Business Process Modeling with Levels of Abstraction

A Survey of Practitioners with Experience

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***Abstract*—The success of a software project depends on the quality of the software requirements specifications. Business process models are frequently used for eliciting software requirements; therefore, it is critical to produce high-quality business process models. To achieve this, the use of multiple levels of abstraction has been suggested in the literature as a modeling strategy. This paper presents the findings from a survey of experienced practitioners in order to test a set of propositions to address some of the issues with this strategy. The findings show, among other things, that practitioners need to represent business processes at the strategic, tactical and operational levels of abstraction. The survey findings also provide useful insights for selecting a business process modeling notation.**

Business process model; software requirements; survey; empirical research; BPMN; Qualigram; levels of abstraction

I. INTRODUCTION

The success of a software development project is highly dependent on the quality of the software requirements specifications (SRS). Producing high-quality SRS demands the active interaction of all stakeholders involved with the software development team [1]. For representing and communicating software requirements expressed by different groups of stakeholders, conceptual modeling is considered a valid approach [1], and business process modeling (BPM) is one of the popular techniques for performing conceptual modeling [2]. Therefore, if a business process model is meant to be used as part of the SRS it must: 1) be generated after taking into consideration the needs and constraints expressed by the various stakeholders; 2) represent, in a consistent way, those needs and constraints; 3) easily communicate the requirements to the various stakeholders; 4) be shared among the various stakeholders; and 5) be rigorous enough to be used as a source of information by the software development team.

The use of multiple levels of abstraction has been proposed as a strategy to facilitate the participation of various groups of stakeholders in a BPM initiative [3]. A novel BPM approach based on an abstraction hierarchy that includes three levels of abstraction, strategic, tactical, and operational, has been proposed in [4,5] and it will be referred to here as BPM$^+$. These levels of abstraction correspond to the typical classification of managerial activities within an organization (i.e. the organizational pyramid). Each managerial activity has, according to its hierarchical level, enough particular properties to require a particular detail of information such as:

- The strategic level covers all activities related to the goals and policies of the organization.
- The tactical level activities deal with the attainment and efficient use of the resources of the organization.
- The operational level activities procure the efficient and effective execution of specific tasks.

Therefore, at the top level (i.e. strategic level) BPM$^+$ models a high-view of the core processes and their main relationships. It also represents the external stakeholders who are relevant to the organization, thereby answering the question "why". The intermediate level (i.e. tactical level) models the flow of activities of the business processes (i.e. the procedures), depicting how the various roles and departments within the organization interact, and answering the "who" and "what" questions. Finally, the lowest level (i.e. operational level) models the work instructions according to the specific needs of each stakeholder, answering the question "how". These concepts are illustrated in Fig. 1.

The strategic and tactical levels of abstraction of BPM$^+$ have been tested in a case study conducted at a small Canadian software development company [5]. This pilot case study produced some results that require further validation through additional empirical research. The survey reported here has been designed for finding additional evidence to support the

Figure 1. Hierarchy of levels of abstraction

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results of the pilot case study.

The structure of this paper is as follows. Section 2 presents an overview of the pilot case study where the strategic and tactical levels of abstraction of BPM$^+$ were previously studied by Monsalve, April and Abran. Section 3 presents the research design of the survey. Section 4 presents the data collected and its analysis. Finally, section 5 concludes with a review of the contributions of this research, its limitations, and future work.

II. Overview of the Pilot Case Study

A. Description of the Case Study

A pilot case study was conducted at a small Canadian software development company to test the strategic and tactical levels of abstraction of BPM$^+$. The case study followed an action research methodology [6], that is, members of the research team collaborated in the BPM initiative together with the members of the participating company.

The company was willing to model the business processes supported or affected by one of its software products in order to: 1) document the business processes; 2) show customers how the software product interacts with the various end-users and business processes of a customer organization; and 3) communicate the functional characteristics of the software product to their new employees.

The case study required the participation of members of the research team together with two members of the company for a period of 4 months. The members of the research team who participated in the BPM initiative had knowledge of the BPM notations and methodology used in the case study.

Regarding the members of the participant company, one was its owner and top-executive; his participation was complemented by a member of the technical staff who supports the development of the software product. These two members had no previous experience with BPM nor did they have knowledge of the BPM notations used in this case study. BPM$^+$ was applied to three business processes selected by agreement with the participant company at the beginning of the project: procurement, sales at the counter, and sales by contract.

The choice of the right modeling notation has been identified as one of the key factors for generating high-quality business process models [7]. The case study evaluated the use of two BPM notations available: the Business Process Model and Notation (BPMN) [8] and Qualigram [9]. BPMN was selected because: 1) it is growing in popularity; 2) it is considered as a standard by the Object Management Group (OMG); and 3) it is considered as the most complete of all the graphical BPM notations studied over the years [10]. However, evidence shows that management stakeholders value simplicity in a BPM notation [5] and BPMN is considered as a highly complex BPM notation [11]. To take this into account and address this concern, the management-oriented notation of Qualigram was also selected. Qualigram notation provides other characteristics: 1) its modeling tool is based on Microsoft's Visio; 2) it is based on the ISO 9000 family of standards (i.e. quality management) [9]; and 3) it is simple.

B. Findings from the Pilot Case Study

The hierarchy of levels of abstraction proposed by BPM$^+$ was well accepted by the members of the participant company:

1) The *strategic level of abstraction* was found useful for communicating the business processes to customers and new employees of the participant company.

2) The *tactical level of abstraction* was found useful for delivering the details of the business processes to both the technical staff responsible for the maintenance of the software product, and the persons responsible for executing the business processes within a customer organization.

Two of the types of models offered by Qualigram at the strategic level were found useful, that is, the macroscopic type of model, and the detailed type of model [9]:

- The macroscopic type of model was found useful because it allows to: 1) represent the customers and providers of an organization; 2) identify the core business processes of an organization; and 3) structure the business processes in a meaningful way.
- The detailed type of model was found useful because it allows to: 1) represent each business process at a high-level; 2) depict the interactions between the customers, the providers and the business processes; 3) position each business process in relation to its own context; and 4) bind the strategic and tactical levels of abstraction.

From the two assessed BPM notations, only Qualigram allows for representing the business processes at the strategic level of abstraction. In addition, the participants found Qualigram's notation easier to be understood than BPMN's notation. However, they found that the models generated with BPMN were more detailed and rigorous than those generated with Qualigram. Moreover, the participants found Qualigram models useful for introducing the business processes to customers, management staff, and new employees; while BPMN models were found useful as a source of information for the software development team.

III. Research Design

Based on the findings of the pilot case study reported in the previous section, a set of five propositions is formulated:

P1: Modeling business processes at the strategic, tactical and operational levels of abstraction contributes to generating consistent business process models that can be shared by the various groups of stakeholders.

P2: A business process model at the strategic level of abstraction eases the communication to customers, non-IT employees, and new employees involved in the business processes represented.

P3: The macroscopic and detailed types of models are the most useful types of models from the four types of models offered by Qualigram at the strategic level of abstraction.

P4: Qualigram notation is preferred over BPMN notation by practitioners to model business processes when the

target user is a customer, a non-IT employee, a new employee, or a management-oriented stakeholder.

P5: BPMN notation is preferred over Qualigram notation by practitioners to model business processes when the target user is an IT-oriented stakeholder or a business analyst.

Such propositions must be empirically tested. Feasible and empirical research methods needed to be identified for all of them. After analyzing the feasible research methods, one research method and corresponding participant's profile was defined: a survey with practitioners with experience in BPM and Software Requirements Elicitation (SRE).

To increase the validity of the results, the survey was designed and conducted following many of the principles recommended by Kitchenham and Pfleeger [12] and by Salant and Dillman [13]. Based on these recommendations, a protocol was elaborated and is described below.

The design objective of this survey was to test all five propositions. The practitioners might be software engineers, business analysts, or professionals from related backgrounds. It would also be desirable that practitioners have knowledge or experience with BPMN.

A questionnaire was designed based on the structure proposed by Davies et al. [14] (see Fig. 2). The structure of this questionnaire has been used and validated by several previous studies conducted by other authors [14,17,18]. The questionnaire was pre-tested three times with the help of IT professionals with more than five years of experience in software development projects. The pre-tests were planned to: 1) improve the quality of the questions; and 2) ensure an appropriate timeframe for answering the questionnaire. All the questions were of the closed type to facilitate their answering and coding. A copy of the questionnaire can be found in https://www.dropbox.com/s/v41xj5i5vq9mzuq/questionnaire.pdf?dl=0.

The survey was administered to the participants following a semi-supervised format, that is, it was conducted as a workshop within the framework of the 2nd International Symposium in Software Engineering Management held in Montreal, Canada. A member of the research team introduced the motivation and objectives of the survey, and was available on site to answer any questions from the participants. The participants were volunteers and had the opportunity to withdraw from the survey at any time.

Given that the target audience is very specialized, the true population is difficult to determine. Therefore, a non-probabilistic sample (i.e. purposive sampling) was chosen for this survey [12,13]. To ensure a representative number of participants, personal invitations to participate in this survey were sent to members of the Montreal chapter of the International Institute of Business Analysis (IIBA) and to the members of the social network of Montreal Business Analysts, in addition to the regular promotion channels used by the international symposium.

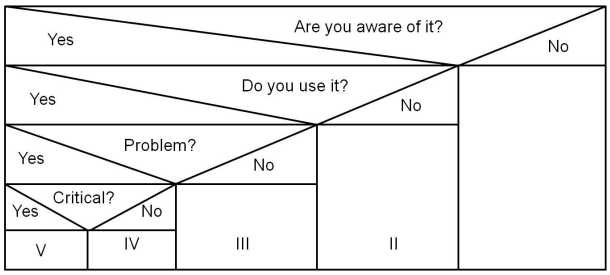


Figure 2. Questionnaire structure and severity levels (based on [14])

Nineteen participants were present at the beginning of the survey workshop; seventeen of them finished the activity and returned their answers. Similar studies have previously been conducted by other authors [14-18] with groups varying from 4 to 21 participants (refer to Table I).

IV. DATA ANALYSIS

The three major variables that define the demographics of the set of participants are: 1) their profession or job function; 2) their years of experience in BPM; and 3) their years of experience in SRE.

Fig. 3 depicts the distribution of the participants according to the first two variables. It can be noticed that over half of the participants (53%) have more than 2 years experience in BPM.

Regarding the profession or job function, 6 out of 17 have been classified under "other" of whom:

- three indicated to perform several professions, even though the question explicitly asked to choose the answer that best describes their profession or job function;
- one is a Ph.D. researcher, and
- the other two indicated they were a measurement consultant and a process improvement specialist respectively.

Fig. 4 depicts the distribution of the participants according to their profession or job function and the years of experience in SRE. It can be noted that almost 50% of the participants have more than 6 years of experience in SRE.

Regarding the use of levels of abstraction in BPM,

TABLE I. PREVIOUS EMPIRICAL RESEARCH WORK.

Reference	Green 2001[15]	Green 2002 [16]	Davies 2004 [14]	Recker 2005 [17]	Recker 2006 [18]
Method-Instrument	Pilot survey	Pilot survey & Structured interview	Interview	Semi-structured interview	Semi-structured interview
Target Population	16 graduate students	12 graduate students (pilot) & 4 practitioners from 2 organizations (interview)	21 modelers from 8 organizations	11 participants with different levels of experience from 6 organizations	19 participants with different levels of experience from 3 organizations

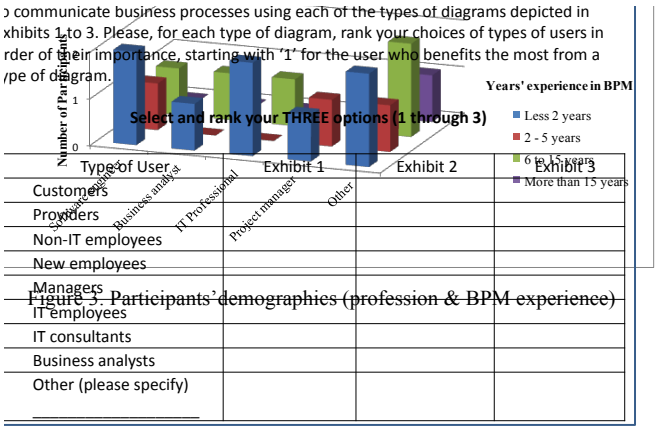


Figure 3. Participants' demographics (profession & BPM experience)

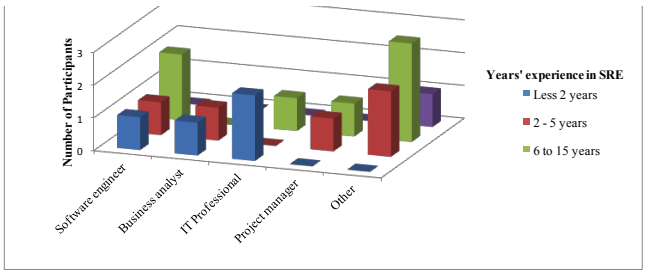


Figure 4. Participants' demographics (profession & SRE experience)

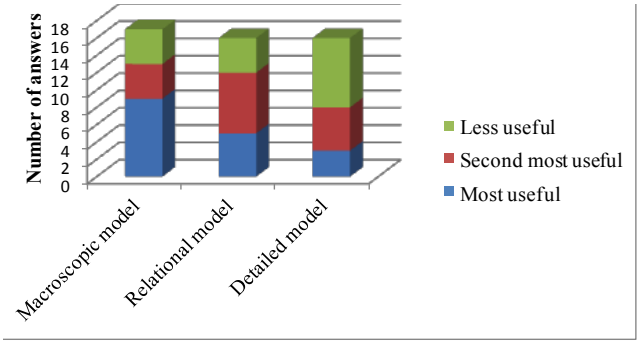
Figure 5. Survey question for proposition P2.

participants were required to answer a dichotomous question (i.e. yes or no question): "When modeling business processes, do you need to represent the business processes at the strategic, tactical and operational levels of abstraction?". Participants whose response was affirmative were required to answer an additional multiple response question: "In your experience, which are the most important benefits for modeling business processes at different levels of abstraction? (Circle as many as necessary)". 82% of the participants answered the first question affirmatively. From these participants, 65% identify "to be able to represent a general view of a business process, in addition to a detailed view of it" as a benefit of modeling at different levels of abstraction. The next two most common benefits are: a) "to ease the sharing of the business process between various stakeholders" (53%) and b) "to be able to represent in a consistent and structured way the decomposition of a business process" (41%). These findings support **proposition P1**.

Regarding proposition P2, participants were provided with three exhibits, each depicting a business process model at a different level of abstraction: Exhibit 1 represented the business process at a higher level of abstraction, Exhibit 2 at a medium level of abstraction and Exhibit 3 at a lower level of abstraction. Based on those exhibits, participants were required to answer the question presented in Fig. 5. Participants identified that customers, non-IT employees, new employees, and managers are the types of stakeholders who benefit the most from modeling at a higher level to communicate business processes. In addition, a Pearson Chi-square test of independence was performed to examine whether a relationship exists between the various types of stakeholders and the importance of modeling at a higher level of abstraction. The types of stakeholders were classified in two groups: Group A (i.e. customers, non-IT employees, new employees and managers) and Group B (i.e. providers, IT employees, IT consultants and business analysts). Each cell in Table II corresponds to the sum of frequencies of a given rank of importance (i.e. High = 3; Medium = 2; and Low = 1) of modeling at the higher level for each of the types of stakeholders included in a given group. The null hypothesis is that the two groups of stakeholders and the importance of modeling at the higher level of abstraction are statistically independent. As the p-value of the Pearson Chi-square is below the 0.01 level (p=2.57x10^{-6}), statistical evidence was found to confirm that a relation exists between the groups of stakeholders and the importance of modeling at this level of abstraction. These findings support **proposition P2.**

Fig. 6 depicts the preferences regarding the usefulness of the various types of business process models that Qualigram notation allows to represent at the strategic level. The macroscopic (56%) and the relational (29%) types of models are considered the most useful. We decided not to perform a Pearson Chi-square test of independence to further examine these results because some of the participants' preferences showed frequencies lower than five, which violate the acceptability requirements for this statistical technique. However, our survey also included dichotomous questions that asked the participants to answer if in their experience, they needed all the possible types of models at the strategic level of abstraction to represent a business process. The macroscopic and the relational types of models presented the highest frequencies of need: 88% and 59% respectively. Therefore, these results concur with the results depicted in Fig. 6. These findings partially support **proposition P3**, which proposes the macroscopic and detailed types of models as the most useful.

Participants were provided with two more exhibits in order to test propositions P4 and P5. Both exhibits represented the



gure 6. Usefulness of Qualigram's types of models at the strategic level of abstraction

same business process using different BPM notations: Exhibit 4 used Qualigram notation, and Exhibit 5 used BPMN notation. Based on these exhibits, participants were required to answer the question "In your experience, which of the two modeling notations should be the most appropriate to communicate business processes to the following types of users in your organization?" and selecting one of the two exhibits for each of the types of stakeholders that were presented in a list.

More than 59% of the participants prefer Qualigram notation to BPMN notation in order to communicate business processes to the following types of stakeholders: customers, providers, non-IT employees, new employees, managers, and project managers. In addition, if we consider that participants had the option to select "Any of the two" BPM notations as their preference, and if we add the frequencies of "Any of the two" to the Qualigram frequencies of preference, then we can add the administrative employees to the group of stakeholders to whom over 59% of the participants prefer Qualigram notation to communicate business processes. That is, this group of stakeholders includes: customers, providers, non-IT employees, new employees, managers, administrative employees and project managers. If we name this group of stakeholders Group A, and we group the rest of stakeholders (i.e. IT-oriented employees, IT consultants, business consultants, business analysts and quality assurance managers) as Group B, we can perform the Pearson Chi-square test of independence. By doing so, we can determine whether a relationship exists between these two groups of stakeholders and the preference of BPM notation (Qualigram vs. BPMN). The null hypothesis is that these two groups of stakeholders and the preference of BPM notation are statistically independent. As the p-value (p=0.0229) of the Pearson Chi-square is below the 0.05 level, statistical evidence was found to confirm that a relation exists between the two groups of stakeholders and the preference of BPM notation (see Table III). Therefore, it is possible to conclude that Qualigram notation is preferred over BPMN notation to communicate business processes to the types of stakeholders that belong to Group A. These findings support **proposition P4**.

On the other hand, there is no clear preference for the use of BPMN notation when modeling business processes for the types of stakeholders included in proposition P5 (see Fig. 7). According to the participants, BPMN notation presents an advantage over Qualigram notation when the target users are IT-employees (57%) or IT-consultants (52%). However, 57% of the participants perceive an advantage with Qualigram notation over BPMN notation when the target users are business analysts or business consultants. These findings provide partial support for **proposition P5**, which proposed the preference of BPMN by IT-oriented stakeholders and by business analysts.

Finally, from the five propositions originally formulated to guide this empirical research, three have been supported by the results of the survey, and two have been partially supported. Table IV summarizes these results.

V. Contributions, Future Work, and Threats

The results confirm that modeling business processes at the strategic, tactical and operational levels of abstraction contributes to the generation of consistent business process models that can be shared by various groups of stakeholders. The strategic level of abstraction is particularly useful for communicating business processes to non-IT stakeholders and new employees. Moreover, practitioners perceive that for these types of stakeholders, it is better to represent a business process using Qualigram notation.

The findings from this survey have also confirmed that practitioners perceive as very useful the macroscopic type of model offered by Qualigram notation at the strategic level of abstraction. The macroscopic type of model offers a general view of the core business processes of the organization and allows for identifying the main external stakeholders that interact with those core business processes.

Regarding practitioners' preference of BPM notations,

TABLE IV. SUMMARY OF SURVEY RESULTS

	Propositions	Observations
Supported	P1, P2, P4	
Partially Supported	P3, P5	Detailed type of model was not found as useful as the relational type of model. BPMN presents only a slight advantage over Qualigram for IT-oriented stakeholders. Qualigram is preferred for business analysts.

further empirical research should be conducted to study the preference of BPMN notation over Qualigram notation when the target users are business analysts. The pilot case study revealed that BPMN presents an advantage over Qualigram when communicating business processes to business analysts; however, the survey results show a preference of Qualigram over BPMN.

A discussion of the validity threats of this research follows. To increase construct validity, the questionnaire design followed well accepted guidelines found in the literature [12,13], and used a structure (refer to Fig. 2) that has been already validated in similar studies. The formulation of the questions was based on the propositions to be tested. Moreover, the questionnaire was pre-tested and discussed three times with professionals that fit the target-audience profile.

Regarding internal validity, a great effort was made to ensure participants had experience both in BPM and SRE, although they did not have the same levels of experience (Figs. 3 and 4). The Ph.D. researcher who participated in the survey might be acceptable as a proxy participant since he presents a similar profile to the target professionals. In future work, the data collected will allow for analyzing the impact of the participants' demographics on the variations of their answers. In addition, since the survey was semi-supervised, participants could ask for clarification, obtaining more accurate responses.

Regarding external validity, the main threat is the sample size used in this research. The sample size of this survey is similar to the sample size of previous studies (refer to Table I). However, the results are strengthened in terms of generalization by the fact that the propositions being tested were derived from previous theoretical and empirical research work; that is, for the propositions that have been supported, the results of the survey converge with the results of our previous work. In this sense, a new case study is being conducted in order to further validate the results of this survey.

Finally, to increase reliability a survey protocol was elaborated, the questionnaire was retested with one of the professionals who volunteered for the pre-tests, and closed questions were preferred to reduce the bias of the researcher when coding the responses.

REFERENCES

[1] A. Abran, J. Moore, P. Bourque, and R. Dupuis, SWEBOK: Guide to the Software Engineering Body of Knowledge 2004 Version. Los Alamitos, California: IEEE Computer Society, 2004.

[2] I. Davies, P. Green, M. Rosemann, M. Indulska, and S. Gallo, "How do practitioners use conceptual modeling in practice?," Data & Knowledge Engineering, vol. 58, pp. 358-380, 2006.

[3] C. Monsalve, A. April, and A. Abran, "BPM and requirements elicitation at multiple levels of abstraction: a review," in IADIS International Conference Information Systems 2011. Avila, Spain: International Association for Development of the Information Society, 2011, pp. 237-242.

[4] C. Monsalve, A. April, and A. Abran, "Representing unique stakeholder perspectives in BPM notations," in 8th ACIS International Conference on Software Engineering Research, Management and Applications, SERA 2010. Montreal: IEEE Computer Society, 2010, pp. 42-49.

[5] C. Monsalve, A. April, and A. Abran, "Requirements elicitation using BPM notations: focusing on the strategic level representation," in 10th WSEAS International Conference on Applied Computer and Applied Computational Science (ACACOS '11). Venice, Italy: WSEAS Press, 2011, pp. 235-241.

[6] R. Davison, M. Martinsons, and N. Kock, "Principles of canonical action research," Information Systems Journal, vol. 14, pp. 65-86, 2004.

[7] W. Sedera, G. Gable, M. Rosemann, and R. Smyth, "A success model for business process modeling: findings from a multiple case study," in 8th Pacific Asia Conference on Information Systems, PACIS 2004. Shanghai, China, 2004.

[8] OMG, "OMG Business Process Model and Notation (BPMN), version 1.2," Object Management Group, 2009.

[9] C. Berger and S. Guillard, La rédaction graphique des procédures : démarche et techniques de description des processus. Paris: Association Française de Normalisation, AFNOR, 2000.

[10] M. Rosemann, P. Green, M. Indulska, and J. C. Recker, "Using ontology for the representational analysis of process modelling techniques," International Journal of Business Process Integration and Management, vol. 4, pp. 251-265, 2009.

[11] J. Recker, M. Rosemann, M. Indulska, and P. Green, "Business process modeling: a comparative analysis," Journal of the Association for Information Systems, vol. 10, pp. 333-363, 2009.

[12] B. A. Kitchenham and S. L. Pfleeger, "Personal opinion surveys," in Guide to Advanced Empirical Software Engineering, F. Shull, J. Singer, and D. I. K. Sjoberg, Eds.: Springer London, 2008, pp. 63-92.

[13] P. Salant and D. A. Dillman, How to conduct your own survey. New York: John Wiley & Sons Inc, 1994.

[14] I. G. Davies, M. Rosemann, and P. Green, "Exploring proposed ontological issues of ARIS with different categories of modellers," in Australasian Conference on Information Systems, (ACIS 2004). Hobart, 2004.

[15] P. Green, M. Rosemann, and A. Ipswich, "Ontological analysis of integrated process models: testing hypotheses," AJIS, vol. 9, 2001.

[16] P. F. Green and M. Rosemann, "Perceived ontological weaknesses of process modeling techniques: further evidence," in 10th European Conference on Information Systems: Information Systems and the Future of the Digital Economy, ECIS 2002, S. Wrycza, Ed. Gdansk, Poland: University of Gadalsk, 2002, pp. 312-320.

[17] J. Recker, M. Indulska, M. Rosemann, and P. Green, "Do process modelling techniques get better? A comparative ontological analysis of BPMN," in 16th Australasian Conference on Information Systems. Sydney, Australia: Australasian Chapter of the Association for Information Systems 2005.

[18] J. Recker, M. Indulska, M. Rosemann, and P. Green, "How good is BPMN really? Insights from theory and practice," in 14th European Conference on Information Systems: ECIS' 06. vol. 14. Goeteborg, Sweden: IT University of Gotteborg, 2006.