Towards a structured process modeling method: Building the prescriptive modeling theory

Regular paper

Jan Claes[1], Irene Vanderfeesten[2], Frederik Gailly[1], Paul Grefen[2], and Geert Poels[1]

[1]Department of Business Informatics and Operations Management,
Ghent University, Tweekerkenstraat 2, 9000 Gent, Belgium
{jan.claes, frederik.gailly, geert.poels}@ugent.be

[2]Department of Industrial Engineering and Innovation Sciences,
Eindhoven University of Technology, Postbus 513, 5600 MB Eindhoven, The Netherlands
{i.t.p.vanderfeesten, p.w.p.j.grefen}@tue.nl

Abstract. In their effort to control and manage processes, organizations often create process models. The quality of such models is not always optimal, because it is challenging for a modeler to translate her mental image of the process into a formal process description. In order to support this complex human processing task, we are developing a smart process modeling method. This paper describes how we have built the underlying prescriptive theory, which is constructed from existing evidence about successful information processing techniques in cognitive psychology.

Keywords: business process management, business process modeling, human aspects of bpm, smart bpm, process of process modeling

1 Introduction

In an ever-increasing competitive market and in the context of globalization, mass-customization and risk management, it is currently considered important for organizations to manage and control their core processes. One of the instruments developed to support process management are process models, i.e., representations of certain aspects of the process that abstract from individual process executions [1].

Process models are typically constructed to support communication, documentation, analysis, simulation, execution, etc. [1]. Quality of process models can thus be seen as a measure of how well the model succeeds in supporting the goal: i.e. the fit-for-purpose. Hence, various process model quality variables and metrics have been studied and developed, related to different goals [2, 3]

As such, the business process management community has developed a good understanding of *what* constitutes a 'good' process model. In contrast, far less is known about *how* to build such a 'good' process model. Although in the past researchers have studied how process models are currently constructed [4, 5] and what principles to keep in mind when creating a process model [6, 7], we are not convinced that a sufficient answer to this question has been formulated.

Therefore, we started a methodological approach towards the development of a quality-oriented process modeling method. This approach consists of three phases. First, a set of more than 1.000 observations of modeling sessions was collected and analyzed [8, 9]. Second, we are currently completing the knowledge generation phase guided by the work of Gregor, et al. about theory building [10]. Third, the produced knowledge will serve as the base for developing a practical method containing concrete steps on how to successfully approach a process modeling task.

In the knowledge generation phase, we first constructed a descriptive theory that can be used to explain our observations. This is the Structured Process Modeling Theory [11], which is discussed in more detail further in this paper. Being an explanatory theory, it describes potential mechanisms about when and why people make mistakes during process modeling. In order to develop a method in the next phase of the research, this theory first needs to evolve towards a prescriptive theory. Such a theory goes beyond the explanation of the occurrence of mistakes and tries to formulate rules on how to avoid making mistakes in the first place [10]. The evolution from explanatory towards prescriptive theory is the contribution of this paper.

The development of a method that comprises the concrete implementation of these rules and that addresses the practical issues is out of the scope of this paper and has to be considered as future research. For now, the focus is on the conceptual solution, rather than on the practical method. We refer to the work of Gregor, et al. [10] for a deeper understanding about the distinction between an explanatory theory, a predictive theory and a practical method.

This paper is structured as follows. Section 2 presents related work. Section 3 provides the theoretical background. Section 5 describes the developed prescriptive theory. Section 6 concludes the paper with a discussion.

2 Related work

Related work includes research about process model quality and about how people construct process models. State of the art of both research streams is discussed below.

2.1 Process model quality

Process model quality is investigated in conceptual terms by the development of *top-down quality frameworks*. They employ ontological and semiotic theories to provide a structured overview of the relations between various aspects of modeling and to identify potential quality issues for each relation. Examples are the (more general) Conceptual Modeling Quality Framework (CMQF) [12] and the (process model oriented) semiotic quality framework (SEQUAL) [13]. Both frameworks are based on the LSS framework by Lindland [14] and thus make a distinction between the correct use of symbols (syntactic quality), the correct intended meaning of the symbols (semantic quality), and the correct actual understanding of the symbols by the model readers (pragmatic quality).

Further, *bottom-up quality metrics* describe how concrete, quantifiable properties of process models are related to various quality dimensions. In the course of the years, an abundance of metrics has been defined and related to quality dimensions. Instead of discussing those metrics here, the reader is referred to the extensive literature reviews of Sánchez-González [2] and De Meyer [3].

Next, through *empirical surveys* researches have tried to gather information about the success of process modeling techniques. Recker, et al. compared modeling techniques and derived improvement opportunities about process decomposition, declarative modeling, process model lifecycle, context and modeling conventions [15]. Rosemann distracted from focus groups and semi-structured interviews a list of 22 pitfalls related to strategy, stakeholders, requirements, practicalities, future-orientation and maintenance that characterize unsuccessful process modeling [16].

Concerning *pragmatic guidelines* for process modeling, little research exists. Mendling, et al. formulated Seven Process Modeling Guidelines (7PMG), which advise to use few elements, minimize routing paths, use single start and end event, model structured, avoid OR construct, use verb-object labels, and to decompose big models [7]. Further, Becker, et al. formulated Guidelines of Modeling (GoM) about correctness, relevance, economic efficiency, clarity, comparability and systematic design of process models. The guidelines of 7PMG and GoM are criticized to lack support for the modeler on how to achieve these desired process model characteristics during modeling [17]. For such practical support, it appears that modelers have to trust on their experience and on emerged best practices [7, 18].

2.2 The process of process modeling

Researchers have studied how people typically construct process models in a research stream they called "the process of process modeling" [19]. Recker, et al. identified five methods that novices apply to construct a process model: textual design, flowchart design, hybrid design, storyboard design, and canvas design [20]. Pinggera, et al. coded modeling observations in sequences of adding, deleting and laying out model elements and used clustering techniques to define three modeling styles: slower modeling/more reconciliation, slower modeling/less reconciliation, and faster modeling/less reconciliation [5]. Sedrakyan, et al. performed a process mining analysis on observational data and concluded that process modeling seems to require more effort than data modeling, and that in general it seems to be a successful tactic to start with the essence and iteratively add details to your model, which results in a quick growth of the model at the start and a slower pace of adding elements later on when thinking about the more challenging details [21]. To conclude, Claes, et al. described various patterns of process modeling, ranging from timing and spread of creation, movement and deletion of model elements to more general modeling patterns such as the process modeling styles discussed in Section 3.1 [9, 11].

3 Theoretical background

The sections hereafter describe the development of the prescriptive theory, which is the main contribution of this paper. First, this section briefly presents the existing knowledge on which the developed theory is based.

3.1 Process modeling styles

In recent research we identified three main process modeling styles: flow-oriented, aspect-oriented and combined process modeling [11]. They are described below.

Flow-oriented process modeling is a strategy where the modeler constructs the process model following the control flow order of the process. The model elements are created, laid out and formatted in blocks from the start towards the end of the process. Every block is first completely finished, before the modeler turns to the next one. It is up to the modeler to decide what she considers a ‘block’.

Aspect-oriented process modeling is a strategy where the modeler constructs the process model by focusing consecutively on different aspects of the whole model, such as content, structure, lay-out, formatting, etc. The process model is thus constructed iteratively. In each iteration another aspect of the model is considered from start to end. It is up to the modeler to decide when to address which aspects.

Combined process modeling is a strategy where the elements of the model are created in a flow-oriented way, now and then interspersed with a phase where the modeler works on a particular aspect of the partial model so far (for example interrupting the creation of elements to first layout the partial model so far).

3.2 The Structured Process Modeling Theory (SPMT)

The Structured Process Modeling Theory (SPMT) [11] is a descriptive theory that explains why mistakes are made during process modeling. Mistakes are defined as errors that are caused by cognitive failure, rather than by missing knowledge (about the process or about process modeling). Mistakes can thus be seen as cognitive imperfections during modeling that hinder a modeler to accomplish her intentions. Assuming perfect modeling intentions and perfect knowledge, mistakes would thus be the only reason a modeler doesn’t create a perfect high quality model. The SPMT blames cognitive overload of the modeler’s working memory due to the complexity of modeling for the occurrence of modeling mistakes.

It states that cognitive overload can be avoided if one (i) *serializes the modeling approach* (i.e., divide the modeling task into subtasks that are handled consecutively rather than simultaneously), (ii) *in a structured way* (i.e., applying a consistent and logical approach), (iii) *that fits with the relevant properties of the modeler* (i.e., the approach matches the cognitive style and preferences of the modeler).

4 Evidence collection

The SPMT identifies learning style, field dependency and need for structure as relevant cognitive drivers of the modeler [11]. An in-depth study of various personality factors revealed that mainly these three factors relate to the structuredness of cognitive processing during modeling. In order to transform the SPMT into a prescriptive theory, more details about the drivers - being the principal independent variables of the theory - need to be known and relative priorities in the described effects have to be determined. Therefore, we conducted a targeted literature review to collect evidence about the existent prescriptive knowledge related to these cognitive drivers, which is presented in this section. For the sake of brevity, the referenced sources are limited to a minimal amount of different papers.

4.1 Learning style

Learning style is defined by Keefe as *"characteristic cognitive, affective, and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment"* [22], p. 4. A person's learning style can be classified using various dimensions such as the perception, input, organization, processing and understanding style for handling information [23]. In the context of the SPMT only the understanding dimension is considered: i.e., sequential versus global learning. The Index of Learning Styles [23] contains 11 questions that rate someone's understanding learning style. It results in an odd integer score between -11 (global learner) and +11 (sequential learner).

Table 1. Overview of relevant knowledge related to learning style

Sequential learners…
"… follow ***linear reasoning*** *processes* ***when solving problems****"* [23], p. 679
"… learn best when material is presented in a ***steady progression of complexity and difficult****"* [23], p. 679
"… absorb information and acquire understanding of material in small ***connected*** *chunks"* [24], p. 289
"… progress ***logically****,* ***step-by-step****"* [25], p. 92
"… move to a different context ***only when he or she has assimilated one portion thoroughly****"* [25], p. 92
"… ask questions about much narrower relations and their hypotheses are ***specific****"* [26], p. 130
Global learners…
"… make ***intuitive leaps*** *and may be unable to explain how they came up with* ***solutions****"* [23], p. 679
"… sometimes do better by ***jumping directly to more complex and difficult material****"* [23], p. 679
"… take in information in ***seemingly unconnected*** *fragments (…) in large holistic leaps"* [24], p. 289
"… [are inclined to focus] upon ***global****, large-predicate rules"* [25], p. 93
"… are assimilating information ***from many topics*** *in order to learn the 'aim' topic"* [26], p. 130
In general
"The enigma lies in the ***invariance of personal style****"* [25], p. 90
"(…) yet [the students] ***consistently*** *prefer a particular type of learning strategy (…)"* [26], p. 132
"(…) competence in using a strategy ***does not always*** *go alongside disposition to* ***adopt it****"* [26], p. 132
"(…) some students are disposed to ***act 'like holists'*** *(…) and others* ***'like serialists'*** *(…), with* ***more or less success****."* [26], p. 133
"Strategic match or mismatch showed an influence upon learning - ***mismatch leading to difficulty in understanding*** *and sometimes to complete misunderstanding of relevant topics"* [25], p. 88
"The ***matched consistently performed better*** *than the mismatched"* [25], p. 88

Table 1 presents an overview of the collected evidence related to learning style that is relevant in the context of the SPMT. From this table it can be concluded that - in contrast to sequential learners - global learners (i) work in intuitive leaps, (ii) do not use a steady pace, (iii) work on seemingly unconnected fragments, (iv) do not necessarily work in consecutive blocks, and (v) work globally.

Literature on learning style also suggests (i) that one's learning style is rather invariant, (ii) that one can apply a mismatching learning strategy, and (iii) that applying a mismatching strategy often has negative consequences. Furthermore, the literature implies that serial learners may often be field-dependent (see further).

4.2 Field dependency

Field dependency is defined by Witkin, et al. as *"the extent to which the surrounding organized field has influenced the person's perception of an item within it"* [27], p. 6. It indicates the ease with which someone can abstract from details (i.e., the surrounding field). It is usually measured with the Hidden Figures Test [28] in which a participant has to find simple figures in a complex pattern of lines. The amount of figures that were not discovered (in the provided time) is expressed as a percentage, which quantifies someone's field dependency.

Table 2. Overview of relevant knowledge related to field dependency

Field-independent learners…
*"… **profit less** from such a teaching approach [providing students with a plan]"* [27], p. 23
*"… discern **discrete parts of the field**, distinct from the organized background"* [29], p. 239
*"… are also **more focused and disciplined learners**"* [29], p. 239
*"… are characterized by a **longer attention span** and a **greater contemplative disposition**"* [29], p. 239
*"… **depend more on internal than external cues**"* [29], p. 239
*"… are likely to **overcome the organization of the field, or to restructure it**"* [27], p. 9
Field-dependent learners…
*"… **profit more from 'providing students with a plan'** "* [27], p. 23
*"… engage a global organization of the (…) field, and **perceive parts of the field as fluent**"* [29], p. 239
*"… have **short attention spans**, are **easily distracted** (…)"* [29], p. 239
*"… **depend on the cues and structure from their environment**"* [29], p. 239
*"… **tend to adhere to the organization of the field as given**"* [27], p. 9
In general
*"(…) evidence of **self-consistency** in performance across tasks"* [27], p. 6
*"People are likely to be **quite stable** in their preferred mode of perceiving, even over many years"* [27], p. 7
*"This **does not imply that they are unchangeable**; indeed, some **may easily be altered**"* [27], p. 15
*"(…) it seems **easily possible** to induce FD persons to use an hypothesis-testing approach **by as simple a means as providing directions** to use such an approach"* [27], p. 26
*"(…) that relatively FD and FID persons tend to **favor different learning approaches**"* [27], p. 27
*"The approaches (…) **do not necessarily make for better achievement**"* [27], p. 27
*"(…) a **better learning outcome** than others seems to depend rather on the specific characteristics of the learning tasks and the particular circumstances under which learning takes place"* [27], p. 27
*"(…) teaching students to **use problem-solving strategies most appropriate to their styles**"* [27], p. 15

Table 2 presents an overview of the collected relevant evidence related to field dependency. From this table it can be concluded that - in contrast to field-independent people - field-dependent people (i) apply the given order, (ii) work in connected parts, and (iii) have a short attention span. It also appears that they have a high desire for structure (nfs-1) and have a high reaction to missing structure (nfs-2) (see further).

Similar to learning style literature, it is stated (i) that one's field dependency is rather stable by nature, (ii) but it can be changed, (iii) and changing it may be rather easy, (iv) that the field dependency influences the selected learning approach, (v) but the effect of the selected approach on learning success may be limited, and (vi) that these learning effects are also considered for problem solving.

4.3 Need for structure

Need for structure is defined by Thompson, et al. as the extent to which *"an individual (...) prefers structure and clarity in most situations, with ambiguity and grey areas proving troublesome and annoying"* [30], p. 20. It falls apart in two orthogonal factors: the desire for structure (nfs-1) and reaction to missing structure (nfs-2), which are jointly measured via the 12 questions of the Personal Need for Structure Scale of [31]. For both factors an integer score between 1 (low nfs) and 6 (high nfs) is calculated as the mean of the answers to the applicable 6-point Likert-scale questions.

Table 3. Overview of relevant knowledge related to Personal Need for Structure

People with low need for structure…
"... might be ***less confident*** *in their most accessible judgments"* [30], p. 30
"... would be ***motivated to consider alternative judgments****"* [30], p. 30
"... their impressions are less reflective of the classic assimilation effect because they do not simply and confidently draw new information into the category that is the most readily available" [30], p. 30
People with high need for structure…
"... tend to ***freeze on the first available explanation****"* [30], p. 30
"... are ***confident in their decision****"* [30], p. 30
"... are ***unlikely to search for further alternative judgements****"* [30], p. 30
"... may be ***more likely to stereotype*** *in ambiguous situations than are low-PNS individuals"* [31], p. 124
"... are likely to ***pay attention to structure-relevant and structure-consistent information****"* [31], p. 126
"... ***actively gather structure-consistent information****"* [31], p. 126
"... ***use confirmatory hypothesis-testing styles****"* [31], p. 126
"... are particularly likely to ***interpret ambiguous information as being structure consistent****"* [31], p. 126
"... expend great efforts to ***discount information perceived as being structure inconsistent****"* [31], p. 126

As can be derived from the collected relevant evidence about need for structure presented in Table 3, people with a relatively high need for structure are (i) more confident in their decisions and (ii) are biased towards information that confirms their initial thoughts.

This concludes the section that presents the theoretical background for the construction of the prescriptive theory. Based on the accumulated knowledge about process modeling styles, structured process modeling and the relevant cognitive drivers, the next section presents the developed prescriptive process modeling theory.

5 From a descriptive to a prescriptive theory

The goal of the prescriptive theory is to support the development of a quality-oriented practical process modeling method. In accordance to the Structured Process Modeling Theory, the general strategy of this method will be to divide the task of process modeling into subtasks (i.e., to serialize modeling), and to perform this approach in a consistent and logical way (i.e., in a structured way). Furthermore, the way the modeling is serialized and structured has to fit with the three identified cognitive drivers. The prescriptive theory contains the knowledge that describes how to determine which process modeling approach fits with these cognitive drivers.

The evidence presented in Section 4, shows that the learning style partially determines one's field dependency and in its turn the field dependency determines the need for structure. Therefore, the instructions of the prescriptive theory will consider the cognitive drivers in this order.

5.1 Learning style

The general suggested approach is derived from the modeler's learning style. After carefully studying the identified process modeling styles (see Section 3.1), it was discovered that each style fits all the described needs of a certain type of learner (see Section 4).

Practically, this results in next instructions (recall that the learning style of a subject is expressed as an integer odd number between -11 and +11):

- If a modeler's learning style score is between -11 and -5 (global learner),
  the modeler is instructed to apply the aspect-oriented process modeling style.
- If a modeler's learning style score is between -3 and +3,
  the modeler is instructed to apply the combined process modeling style.
- If a modeler's learning style score is between +5 and +11 (sequential learner),
  the modeler is instructed to apply the flow-oriented process modeling style.

5.2 Field dependency

The field dependency of a modeler defines additional guidelines to be implemented in combination with the general modeling style determined by the learning style.

Based on the collected evidence (see Section 0), next directions are added to the flow-oriented, aspect-oriented or combined process modeling style (recall that the field dependency is measured with a real number between 0 and 1):

- If a modeler's score is between 0.5 and 1.0 (relatively field-dependent),
  the modeler is instructed to take frequent short breaks and to work on smaller parts at once (because of the short attention span), to model in the provided order and to try to keep all the parts of the model connected while modeling.
- If a modeler's score is between 0.0 and 0.5 (relatively field-independent),
  the modeler is instructed to not be afraid to create the model in one take, to not

be afraid to skip parts temporarily, to not be afraid to be working all over the model, working in big parts or working on different parts in parallel.

Note how we chose to formulate the instructions for field-independent modelers in the form of '*not be afraid to*' instead of '*try to*' because it doesn't make sense to instruct these modelers for instance to work all over the place.

5.3 Need for Structure

Whereas the evidence that was found for learning style and field dependency can be considered prescriptive because it includes references to matching and mismatching behavior (see Sections 4 and 0), the collected evidence about need for structure seems to only describe how people behave given their personal need for structure (see Section 0). Therefore, it will be used in the prescriptive theory only to warn the modelers in order to create awareness, rather than translating it into concrete guidelines. Moreover, we feel that the evidence relates more to the desire for structure (nfs-1) variable than to the reaction to missing structure (nfs-2) variable.

Next information complements the previous instructions (recall that the desire for structure is quantified as an integer score between 1 and 6):

- If a modeler has a nfs-1 score between 1 and 3 (low desire for structure), the modeler is informed that the guidelines provided may not feel natural, but yield a high potential improvement and the modeler is requested to do an effort to apply the instructions carefully.
- If a modeler has a nfs-1 score between 4 and 6 (high need for structure), the modeler is informed that the guidelines may feel familiar, because she may already apply them and the modeler is requested to consider them as an instrument to perfect her current structured modeling style.

5.4 Summary

The prescriptive guidelines are summarized below.

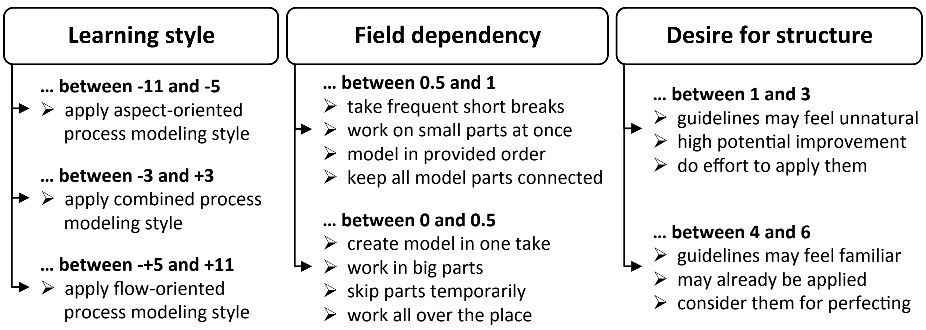

Fig. 1. Summary of the prescriptive structured process modeling guidelines

6 Conclusion

The research presented in this paper focuses on human aspects of business process modeling. Real-life processes are often complex and it appears to be hard for humans to construct high quality models representing the processes. Therefore, we are developing a practical method for process modeling based on scientific theories about the human mind. The literature suggests that changing someone's modeling approach may be "*as simple (...) as providing directions to use such an approach*" [27], p. 26. One crucial step in this development is thus the formulation of the prescriptive theory that forms the basis of the method. This paper describes the transformation from the existing explanatory Structured Process Modeling Theory (SPMT) towards a prescriptive theory, which is summarized in Fig. 1.

The theory was built from the SPMT and various sources in the cognitive psychology literature. It thus combines existing knowledge in a fundamentally new way. According to Gregor, et al. such a transformation from an explanatory towards a prescriptive theory is feasible and it should be evaluated against innovativeness, utility and persuasiveness. However, in order to perform an extensive evaluation of the prescriptive theory, it first needs to be embedded in the practical method.

Therefore, a thorough validation of the theory is out of the scope of this paper. Nevertheless, we can already report on some initial results. Indeed, the method that will use the theory that is the contribution of this paper is currently under development. It consists of a digital workflow starting with the measurement of a modeler's cognitive preferences, selecting a fitting process modeling strategy based on the prescriptive theory presented in this paper, learning the strategy via a one-hour interactive digital tutorial and applying the strategy on a modeling case.

The initial results are promising and indicate (i) that it seems possible to accurately measure one's cognitive preferences in an automated digital way, (ii) that it indeed seems possible to change a modeler's modeling style with a limited intervention in the form of a digital tutorial, and (iii) that this indeed has a significant beneficial effect on modeling quality. This confirms the utility of the developed prescriptive theory.

References

1. Dumas, M., La Rosa, M., Mendling, J., Reijers, H.A.: Fundamentals of business process management. Springer, Berlin Heidelberg (2013).
2. Sánchez-González, L., García, F., Ruiz, F., Piattini, M.: Toward a quality framework for business process models. Int. J. Coop. Inf. Syst. 22 (01), 1–15 (2013).
3. De Meyer, P.: Kwaliteit van procesmodellen: literatuurstudie, (2015).
4. Pinggera, J., Zugal, S., Weidlich, M., Fahland, D., Weber, B., Mendling, J., Reijers, H.A.: Tracing the process of process modeling with Modeling Phase Diagrams. In: Proc. Proceedings of the 9th International Conference on Business Process Management - Workshops (BPM '11), Clermont-Ferrand, France, August 28-September 2, 2012, LNBIP 99, 370–382 (2012).

5. Pinggera, J., Soffer, P., Fahland, D., Weidlich, M., Zugal, S., Weber, B., Reijers, H.A., Mendling, J.: Styles in business process modeling: An exploration and a model. Softw. Syst. Model. 14 (3), 1055–1080 (2013).
6. Becker, J., Rosemann, M., Von Uthmann, C.: Guidelines of business process modeling. In: Proc. Business Process Management. Models, Techniques, and Empirical Studies. Part I., LNCS 1806, 30–49 (2000).
7. Mendling, J., Reijers, H.A., Van der Aalst, W.M.P.: Seven process modeling guidelines (7PMG). Inf. Softw. Technol. 52 (2), 127–136 (2010).
8. Claes, J., Vanderfeesten, I., Reijers, H.A., Pinggera, J., Weidlich, M., Zugal, S., Fahland, D., Weber, B., Mendling, J., Poels, G.: Tying process model quality to the modeling process: The impact of structuring, movement, and speed. In: Proc. Proceedings of the 10th International Conference on Business Process Management (BPM '12), Tallinn, Estonia, September 3, 2012, LNCS 7481, 33–48 (2012).
9. Claes, J., Vanderfeesten, I., Pinggera, J., Reijers, H.A., Weber, B., Poels, G.: A visual analysis of the process of process modeling. Inf. Syst. E-bus. Manag. 13 (1), 147–190 (2015).
10. Gregor, S.: The nature of theory in information systems. MIS Q. 30 (3), 611–642 (2006).
11. Claes, J., Vanderfeesten, I., Gailly, F., Grefen, P., Poels, G.: The Structured Process Modeling Theory (SPMT) - A cognitive view on why and how modelers benefit from structuring the process of process modeling. Inf. Syst. Front. 17 (6), 1401–1425 (2015).
12. Nelson, H.J., Poels, G., Genero, M., Piattini, M.: A conceptual modeling quality framework. Softw. Qual. J. 20 (1), 201–228 (2012).
13. Krogstie, J., Sindre, G., Jørgensen, H.: Process models representing knowledge for action: A revised quality framework. Eur. J. Inf. Syst. 15 (1), 91–102 (2006).
14. Lindland, O.I., Sindre, G., Solvberg, A.: Understanding quality in conceptual modeling. IEEE Softw. 11 (2), 42–49 (1994).
15. Recker, J.C., Rosemann, M., Indulska, M., Green, P.: Business process modeling: a comparative analysis. J. Assoc. Inf. Syst. 10 (4), 333–363 (2009).
16. Rosemann, M.: Potential pitfalls of process modeling: part A. Bus. Process Manag. J. 12 (2), 249–254 (2006).
17. Moreno-Montes de Oca, I., Snoeck, M., Reijers, H.A., Rodríguez-Morffi, A.: A systematic literature review of studies on business process modeling quality. Inf. Softw. Technol. 58 (February), 187–205 (2014).
18. Silver, B.: BPMN: Method & style. Cody-Cassidy Press (2011).
19. Soffer, P., Kaner, M., Wand, Y.: Towards Understanding the Process of Process Modeling: Theoretical and Empirical Considerations. In: Proc. Business Process Management Workshops. BPM 2011 International Workshops, Clermont-Ferrand, France, August 29, 2011, Revised Selected Papers, Part I, LNBIP 99, 357–369 (2012).
20. Recker, J.C., Safrudin, N., Rosemann, M.: How novices design business processes. Inf. Syst. 37 (6), 557–573 (2012).

21. Sedrakyan, G., Snoeck, M., De Weerdt, J.: Process mining analysis of conceptual modeling behavior of novices: Empirical study using JMermaid modeling and experimental logging environment. Comput. Human Behav. 41 (December), 486–503 (2014).
22. Keefe, J.W.: Learning style: An overview. In: Proc. NASSP's Student learning styles: Diagnosing and proscribing programs, 1–17 (1979).
23. Felder, R.M., Silverman, L.K.: Learning and teaching styles in engineering education. Eng. Educ. 78 (June), 674–681 (1988).
24. Felder, R.M.: Reaching the second tier: Learning and teaching styles in college science education. J. Coll. Sci. Teach. 23 (5), 286–290 (1993).
25. Pask, G.: Learning strategies, teaching strategies, and conceptual or learning style. In: Proc. Learning Strategies and Learning Styles, 83–100 (1988).
26. Pask, G.: Styles and Strategies of Learning. Br. J. Educ. Psychol. 46 (2), 128–148 (1976).
27. Witkin, H.A., Moore, C.A., Goodenough, D.R., Cox, P.W.: Field-dependent and field-independent cognitive styles and their educational implications. Rev. Educ. Res. 47 (1), 1–64 (1977).
28. Ekstrom, R.B., French, J.W., Harman, H.H.: Kit of factor-referenced cognitive tests. , Princeton, New Jersey (1976).
29. Wooldridge, B., Haimes-Bartolf, M.: The field dependence/field independence learning styles: Implications for adult student diversity, outcomes assessment and accountability. In: Proc. Learning Styles and Learning: A Key to Meeting the Accountability Demands in Education, 237–257 (2006).
30. Thompson, M.M., Naccarato, M.E., Parker, K.C.H., Moskowitz, G.B.: The personal need for structure and personal fear of invalidity measures: Historical perspectives, current applications, and future directions. In: Proc. Cognitive social psychology: The Princeton symposium on the legacy and future of social cognition, 19–39 (2001).
31. Neuberg, S.L., Newsom, J.T.: Personal need for structure: Individual differences in the desire for simpler structure. J. Pers. Soc. Psychol. 65 (1), 113–131 (1993).
32. Dumas, M.: From Models to Data and Back: The Journey of the BPM Discipline and the Tangled Road to BPM 2020. In: Proc. Business Process Management. 13th International Conference, BPM 2015, Innsbruck, Austria, August 31 - September 3, 2015, Proceedings - Preface, LNCS 9253, I–XXIV (2015).
33. Van der Aalst, W.M.P., La Rosa, M., Santoro, F.M.: Business Process Management. Don't forget to improve the process! Bus. Inf. Syst. Eng. 58 (1), 1–6 (2016).