support
Proposition	P3, P5, P6, P7 (6 of 12)	P2, P4, P7 (4 of 12)	P1, P7 (2 of 12), P8, P9

Table 4. Summary of results

Our findings also indicate that the matter of core set versus extended set of BPMN constructs seems to be a factor impacting the suitability of BPMN for different purposes. For example, while interviewees from a managerial background pointed out that the use of the core set would be very effective in creating concise models that are easily understood by business people, some interviewees with an IT background repeatedly demanded more symbols with extended expressiveness to add sufficient rigor for making their models fit for use in software implementation projects. In conclusion, it may be advisable to develop appropriate guidelines and filters that specify the set of BPMN constructs to be used dependant on a given modelling purpose.

While this research provides valuable insights into both theoretical capabilities of BPMN and its actual perceived shortcomings, it has limitations. First, the selection of the BWW model forms a specific filter on our analysis. In the first step of our theoretical analysis, we only identified issues in light of this model. While a focus on representational capabilities has been found to be useful in studies on modelling techniques (Green & Rosemann 2004), without any doubt, further criteria such as BPMN’s perceived understandability, have to be considered for a more comprehensive analysis of BPMN. Second, all our interview participants are based in Australia. However, while we lack evidence for it, we do not see any indications that our findings could not be extended beyond the limited regional scope.

In our *future research*, we intend to work in the following three areas. First, we will extend the empirical base of our analysis by converting our semi-structured interview protocol into a web survey instrument to facilitate the collection of global evidence for our propositions. Second, we have been discussing our findings with the developers of BPMN in order to get a better understanding of the extent to which the design paradigms behind BPMN can explain the confirmed shortcomings. Third, we want to provide recommendations for revisions and extensions of the current BPMN specification as well as methodical guidance for the use of BPMN in modelling initiatives, both of which can help to overcome the identified issues.

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