Case-based Selection of Business Process Modeling Tools: An Evaluation Criteria Framework

Completed Research Paper

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ABSTRACT

Modeling tools are one of the major success factors for business process management endeavors. They not only ultimately provide the modeling language to be used but also define the way of interaction when creating and using those models. Thereby, already the selection of the right modeling tool is a decisive factor for success or failure of any modeling project. Through a systematic literature review, we have identified a lack of a holistic criteria framework for the evaluation of business process modeling tools. To overcome this gap, we propose a structured evaluation criteria framework for modeling tools in this article. Our design enables an efficient selection while ensuring that all major decision factors have been considered. We evaluate our proposed framework in a real-life use case about sustainable process design for home care.

Keywords


INTRODUCTION

Businesses should be able to adjust and change their activities and processes in an organized and well-considered way. Business process management (BPM) emerged as the distinct field within academia and practice, facilitating design and operation of the increasingly interconnected and interdependent processes (Houy, Fettke, Loos, Van der Aalst and Krogstie, 2011; Rosemann and de Bruin, 2005). The modeling of processes is often seen as a central area of business process management and is highly interrelated with process design (Weske, Van der Aalst and Verbeek, 2004). Process models not only help to design business processes, they also foster communication on experiences made and any required action (Kesari, Chang and Seddon, 2003). Therefore, for BPM the distinct practice of business process modeling is crucial (Becker, Niehaves and Thome, 2010). An important aspect of any modeling endeavor is the choice out of the plethora of modeling methods and languages (Becker et al., 2010) as well as the supporting software tools (Weske et al., 2004). With the decision for a specific tool also the language and the way it must be used is set, e.g. which forms of collaboration are available for what language. Thus, the selection process is a decisive factor for the success of any modeling project and must therefore be both efficient and comprehensive. To this end, we propose a structured evaluation criteria framework which may support practitioners and academics alike to choose the appropriate tool efficiently and without missing important aspects.

Our paper starts with the explication of the method chosen. After examining the state-of-the-art and related work in the areas of evaluation criteria and studies concerned with business modeling tools, we present the basic structure and insights into our framework. Before closing the paper with our conclusion and outlook, the key results are validated and evaluated in a use case from the field of sustainable health care.

METHOD

The paper at hand follows the design science paradigm of Information Systems (IS) Research (Österle et al., 2011) by providing a framework to enhance the user-oriented conception of IS artifacts. It addresses the generation of socio-
technological, systems-affiliated hypotheses and theories to tackle the innovative research focus: creating an evaluation criteria framework for the selection of modeling tools as an artifact meeting the requirements of the scientific principles of abstraction, originality and reason (Frank, 2006). In order to achieve the targets set, we had to define a solution approach in order to articulate the framework of evaluation criteria as a proper design science artifact (Hevner, March, Park and Ram, 2004):

1. Analysis of the status quo
2. Conception of the evaluation criteria framework
3. Application of the artifact to allow for a validation
4. Diffusion

The analysis involved a comprehensive extraction of relevant criteria describing requirement categories concerning modeling tools. Therefore, the studies to be analyzed have been identified during a systematic literature review. Reviews represent an integral part of the creation of an artifact in design science research (Offermann, Levina, Schönherr and Bub, 2009). According to Darke, Shanks and Broadbent (1998), the number of comprehensive and/or detailed studies analyzed (eleven, cf. Table 2) was limited to around ten.

The conception of the evaluation criteria framework was executed by modeling it as a class diagram with the Unified Modeling Language (UML) notation, version v2.4.1 (OMG, 2011). The validation of the framework artifact was performed in a use case (Frank, 2010). We practically applied the artifact during an international research project featuring the IT support of mobile health care providers. Moreover, the highly interdisciplinary character and the economic, ecological as well as social significance of the domain shall challenge the applicability of the framework (Breitschwerdt, Iedema, Robert, Bosse and Thomas, 2012). Eventually, diffusion occurs by communicating results so that feedback can be collected for iterative refinement (Hevner et al., 2004). Thereby, we fulfill the fourth required design science research stage by publishing our findings in this paper.

To set up the evaluation criteria framework on a solid base, we conducted a systematic literature review in the following order as suggested by Vom Brocke et al. (2009) and Webster and Watson (2002):

![Figure 1: Underlying research approach for the literature review.](image)

By strictly following this approach, we were able to create a firm foundation for advancing knowledge through further research efforts. It also enables an overview of past research and reveals areas where additional research is needed (Webster and Watson, 2002).

<table>
<thead>
<tr>
<th>Search Terms</th>
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<tbody>
<tr>
<td>Business process*</td>
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<tr>
<td>Business process modeling</td>
</tr>
<tr>
<td>* modelling software *</td>
</tr>
<tr>
<td>BPMN modeling*</td>
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<tr>
<td>Business Process Management</td>
</tr>
<tr>
<td>modelling tool</td>
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<tr>
<td>* modeling software *</td>
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<tr>
<td>EPC modelling*</td>
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<td>BPM</td>
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<td>modeling tool</td>
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<tr>
<td>BPMN modelling*</td>
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<td>EPC modelling*</td>
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Table 1: English search terms used in the literature review.

As a first step, we limited the topic to terms relevant to business process modeling tools. According search queries include terms such as *business process* and *modeling software* (cf. Table 1). The wildcards used ensure the identification of related terms. Furthermore, we conducted the search for each term both in English and German: terms like EPC modeling (Event-driven Process Chain, EPC) were translated into EPK Modellierung etc. Then we performed the actual literature review in scientific databases. We scanned the digital databases of the A-ranked conferences HICSS, ECIS, AMCIS, ICIS, PACIS (Core, 2008) and the German A-ranked conference WI (Heinzl, 2008) as well as the scientific databases EBSCO,
Science Direct, SpringerLink and AISel, which contain peer-reviewed papers. More widely, the top ten ranking of economic journals of computer science and information management (VHB, 2008) and the MIS journal rankings (AIS, 2010) were included in the research. To increase the number of relevant contributions, we carried out a forward (author-centric review) and backward search (review of reference lists) based on the previous results (Vom Brocke et al., 2009). Concentrating our search on high-quality articles allows for reliable statements about the state-of-the-art.

RELATED WORK

According to our findings, modeling grammars (languages, techniques or paradigm) is the most perfected area of process modeling research in IS. Additionally, criteria to evaluate process modeling tools have been investigated from different areas of interest. The amount of references on business process modeling is immense which makes it very time consuming to get an overview of important software criteria. Riemer, Holler and Indulska (2011), for instance, present criteria regarding collaborative process modeling. They analyze and classify a sample of modeling tools with regards to their collaborative features for supporting the modeling task, for example user/role management and import/export mechanisms.

<table>
<thead>
<tr>
<th>Source</th>
<th>Focus</th>
<th>Short description</th>
</tr>
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<tbody>
<tr>
<td>(Bartels, Frank and Völz, 2007)</td>
<td>Comparison of BPMN tools</td>
<td>By use of the knock-out-criteria export to BPEL, expandable meta model and free trial a list of 48 tools has been shortened to 8 tools, which have then been evaluated.</td>
</tr>
<tr>
<td>(Böhn, Burkhardt and Gantner, 2010)</td>
<td>Comparison of tools for documentation, design, simulation and analysis of processes</td>
<td>Prior to the evaluation of 12 tools, detailed introduction to the relevant topics (e.g. strategic BPM and process controlling) is provided.</td>
</tr>
<tr>
<td>(Bullinger and Schreiner, 2001)</td>
<td>Evaluation of BPM tools</td>
<td>More than 30 tools have been analyzed and evaluated by means of 100 criteria. These criteria contain, for example, general requirements as well as new requirements like integration and internet capability.</td>
</tr>
<tr>
<td>(Böhn et al., 2008)</td>
<td>Evaluation of BPM tools</td>
<td>In total, 18 process management tools have been evaluated and compared by means of software- and manufacturer-related criteria. The spectrum ranges from documentation to automation of processes.</td>
</tr>
<tr>
<td>(Drawehn et al., 2008)</td>
<td>Evaluation of process tools supporting executable processes modeled with BPMN</td>
<td>This study primarily focuses on the process execution, or rather the standardized mechanisms for IS integration (i.e. WSDL and BPEL); Then it covers the standardized modeling notation BPMN.</td>
</tr>
<tr>
<td>(Gadatsch, 2010)</td>
<td>Introduction into the BPM area, especially methods and tools</td>
<td>One chapter of this book concentrates on the software selection for process management, advised criteria categories are, for example, product and license model and technologies and interfaces.</td>
</tr>
<tr>
<td>(Nägele and Schreiner, 2002)</td>
<td>Evaluation of BPM tools</td>
<td>In order to understand actual positioning and targets of a tool, a brief overview of the market development and current trends is presented. Furthermore BPM tools are evaluated by using a criteria catalog, an analysis framework and a reference process.</td>
</tr>
<tr>
<td>(Nüttgens, 2002)</td>
<td>Framework for the evaluation of modeling tools for BPM</td>
<td>This scientific paper contains a framework, or rather an ordered criteria catalog, including criteria like model reader/viewer, installation, help functions and model version management.</td>
</tr>
<tr>
<td>(Peyret, Leganza, Smillie and An, 2009)</td>
<td>Business process analysis and enterprise architecture tools</td>
<td>The evaluation criteria consist for example of product must provide broad meta-model capabilities and product version has been released and is generally available prior to August 1, 2008.</td>
</tr>
<tr>
<td>(Rosemann and De Bruin, 2005)</td>
<td>Preliminaries for process modeling</td>
<td>The chapter concentrates on preliminaries for process modeling, including the principles of orderly modeling. Evaluation criteria can be inductively deduced from these explanations.</td>
</tr>
<tr>
<td>(Winkelmans, Knackstedt and Vering, 2007)</td>
<td>Software quality</td>
<td>This scientific paper focuses software quality as a preliminary for software selection.</td>
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</table>

Table 2: Sources analyzed for building the evaluation criteria framework.

Davies and Reeves (2010) provide an insight into the business process modeling tool selection process for the Queensland (AU) Court of Justice. In the beginning of the selection process they cluster 35 setting requirements and criteria into the clusters functional requirements, technical requirements, support and maintenance, training, reference sites, costs and other...
considerations. Indeed, the requirements and evaluation criteria will differ for each organizational context, but Davies and Reeves (2010) provide guidance for business managers on how they may structure and conduct a business process modeling tool evaluation from a business user perspective. Becker, Rosemann and Schütte (1995) specify the principles of orderly modeling, namely the principles of correctness, relevance, economic efficiency, clarity, comparability and systematic design. Software evaluation criteria can inductively be deduced from these principles, e.g., the criteria initial costs or even total cost of ownership regarding the principle of economic efficiency or the criteria support of (de-facto) notations like EPC and BPMN regarding the principle of clarity. Bandara, Gable and Rosemann (2005) claim that the modeling methodology, the modeling language and the modeling tool are success factors of effective process modeling. Therefore, the choice of the right modeling software is important.

Although some specific topics like workflow management or collaborative process modeling are covered, in scientific literature there are no relevant sources providing a general overview of business process modeling tools. We want to close this gap by presenting an evaluation criteria framework that is providing a comprehensive, but also detailed point of view. During our systematic literature review, studies on business process modeling tools have been identified (cf. Table 2). By using criteria already applied in current market studies and/or published in scientific literature, it is guaranteed that all basic criteria are covered by the methodology.

KEY RESULTS

The underlying meta-model of our evaluation criteria framework is depicted in Figure 2. The Figure shows that each criterion can consist of several subordinate criteria, indicating a hierarchical relationship. Furthermore, manifestations are assigned to each of the criteria identified.

![Figure 2: Meta-model for the evaluation criteria framework.](image)

The framework of evaluation criteria for modeling tools is based on literature concerned with software selection in general and modeling tool selection in particular. Further criteria have been derived from the principles of orderly modeling. In the following, as an example, we want to focus on the principle of correctness and extract implicitly contained criteria. A correct model is both syntactically and semantically correct. Semantically correctness can be achieved by an automatic verification against the meta-model of (de-facto-) standards like BPMN or EPC. In case a company uses a customized version of a modeling language, the meta-model has to be customized as well. Furthermore, a repository containing regularly used element names can help to achieve consistent element naming. Moreover, based on the current element a pre-selection of semantically correct following elements can be provided. After bottom-up identification of evaluation criteria in a literature review (cf. Table 2), we aggregated and structured these criteria and developed an evaluation framework. To get an impression of our criteria framework, we present a partial extract – focusing a software’s supported notations – in Figure 3.

The evaluation criteria framework is made up of more than 950 criteria and manifestations offering important benefits (e.g. the possibility to gain an overview of adequate criteria; time savings leading to monetary savings) for an efficient evaluation and selection of modeling tools. We present these criteria in a hierarchical order. The evaluation criteria framework can be found online. In order to further refine our evaluation criteria framework, we invite researchers and practitioners to visit http://www.uwi.uni-osnabrueck.de/criteria_catalogue/ and to provide feedback. For clarity reasons, we have published the online version of the criteria framework using a non-standardized autonomous hierarchical notation instead of UML.

The main differentiation was made in the first layer of the hierarchical framework of evaluation criteria: we distinguish between features closely related to modeling (i.e. building and analyzing models) and criteria not directly concerned with modeling (i.e. information concerning the product or the service provider). We believe this differentiation to be fundamental as it divides the criteria in two groups of approximately the same size (49% modeling-related and 51% non-modeling related criteria). Thus, our framework provides a structure that allows for an efficient evaluation of business process modeling tools from a modeling as well as a general, market-oriented perspective.
Following the branch of features directly related to modeling, we distinguish between analysis of modeling functions, quality management, reference models and maturity models as well as analysis, simulation and optimization of processes. Criteria not directly concerned with modeling are subdivided into those related to the modeling tool and those related to the manufacturer. In addition to that, we provide a third sub-division on the first level of the hierarchy called special features; this category leaves room for any additional criteria not covered by our framework but regarded desirable in a selection project. This classification has been undertaken in accordance with existing studies and is of logical nature.

In total, the evaluation criteria framework consists of up to seven layers of criteria, meaning that a hierarchy of subordinate criteria has been identified up to this depth. Hence, we cover a wide range of evaluation criteria. These include modeling languages, process execution, process cost accounting, validation of process syntax, printing and exporting functionality as well as costs and licensing of tools, user manuals and the number of installations, to name but a few. Manifestations of the evaluation criteria used in our framework enable development of classifications for modeling tools. The framework provides a holistic overview of criteria that may be relevant in a modeling tool selection project, but not each criterion has necessarily to be applied. Consequently, the criteria selected out of the framework depend on the case the tool is going to be used for. Therefore, the user is free to choose the criteria he deems to be important for his special case.

In this section, we will present a subjective selection of criteria we consider essential to offer an insight into the areas covered by our evaluation criteria framework. Essential criteria are those that have been identified by numerous authors and publications as relevant to the selection of modeling tools.

Modeling languages: Arguably, one of the most relevant criteria on which many authors focus (Bartels et al., 2007; Bullinger and Schreiner, 2001; Drawehn et al., 2008, 2010; Gadatsch, 2010; Nägele and Schreiner, 2002; Nüttgens, 2002; Peyret et al., 2009), is the number and type of modeling languages provided by the tool. Depending on whether one or more modeling languages are supported by a tool, it can be classified as a mono- or multi-notation modeling tool. Additionally, modeling tools can be differentiated by the type of modeling language supported (e.g. proprietary, standardized or
independently developed modeling notations). Standardized or de-facto-standardized languages include UML, BPMN, EPC and BPEL. It should be noted that, despite implemented standards, differences may occur and elements may even be missing.

**Representation of input and output data:** Drawehn et al. (2010) state representation of input and output data as an evaluation criterion. This should be enabled by providing a symbol especially dedicated to this purpose. BPMN, for example, provides a “data object”-element. This criterion also covers connections to types of models and to external data, thereby, allowing for connecting not only to information about input and output data but also for connecting the data itself.

**Execution languages:** Depending on the intended use, modeling tools should provide solutions for executing business process models. In this case, modeling tools should support execution languages like BPEL, XPDL and BPML (Drawehn et al., 2010).

**Syntax checking:** As stated in various publications (Bartels et al., 2007; Böhn et al., 2010; Bullinger and Schreiner, 2001; Drawehn et al., 2008; Gadatsch, 2010; Nüttgens, 2002; Winkelmann et al., 2007), syntax checking means verify the syntactical correctness of a business process model. Syntax checking can be carried out in a static or dynamic way. Static checking means that the user will not be alerted in case of syntax errors, whereas dynamic syntax checking ensures a corresponding alert. Syntax checking can occur on-the-fly (i.e. during modeling), after saving or upon user request.

**Model administration:** This criterion includes features like repositories (creating folders, handling files etc.), managing access to models by providing a concept of rights and roles, managing variations and versions of models (Drawehn et al., 2010; Nüttgens, 2002; Rosemann, Schwegmann and Delfmann, 2008; Winkelmann et al., 2007).

**Analysis aspects:** An analysis wizard should provide functions that can be used in order to analyze certain aspects of business processes, i.e. the critical path (Drawehn et al., 2008, 2010; Nägele and Schreiner, 2002; Nüttgens, 2002; Peyret et al., 2009; Winkelmann et al., 2007).

**Costs:** A tool can be offered free-of-charge or with costs. A modeling tool that is offered free-of-charge may be, but this is not necessarily the case, open source software. A tool that comes with costs can be offered in basic and full versions. Note that this criterion only covers purchase prices, not the total cost of ownership of a tool (Bartels et al., 2007; Drawehn et al., 2008; Nüttgens, 2002; Peyret et al., 2009).

**Support:** Support includes website, e-mail and phone-based as well as on-site support. Support subject to charge can be raised via a flat rate or depending on the complexity of the task. Alternatively, service level agreements or maintenance agreements may provide information as to how the support will be charged (Drawehn et al., 2008; Gadatsch, 2010; Nüttgens, 2002; Peyret et al., 2009; Rosemann et al., 2008).

**Ease of use:** Ease of use of a modeling tool can be defined in terms of several sub-criteria: navigation, editing, shortcuts, GUI, screenshots, help menu, uninterrupted workflows, intuitive use and more (Bartels et al., 2007; Böhn et al., 2010; Bullinger and Schreiner, 2001; Drawehn et al., 2010; Gadatsch, 2010; Nägele and Schreiner, 2002; Nüttgens, 2002; Peyret et al., 2009).

**Special features:** This is a basic, “empty” criterion that can be filled with whatever is needed in a modeling tool evaluation process not already covered in our criteria framework. Abnormalities during installation, communication with the vendor or other background information can be filed here and taken into account during the evaluation and decision making process.

**VALIDATION**

We believe that our proposed structured evaluation criteria framework provides the basis for efficient selection activities that are associated with choosing a business process modeling tool and that our framework includes all major decision factors relevant to such a case-based decision making process. We have validated our approach by means of a real-life use case in the context of an international project involving international researchers from IS and Health Communications as well as Australian community nurses as prospective users within the health care domain. Since this is an intercontinental project, inevitably bringing along different international time zones, meetings and networking with project partners could only happen virtually or via phone. Goal of the project is to develop a mobile application system that facilitates the work of community nurses entrusted with end-of-life care.

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Australia is a vast country and community nurses, even in metropolitan regions, have to take long rides from patient to patient and use advanced mobile devices like smartphones and pads on a regular basis. In our case we searched for a tool to develop feedback-enabled conceptual models of the clinical pathways to be later represented by the application system in a collaborative manner. We determined the case-based tool requirements during two consecutive 2.5h-workshops with at first twelve and later five prospective users, namely staff members of care providers (doctors, nurses, therapists, management, administrators) from the Sydney metropolitan area. Afterwards, four German information systems developers at Bachelor
degree level and other than the authors separately refined the requirements. Those reflect that the end users (both using the models and later modeling), ambulant care providers, are often on the fly and have to interact with colleagues like developers in corresponding IS via their mobile devices (Breitschwerdt, Robert and Thomas, 2011). On this basis, a business process modeling tool shall be chosen. We mapped the refined requirements elicited and noted during those workshops (cf. Table 3) to our framework and deduce the criteria needed for our case.

<table>
<thead>
<tr>
<th>Location in evaluation criteria framework</th>
<th>Requirements (refined)</th>
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<tbody>
<tr>
<td>Non-modeling-related criteria &gt; product &gt; technology and interfaces &gt; ease of use</td>
<td>intuitively understandable user interface (UI)</td>
</tr>
<tr>
<td></td>
<td>The tool’s user interface has to be intuitively understandable, so that all possible user groups are able to use the modeling tool instantly.</td>
</tr>
<tr>
<td>Modeling-related criteria &gt; analysis of modeling functions &gt; functional modeling &gt; modeling language</td>
<td>Second, intuitive notations like BPMN should be supported by the modeling tool.</td>
</tr>
<tr>
<td>Non-modeling-related criteria &gt; product &gt; technology and interfaces &gt; installation; Non-modeling-related criteria &gt; product &gt; support &gt; updates</td>
<td>Installing and updating the tool should be done easily and quickly.</td>
</tr>
<tr>
<td>Non-modeling-related criteria &gt; product &gt; technology and interfaces &gt; product variants</td>
<td>The tool has to run platform-independent, ideally web-based, and has to be available on both stationary and mobile devices. Consequently, the tool should be capable of being used via touch-screen and keyboard.</td>
</tr>
<tr>
<td>Non-modeling-related criteria &gt; product &gt; general details &gt; costs</td>
<td>A low-cost solution is desirable as funding is a critical issue in the health care domain.</td>
</tr>
<tr>
<td>Non-modeling-related criteria &gt; product &gt; technology and interfaces &gt; language</td>
<td>An English user interface must be provided as the tool is meant for Australian nurses.</td>
</tr>
<tr>
<td>Non-modeling-related criteria &gt; product &gt; technology and interfaces &gt; business process execution</td>
<td>The option to create instances of processes and execute processes has to be provided, thus, a workflow engine should exist at least in terms of an additional feature.</td>
</tr>
</tbody>
</table>

Table 3: Requirements for the tool selection.

In order to select a business process modeling tool for the purpose of assisting care practitioners, the next step is to identify, shortlist (e.g. by looking for rare features within the required criteria; here, we went for a relatively novel tool feature: web-based functionalities) and evaluate a set of tools meeting the requirements mentioned above. Therefore, we propose using a weighted scoring model (Belton, 1985; Keeney and Raiffa, 1976): a weighting is defined amongst the responsible project members considering existing priorities and assigned to each of the requirements identified, using a scale of 1 (low significance) to 10 (high significance). In our example, all requirements listed above are rather vital in order to allow for comprehensive analysis of sustainability in health care processes. Depending on which of these requirements are considered most significant, different weightings are possible. Here, the intuitively understandable user interface, UI language, costs and platform independency are considered most important and therefore received the highest weightings, while the remaining criteria are seen slightly less relevant, thus received a lower weighting. Next, the business process modeling tools identified from the shortlist have to be evaluated by as many project-specific or independent experts as available within efficient limits (e.g. based on project budget) for mitigating individual preferences and corresponding effects or deficiencies. Per tool, each criterion is given a score out of 10 (10 meaning complete satisfaction; 0 meaning a feature is not available in the tool). Every score is then adjusted according to the weighting assigned before (Davies and Reeves, 2010). In the end, the tool(s) with the highest weighted score is selected for use. The tool thus suggested is still in use of the healthcare workers for access to process representations and process modeling, also via their tablet computers.

CONCLUSION

During the systematic literature review, we found that scientific literature lacks of a holistic evaluation criteria framework for business process modeling tools, which supports business as well as normal end-users during the software selection process. Consequently, we identified criteria by combining current market studies, well-respected scientific literature on software selection in general, modeling tool selection in particular and principles of orderly modeling. Then, the criteria have been merged, hierarchically ordered, modeled in UML and a non-standard notation (cf. criteria framework online and Figure 3), both underlying the meta-model (cf. Figure 1). The evaluation criteria framework at hand supports decision-makers in the step of gathering important, case-based or even subjective criteria for a software evaluation. Using the framework is efficient and comprehensive at the same time. However, the evaluation criteria framework only supports one step in the software
selection process. In this context, one uncertainty has to be emphasized: what will be the future needs, i.e. how do decision-makers weigh the risk of investing money and time in an advanced tool when only just starting process modeling? Future research includes the definition of the selection process itself, considering every facet of modeling tools and being applicable for every size and kind of business with different needs. During our use case, we suggested the scoring method as a starting point. Furthermore, the presented evaluation criteria framework has been validated by means of an use case, but has not yet been evaluated (e.g. by means of questionnaires or expert interviews). Moreover, the provision of a (web-based) decision support tool can be focused. The criteria framework could be implemented in the way that decision-makers pre-select several criteria. In a next step, similar criteria, adapted on the selection, will be suggested following criteria-weighting and finally the presentation of the right modeling tool.

ACKNOWLEDGMENTS

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