A Systematic Mapping on Empirical Studies Concerning the Maintenance of BPMN Diagrams

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Abstract: Business process models help understand the organizational process and the software that supports it. BPMN (Business Process Modeling and Notation) is the standard notation for business process modeling, with wide acceptance in the industry. BPMN models can elucidate the activities carried out by the software during its construction and maintenance. However, during the maintenance of the software that supports the organizational process, usually only the source code of the software undergoes modifications, to insert new features. The software design models, including the BPMN models, often become outdated over time and, in future maintenance, they will not help understand the business process in which the software is inserted and which the software aims to support. Such scenario highlights the importance of supporting the maintenance of BPMN models. However, what has been experimentally investigated on the maintenance of BPMN models? To answer this question, we performed a systematic mapping, which showed experimental studies, factors and technologies that influence the maintenance of BPMN models. These results present conclusions about the state of the art and gaps that can be explored in this field of research.

Keywords: Business Process Model and Notation; BPMN; Software Maintenance; Model Maintenance; Systematic mapping.

1. Review Protocol

1.1. Goal

We further defined the goal of the systematic mapping according to the Basili GQM *(Goal-Questrion-Metric)* Paradigm (Basili e Rombach, 1988), according to Table 1.

Table 1 - Goal of the research according to the GQM Paradigm (BASILI e ROMBACH, 1988).

Analyze	Scientific publications, through a systematic mapping.
For the purpose of	Characterization
With respect to	Experimental Evidence on BPMN Model Maintenance
From the point of view of	Researcher
In the following context	Software development

1.2. Scope of Research

This section describes the search strategy used: the language, the terms used, and the search string.

1.2.1. Language of the papers

We select English and Portuguese languages. We chose English because it is a universal language and adopted by the great majority of international conferences and periodicals. We select Portuguese as our native language and because it is the language used in national conferences, such as those promoted by the Brazilian Computer Society (SBC)

1.2.2. Terms used in search

Table 2 lists the terms and their synonyms we use for the search terms. We used the synonyms of the intervention presented in the systematic mapping of Fernández-Sáez et al. (2013).

Table 2 - Synonym group used for search terms

POPULATION		
BPMN	Business Process Model and Notation	Business Process Modeling and Notation

INTERVENTION		
Maintenance	Evolution	Comprehension
Maintainability	Evolvability	Understandability
Modularity	Modification	Understanding
Reusability	Stability	Misinterpretation
Analyzability	Testability	
Changeability	Comprehensibility	

RESULTS		
Empirical	Survey	Action Research
Experiment	Case Study	

Next, Table 3 presents the search string that we used in the digital libraries Scopus, ACM and Engineering Village.

Table 3– Search string.

(BPMN ***OR*** *"Business Process Model and Notation"* ***OR*** *"Business Process Modeling and Notation")*
AND
(Maintenance ***OR*** *Maintainability* ***OR*** *Modularity* ***OR*** *Reusability* ***OR*** *Analyzability* ***OR*** *Changeability* ***OR*** *Evolution* ***OR*** *Evolvability* ***OR*** *Modification* ***OR*** *Stability* ***OR*** *Testability* ***OR*** *Comprehensibility* ***OR*** *Comprehension* ***OR*** *Understandability* ***OR*** *Understanding* ***OR*** *Misinterpretation)*
AND
(Empirical ***OR*** *Experiment* ***OR*** *Survey* ***OR*** *"Case study"* ***OR*** *"Action Research")*

1.2.3. Strategy for Data Extraction

After completing the selection process, we began the process of extracting data through the complete reading of each of the publications, followed by the completion of the extraction form.

To try to standardize the answers, when possible, we put the possible answers in the extraction form so that the corresponding option is only checked. We extract the information according to each research sub-question. Following the complete extraction form.

Table 4 – Extraction form.

ID:	**Code**	**TITLE OF PUBLICATION**
Authors:		
Source:		
Type of Publication	[ ] Conference [ ] Workshop [ ] Journal	
Year		
Goal of Paper:		
STATE OF ART (**SQ1 -** What is the state of the art in experimental studies on maintenance of BPMN models or source code maintenance when using BPMN models?)		
Experimental Method:	[ ] Experiment Controlled [ ] Case study [ ] Survey [ ] Action Research	
Goal of the experiment:		
Context:	[ ] Industry [ ] Laboratory	
Types of participants:	[ ] Students [ ] Professionals [ ] Academic Professionals	
Number of Participants:		
Maintenance focus object:	[ ] BPMN Diagram [ ] Software / Source Code [ ] Both	
System Type:	[ ] Real [ ] Synthetic [ ] Not specified	
Treatments:		
Origin of the diagrams:	[ ] Development Process [ ] Reverse Engineering	
DEPENDENT VARIABLE (**SQ2 -** Which dependent variables are investigated in the experimental studies?)		
Experiment ID	**Variable Dependent**	**Measure Used**
FACTORS (**SQ3 -** Which of the factors studied influence the software maintenance capability (source code or model?)		
Results obtained		
TECHNOLOGIES (**SQ4 -** What technologies support the maintenance of BPMN models?)		
Does the article feature some Technology? If so, which one?		

2. Papers obtained in the second filter

Code	Title	Authors
PB1	*A Fuzzy Logic-based Approach for Assessing the Quality of Business Process Models*	Fadwa Yahya, Khouloud Boukadi, Hanene Ben Abdallah and Zakaria Maamar
PB2	*The effect of modularity representation and presentation medium on the understandability of business process models in BPMN*	Turetken, O. and Rompen, T. and Vanderfeesten, I. and Dikici, A. and Van Moll, J.
PB3	*Prediction Models for BPMN Usability and Maintainability*	Elvira Rolón, Laura Sánchez, Félix García, Francisco Ruiz, Mario Piattini, Danilo Caivano, Giuseppe Visaggio
PB4	*An Experiment on Process Model Understandability Using Textual Work Instructions and BPMN Models*	Raphael de A. Rodrigues, M´arcio de O. Barros, Kate Revoredo
PB5	*Does cognitive overload matter in understanding bpmn models?*	Bera, P.
PB6	*Cognitive Style and Business Process Model Understanding*	Oktay Turetken, Irene Vanderfeesten, and Jan Claes
PB7	*Analysis and Validation of Control-Flow Complexity Measures with BPMN Process Models*	Elvira Rolón, Jorge Cardoso, Félix García, Francisco Ruiz, and Mario Piattini
PB8	*Evaluation of BPMN Models Quality - A Family of Experiments*	Elvira Rolón, Jorge Cardoso, Félix García, Francisco Ruiz, and Mario Piattini
PB9	*Towards thresholds of control flow complexity measures for BPMN models*	Sanchez-Gonzalez, L. and Ruiz, F. and Garcia, F. and Cardoso, J.
PB10	*An Empirical Review of the Connection Between Model Viewer Characteristics and the Comprehension of Conceptual Process Models*	Jan Mendling · Jan Recker · Hajo A. Reijers · Henrik Leopold
PB11	*How do humans inspect BPMN models: an exploratory study*	Cornelia Haisjackl · Pnina Soffer · Shao Yi Lim · Barbara Weber
PB12	*The Effects of Content Presentation Format and User Characteristics on Novice Developers' Understanding of Process Models*	Jan Recker, Alexander Dreiling

PB13	*Subject-Oriented Plural Method meets BPMN: A Case Study*	Van Den Hurk, H. and Turetken, O. and Van Moll, J.
PB14	*Theoretical foundations and implementation of business process diagrams' complexity management technique based on highlights*	Gregor Jošt · Marjan Herick · Gregor Polancic
PB15	*Identifying Quality Issues in BPMN Models: An Exploratory Study*	Cornelia Haisjackl, Jakob Pinggera, Pnina Soffer, Stefan Zugal, Shao Yi Lim, and Barbara Weber
PB16	*Eye Tracking Experiments on Process Model Comprehension: Lessons Learned*	Michael Zimoch, R¨udiger Pryss, Johannes Schobel, and Manfred Reichert
PB17	*Intuitive Comprehensibility of Process Models*	Doris Weitlaner, Annemarie Guettinger, and Markus Kohlbacher
PB18	*Does Experience Matter? Factors Affecting the Understandability of the Business Process Modelling Notation*	Renata Gabryelczyka, Arkadiusz Jurczukb,*

3. Types of treatment of each publication

Model Complexity			
Treatment	**Description**	**Number of Publications**	**Publications**
Measure X vs Measure Y	Values of different metrics calculated using the diagrams	3	P1, P3, P8
X value of the CFC metric vs Y value of the CFC metric	Different values of the CFC metric in BPMN models	2	P7, P9
Model Representation Form			
Paper x Digital	Model Presentation Media	1	P2
Graphic Model x Textual descriptions of the models	Different representations of Business Process Models	1	P4
Model Features			
Different model features (good layout vs. bad layout)	Types of model representation according to layout	1	P10
Lack of modularization x modularization with groups x modularization	Different types of modular representation	1	P2

with subprocesses in different models			
Models with Swimlanes or Models without Swimlanes	Use of notation elements	1	P5
Model in the participant's native language X Model in the second Language of the participant	User features	1	P12
Type of Model Representation			
BPMN x EPC x eGantt x PetriNet	Different aspects of different language models	1	P16
EPC x BPMN	Form of presentation of the content	1	P12
Traditional BPMN Model x BPMN Model (Opacity Graphical Highlights)	Different representations of Business Process Models	1	P14
BPMN x UML x EPC x SBC	Different order, recurrence and competition elements of UML, BPMN, EPC and SBD notations	1	P17
Method of model construction			
Plural Method x Traditional Method	Different ways of creating models	1	P13
Characteristics of the model maintainers			
Intuitive x Almost Intuitive x Adaptive x Almost Analytical x Analytical	Different cognitive styles	1	P6
Participants experienced in BPM x inexperienced participants in BPM	Different levels of knowledge in BPM	2	P12, P18
Level 1 x Level 2 x Level 3 x Level 4	Different levels of theoretical knowledge in BPMN 2a.0	1	P6
Defects in Models			
Syntactic errors x Semantic errors x Pragmatic errors	Presence of different types of defects in BPMN models	2	P11, P15

4. Glossary of evaluation metrics formulas

GLOSSARY		
Metric	**Paper: How the author names**	**Formula**
F-Measure	P1	$\textbf{Precision} = \frac{CorrectEntitiesFound}{TotalEntitiesFound}$ $\textbf{Recall} = \frac{CorrectEntitiesFound}{TotalCorrectEntities}$ $\textbf{F-measure} = 2 * \frac{Precision * Recall}{Precision + Recall}$
GlobalErrorRate	P1	$\textbf{GlobalErrorRate} = 1 - \frac{CorrectEntitiesFound}{TotalEntities}$
Accuracy	P2: Effectiveness P4: Quantity Correct Answers P6: Effectiveness P12: Test Score P16: Quantity Correct Answers P17: Quantity Correct Answers	Quantity Correct Answers
Efficiency	P2, P3, P7, P8, P9, P10	Test Score / Time spent for correct answers
Perceived Comprehension	P2, P9	Subjective measure obtained through the response of the participants of a questionnaire about comprehension on a Likert scale. P2: 7-point Likert Scale. P9: 5-point Likert Scale.
Perceived Complexity	P3: Subjective Evaluation, P7, P8: Subjective Evaluation	Subjective measure obtained through the response of the participants of a questionnaire on complexity on Likert scale. P3: Scale not specified P7: 5-point Likert Scale  P8: 5-point Likert Scale

Time	P5, P12	Time to answer comprehension tasks
Completeness	P13	Completeness of the model in association with perceived completeness assessed by TAM.
Complexity	P14	Complexity Metrics
Error Detection	P15	% of errors found

5. References

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