Evaluating single features in usability tests for business process modeling tools

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Abstract: Companies today use business process management (BPM) to define, design, document and improve business processes. For the subtask of business process modeling, companies can choose from a large variety of existing modeling tools. The development of the tools challenges software vendors due to the growing number of requested features (resulting in so-called feature creep). Moreover, groups of heterogeneous clients are using the tools. Hence, participation of software users in the development process is necessary for designing 'usable' applications.

In this paper, we discuss the challenges in the development of business process modeling tools in terms of usability measurement with additional features. We present an integrated approach for evaluating usability in two ways: (a) testing overall tool usability and also (b) usability of single features. We focus on the different requirements of different user groups towards the tool and a single feature. As a proof of concept, we applied our approach to the development of a modeling tool in academic environment. The usability test is performed with respect to the tool. As single feature that is to be analysed in the proof of concept, we chose the user support for automatic layout in modeling tools.

Keywords: Business Process Modeling, Tool Evaluation, Usability Test.

1 Introduction

Business process modeling is a task that is performed in increasing frequency when companies today start analysing and optimising their processes [SB10]. For this task, there are many commercial business process modeling tools at hand. As for tools that incorporate a creative process as 'design' or 'exploration', its usability is of particular importance. Usability is key to boost users' acceptance of modeling tools. It should therefore be kept in mind during the software development cycle. The importance and also challenges of usability increase with higher number and heterogeneity of participants in the later modeling process [SGD05].

As a result of the continuous development of business process modeling tools, their functional range is expanding quickly. Usability tests are desirable to perform before or immediately after a new feature is introduced into a tool under development. Developers can then rapidly respond on shortcomings of the new feature before it is integrated in premature state into the main product. Also, prior to software releases, usability tests are a measure to circumvent misunderstandings in terms of users' requirements and expectations. However, major benefits can be drawn from usability tests when they are already integrated into the software development cycle, preferably at low cost.

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The goal of this work is to answer the following: how should a usability framework be designed that provides the flexibility to be integrated in every stage of the development process of a business process modeling tool? Moreover, what are the challenges of usability evaluation in the context of business process modelling?

In our research, we focus on tools using BPMN (business process modeling notation) which is a de-facto standard for the modeling of business processes. Since 2005, BPMN is maintained by the Object Management Group (OMG), an industry consortium for standardisation, and is under constant further development. Version 1.2 of BPMN, which is referenced by us, provides graphical representations of modeling elements, for instance tasks, gateways, as well as definition of structural elements (swimlanes and pools) [(OM09].

Our integrated approach comprehends a pragmatic course of action consisting of four steps. To present our approach, we structure this paper as follows: the next section will examine the preliminaries and the challenges towards usability. We then present in Section 3 the methodological background of our integrated approach. A proof of concept follows where we apply the methodology into ongoing development of an academic modeling tool. Before concluding and presenting future research topics, we give an overview of the results of the application in Section 4.

2 Usability characteristics

When designing an integrated usability approach for business process modeling tools, we will at first create a common ground for the understanding of usability in the context of business process modeling. In detail, what are the relevant aspects of usability that needed to be observed for modeling? To answer this, we first introduce the concept of usability and then draw the connection to the specifics in the field of business process modeling tools.

Usability is a quality attribute that assesses how easy user interfaces are to use [Nie03]. According to standard ISO 9241-11, usability is 'the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use' [ISO98]. Thereby the term 'context of use' subsumes the users, tasks and work equipment as well as the work environment, which all exert influence on usability. Thus, usability describes the relationship between an application and its user in three dimensions: how easily the handling of the product can be learned by the user, how effectively and economically he can use it and how satisfied he is with the use. Applications should be designed such that they support users in terms of their individual strengths and needs, but also take into account their specific weaknesses.

The seven dialogue principles in part 110 of the ISO norm represent standardised usability principles: 1) suitability for the task, 2) self-descriptiveness, 3) conformity with user expectations, 4) suitability for learning, 5) controllability, 6) error tolerance and 7) suitability for individualisation [ISO06]. These usability principles derive from aggregation and abstraction of individual requirements and can be used to design and evaluate interactive systems.

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2.1 Tasks and work environment

Created with the help of process modeling tools, process models are used to document and design the operational and organisational structure, and to configure the landscape of operational information technology. Additionally, process models are used during introduction and operation as starting point and supplier of auxiliary information.

In its early stages, business process modeling was primarily performed by specially trained professionals in IT departments. Other stakeholders were only consulted in subsequent implementation phases. In order to use BPM as a concept for continuous development of an enterprise, the involvement of all employees is essential. In addition to the technical experts and process managers, an increasing fraction of employees is occupied with business process analysis, optimisation and documentation [Har10]. Typical organisational positions are chief process offficer (CPO), process owner, process staff, process consultants and process modeller, which hold different responsibilities and tasks [Gad10]. Since business process modeling is characterised by the design of complex processes, a task that is often located between business and IT, it should be comprehensible and understandable to all stakeholder groups. As a consequence of this development, the requirements on usability of the modeling tools are increasing. The first obvious question is the following: with what kind of tasks do our user groups deal with? In the development of processes, three user groups with different tasks and responsibilities can be distinguished [Whi04]:

- Business analysts who create the initial draft of the processes.
- Technical developers who are responsible for implementing the technology that will support the performance of those processes.
- Business engineers who manage and monitor the processes.

Although the categorisation describes one of many possible classification, see also for instance [RSB+10], it shows the diversity of requirements that modeling tools have to compete with.

The results of a survey in [KSC11] show, that BPM tools were mostly used for the functions 'organisational process modeling' (65.7% of the answers) and 'process publication' (54.6%), followed by other areas of use, for instance 'technical process modeling', 'process control', 'process simulation', 'process monitoring', 'enterprise modeling' and 'process controlling'. Criteria for the selection of a business process modeling tool can be divided in characteristics of the vendor, the technology and the supported methods. One of the method criteria is the layout feature. A clear arranged graphical design of the models can be used for the purpose of presentation, navigation and orientation for new staff [Gad10].

2.2 User experience and requirements

In addition to the tasks and work environment, usability requirements depend on the individual user characteristics. Different ergonomic requirements can lead to optimal usability

for one user, while the same software can be rated negatively by another user. Expertise is among the characteristics that determine personal needs, and thus the quality assessment. Moreover, the users' affinity towards technology and their specific domain knowledge and experience affect the result of users usability evaluation. Significant influence on the 'individual fitness for use' has the mental model, that is, the mental image that a person has of a system. This includes the subjective perception of the user of what actions are required to trigger certain processes, and the reactions of the system resulting from it [All97]. Users have a mental model of a system but also the developers of this system have their own individual mental model of their system. Typically these mental models show distinctions because of different backgrounds of users and developers. To bridge this gap, early participation of users in the software development process is necessary.

Software ergonomics must therefore take into account the heterogeneity between individuals (inter-individuality), but also the fact that people change over time (intra-individuality) [NC97]. A specific adaptation of the software in advance, without the support of user studies, may turn out to be impossible. To simplify the heterogeneous population of potential users, the concept of 'user groups' can be applied. By classification of users, their requirements are bundled on a viable level. A typical classifying attribute is the state of knowledge of an individual, in other words: the 'maturity' of its mental model. An early approach categorises user groups according to their state of knowledge. The following states a grouping for modeling users completed with individual requirements and corresponding usability principle(s):

- Novices will be assisted by simple vocabulary and limited choices. The deliberate proximity to well-known concepts and syntax facilitates connections to pre-existing knowledge. An informative feedback on actions and meaningful error messages are essential. The ISO criteria self-descriptiveness, suitability for learning and error tolerance are highly relevant.
- Knowledgeable intermittent users can be supported by simple and consistent structure e.g. in software menus, terminology in use, etc. Prevention from mistakes, for example by early notification of potential sources of errors, supports the joy of exploration and therefore has a positive effect on the learning process.
- Expert (frequent) users need fast response times after input, a tight feedback that does not distract from the work rhythm and the possibility to speed up input, e.g. by keyboard shortcuts, macros etc. For experienced users it is crucial that they can influence the processes. This aspect is covered by the ISO criteria individualisation and controllability.

However, this grouping may possibly lead to different design goals as pointed out by [Her05, SP10].

3 Integrated usability approach for business process modeling

Tackling the aforementioned challenges on usability requirements in development processes, we now describe our approach. The approach aims to be suitable for integration in an iterative software development process in terms of implementing usability engineering. After the following description of the methodology in the approach, we illustrate the application of the approach to a process modeling tool in current academic development, called BPMN-Designer.

3.1 Design and agenda of the approach

In the field of Human Computer Interaction (HCI) research, there exists a variety of methods for usability evaluation. Among them are methods using guidelines, e.g. research based web-design guidelines and usability guidelines [Sea06], formal methods like the GOMS model (Goals, Operators, Methods, Selection Rules) [CMN86], inspection methods like heuristic evaluation or cognitive walkthrough, usability testing in combination with the thinking-aloud approach, eye- or attention-tracking and questionnaires [SB05]. One rough classification divides them in analytical and empirical methods. Evaluations using analytical methods are regularly applied by usability experts (simulating the user), whereas assessments through 'real' users are typically used for empirical methods. Analytical methods, like heuristic evaluation or cognitive walkthrough, aim at identifying potential usability problems and give precise design recommendations even in an early phase of the development process (as formative evaluation). Empirical methods like usability testing, thinking aloud, interviews or questionnaires are used mainly in an advanced status or even at the end of the development process (as summative evaluation) [DFAB04]. Each method has its strengths and weaknesses, e.g. in terms of output, effort, number of evaluators, reliability, validity and objectivity. Therefore a careful selection of methods regarding the context of use and the achieved results is necessary.

In the HCI literature a combination of usability evaluation methods is recommended (e.g. [WW97, SB05]. Following this recommendation, our goal is to design an integrated usability approach that satisfies: (a) the approach can be integrated in different stages in the development process, (b) the approach meets the challenges towards usability presented in Section 2 and (c) the approach can answer the questions:

- 'Why is it bad?' (identifying shortcomings as for further improvements)
- 'Which is better?' (comparing to other modeling tools)
- 'How good is it?' (regarding fulfillment of required characteristics) [GH02].

Our approach for evaluating usability of business process modeling tools focuses usability test and, if required, a preceding heuristic evaluation. Data analysis is done on the basis of questionnaires after collection of data during both, heuristic evaluation and usability test. Further environmental information can be collected during the test like duration or error ratios.

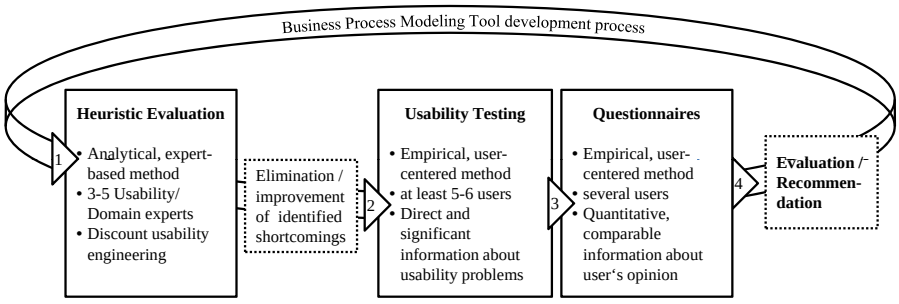

Figure 1: Integrated approach of Usability Evaluation of Business Process Modeling Tools.

The proposed course of action consists of four steps and is also graphically depicted in Figure 1. In the following, we will shortly describe the outline for each step.

Step 1: Heuristic evaluation During the heuristic evaluation, a group of evaluators analyses a tool on the basis of accepted usability principles aiming at discovering deviations between the tool's usability design and the usability principles. Evaluators are chosen from usability specialists. However domain specialist or developers are also integrated to carry out heuristic evaluations. Evaluators act as representatives of the real users. The general goal of each heuristic evaluation is a list with potential usability problems. Given the required resources for a heuristic evaluation, it can be encountered as a method of discount usability engineering, which is 'quick, cheap, and easy'. Heuristic evaluation is one of the most favoured usability inspection methods [Nie05a].

In our application case, the heuristic evaluation is used as a formative evaluation with respect to the question 'Why is the tool bad?'. The findings of a heuristic evaluation present a resource of recommendation for later improvements in the software development process. The given recommendations should be fixed/implemented before the following usability testing with software users.

Step 2: Usability testing with software users Usability testing is the core of our approach is represents an empirical evaluation method were real users or representative users perform specified tasks and thereafter answer questions to occurring problems and their subjective appraisal of the tested software. Beneath quantitative data like duration or error ratios, user testing generates qualitative information. Usability testing is the most well–established evaluation method. The effort for usability testing is relatively high and appropriate infrastructure is required [SB05]. The number of participants is an highly discussed issue in the research. For our approach, we consulted the findings of [Nie03] that states: testing 5 users (per tool) is typically sufficient for evaluating the most significant usability issues. In our approach, that is designed for modeling tools, the usability testing comprehends a hands-on modeling task. The modeling task is expected to make the users familiar with the software and the single feature that is to evaluate. The test serves as preparation for the participants to later communicate their findings and results.

Step 3: Questionnaires Questionnaires are an appropriate evaluation method for studies focusing on comparisons and the determination of quantitative information. A prerequisite to use a questionnaire is that the interviewee is familiar with the tool. Therefore questionnaires were often used after conducting a usability test. The effort caused by questionnaires is rather small and a large group of users can be asked anonymously [SB05].

Step 4: Evaluation and recommendation As a final step in our approach, the results generated through the aforementioned methods (heuristic evaluation, usability testing, questionnaires) must be analysed and interpreted. This final examination is performed by a team of usability and domain specialists and designers. Through these final results, numerous design recommendations may be concluded that render the tools more usable when implemented. Moreover, these results can be used as reference values for follow-up benchmark studies.
The approach permits adjustment at the specific context of use and the given situation. It can be used in different stages in the tool development process e.g. a new feature is designed or implemented. Depending on the individual situation and because of the method mix, it is also possible to divide the approach in two parts: the heuristic evaluation and evaluation/recommendation (step 1 and 4) or usability testing, questionnaires and evaluation/recommendation (step 2, 3, and 4), for instance in cases where short-term results are desirable with less effort. There, a single heuristic evaluation (step 1) without a following usability user testing can lead to minor recommendations e.g. for software prior to alpha/beta status. However, one should keep in mind that the results of the sequential steps influence each other and the approach used as a whole might provide more extensive and meaningful findings. These qualities provide flexibility and individualisation within the integrated approach.

3.2 Proof of concept

In the following, we will describe the application of our approach to our case study 'Evaluation of BPMN-Designer - a Business Process Modeling Tool in progress'. As a single feature, we chose 'Automatic Layout' feature because it affects users directly in the modelling task at hand and therefore has upcoming potential for tool vendors. For a common understanding of the feature in the rest of the paper, we will shortly explain our understanding in the following:
When users begin to design a process model, they start on a blank sheet, or screen respectively, which implies that there are no hints for the user, e.g. where to place single modeling elements. The development of an automatic layout algorithm that supports the user in this placing task is a mere logical progression. Such a layout algorithm could point to possible positions of new elements or could recalculate a 'good' layout from a given sketch. Good layout of models supports the high number of participants to easily modeling, understanding, discussing and presenting business process models.
Layout criteria, also called aesthetics, represent the formal requirements towards a visualised business process model. Immersing in the topic of aesthetics, we find a couple of

- Match between systems and the real world
- Visibility of system status
- User control and freedom
- Consistency and standards
- Error prevention
- Help users recognise, diagnose, and recover from errors
- Recognition rather than recall
- Flexibility and minimalist design
- Aesthetic and minimalist design
- Help and documentation
- Skills
- Pleasing and respectful interaction with the user
- Privacy

Table 1: Catalogue of usability heuristics.

existing approaches (e.g. [Pur97, PAC01, EJS10], but their usage and implementation is inconsistent among the tools that support business process modeling. Thus, we wanted to evaluate the feature in different tools integrated in an overall usability test. In the following, the four steps of approach are described with their adaptions to the application case of the proof of concept.

Heuristic evaluation For the conduction of a heuristic evaluation, heuristics with regard to the context of use must be defined. In literature, different accepted heuristics can be found, e.g. the ten usability heuristics from [Nie05b]. For our purposes, we suggest to use the heuristics listed in Table 1 to evaluate usability based on [NM94] which also takes into account aspects on heuristics from [Piend, Wei94]. In our case, a heuristic evaluation was necessary because developers of BPMN-Designer put their focus on functionality, particularly on the automatic layout feature. Usability aspects or user–centered design were not considered so far. Eventually, the evaluators identified 43 issues. Moreover they added comments, made further recommendations for improvement and found some errors (bugs) in functionality.
The heuristic evaluation is the first step in integrating users' needs in the development process. Users are represented by specialist evaluators. In preparation for the next step in our approach, usability testing, 29 out of 43 deviations could be eliminated. For the remaining issues, time and programming resources were too limited. However, we expected the newly implemented improvements to render the BPMN-Designer 2 notably more usable as the first version BPMN-Designer 1. For the verification of this assumption, we tested the software by using both versions of the BPMN-Designer for the following usability test and the questionnaires.

Usability testing The focus of the user testing and the questionnaires lay on the questions 'Which is better?' and 'How good is our tool?'. In order to prepare participants for completing the questionnaires we created a usability test comprising a typical user scenario. PCs were prepared for each subject equipped with the installed software tools and

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a detailed description of the tasks and the procedure. To simulate typical users out of the target group, we had a subject group 39 male and female students/PhD students out of the disciplines economics and/or computer science as potential future users of modeling tools. Their skills (education and experience) in process modeling were wide spread from very low to very high (simulating novices, knowledgeable intermittent and expert users). We collected this data with a set of questions regarding personal characteristics, experience and education in process modeling. Therefore the usability test was conducted at two different universities in February and April 2010.

A challenge in creating a user scenario was considering simultaneously the typical context of use and the heterogeneity of users. Therefore we created a scenario which is easy to understand for non-experienced users, but also typical in the context of business process modeling. In our scenario, participants should extent an established process that represents a 'book order' instance. Participants were asked to visualise it for a presentation-ready version. The scenario consists of five basic modeling tasks:

- Task 1: Open and load the established process
- Task 2: Understand the established process and the extension
- Task 3: Model the extension (necessary BPMN elements were given as support.)
- Task 4: Use the automatic Layout-Feature to render the process presentation-ready
- Task 5: Save the extended process.

After solving the user scenario, participants were supposed to be familiar with business process modeling, usage of tools and also with the automatic layout results. Test design and understandability of the instructions, the setup (including the questionnaires) was pretested with students prior to the experiment.

In order to find answers to the question 'Which is better?' we tested the original version BPMN-Designer 1 and the revised version BPMN-Designer 2. The evaluation was conducted as a 'between-subject-design', which means each tool was tested by a separate group of participants [RC01]. To answer the question 'How good is our tool?', the test had to be performed with comparable tools. Therefore we needed commercial tools with similar characteristics to compare with. As preparation for the usability testing, we created an overview of currently available software tools for business process modeling with BPMN. According to vendors we found a number of 54 software packages that support BPMN. The tools were expected to fulfill the following criteria: (1) support of BPMN in version 1.2, (2) automatic layout support and (3) availability of an evaluation license. After applying our criteria filters on the list of software tools, we obtained a set of three commercial tools that fulfilled all criteria and that were considered for the study where participants were randomly assigned to one tool. In former work we provide a complete list with all software vendors that were considered [SEJW10].

Questionnaires For our application case we chose standardised questionnaires providing public versions and accompanying documentation. For evaluating the usability, the questionnaire IsoNorm 9241/10 fulfilled these criteria. IsoNorm 9241/10 designed by Prümper and Anft in 1993 consists of seven subscales, each for one of the usability

principles mentioned in the ISO 9241-110 (see Section 2.1). Each subscale is divided in five items and evaluated on a seven-level bipolar rating scale (from +++ to —). In general the duration of answering all 35 questions takes about 10 till 20 minutes. The results can be expressed in mean values and has to be interpreted as hints for weaknesses respectively improvements but not as a detailed list of problems for specified features [SB05, Fig09, Brä08]. Each participant filled in the questionnaire for the specific tool used in the usability test before.

The total time of our study was approximately 60 minutes per participant.

4 Results

One of our goals was to find an answer to the following question: if the conducted heuristic evaluation was successful, is BPMN-Designer 2 ranked better by users than BPMN-Designer 1? Analysing the questionnaires we can state that BPMN-Designer 2 eventually is ranked higher regarding usability (0.25 in contrast to -0.12 on a scale from 3 = very positive to -3 = very negative). In detail BPMN-Designer 2 is evaluated in all usability principles better than BPMN-Designer 1 except the principles self-descriptiveness and error tolerance. Here exists a need of improvements. Concluding, these results confirm the positive effects of the improvements implemented after the heuristic evaluation.

Beneath the comparison of BPMN-Designer 1 and 2, we were analysing how our tool is evaluated in terms of usability in comparison with commercial tools. Therefore we conducted a benchmark between our tools and three commercial tools. Comparing the overall usability values of each tool (BPMN-Designer 1: -0.12; BPMN-Designer 2: 0.25; Tool 3: 0.73; Tool 4: 1.3; Tool 5: 0.7), our academic tools cannot compete with the commercial tools. Looking at the principles suitability for the task, controllability and suitability for learning, BPMN-Designer 2 is equal or better than one of the commercial tools, see Figure 2. Unfortunately, because of the composition of our subject set regarding to modeling experience we could not extract valid results regarding usability requirements of the overall group of possible modeling users. Therefore a follow-up usability study is needed with a higher number of subjects with more wide-spread range in terms of modeling experience.

After the analysis of results from the heuristic evaluation and the usability testing, we recommended to improve BPMN-Designer 2, especially regarding the principles of error tolerance (e.g. specific details for how to prevent and/or circumvent errors are necessary), of self-descriptiveness and of conformity with user expectations. We also provided our results to the vendors of the commercial tools for consideration in further software development.

The usability results can be interpreted as an indication that usability aspects are, at least until today, not in the focus of software developers and/or vendors in the field of business process modeling tools. This could be caused by the fact that business process modeling tools are still considered to be applications for experts and not for other stakeholders in the business process area, for instance process owners or chief process officers (CPOs).

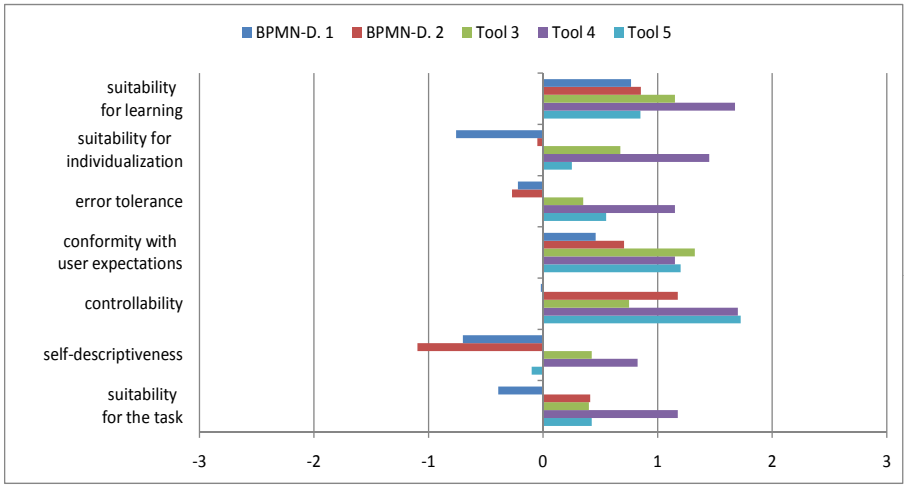

Figure 2: Usability evaluation results.

5 Conclusion

Our goal was to design an integrated usability approach which allows to evaluate usability aspects and single features and which can be used in the software development of a modeling tool. For the first time we applied the combination of usability and single tool features in the development process of a process modeling tool in academic environment. The approach can be utilised for different tasks in BPM like modeling a completely new process or understand an existing process. It is also applicable for users in different positions e.g. CPOs or modelers which have different responsibilities and therefore different requirements. Furthermore it can be adapted for different user groups with different requirements, e.g. novices or experts.

Our integrated approach consists of the four steps heuristic evaluation, usability testing, questionnaires as well as evaluation and recommendation. Through the combination of expert–centered and user–based usability evaluation methods and the modular design, it is possible to implement our approach in different stages in an iterative development process. Also, we hope to see more combinations of tests where usability is combined with specific tool features in the future. In order to test the application of this goal, we plan to exploit the benefits of the approach in the future development process of BPMN-Designer. We plan to circumvent the limitation that we were not able to produce valid results for the wide range in experience among process modelers, Thus, we want to expand the study to a set of subjects with very high experience in business process modeling because these modeling experts may have different requirements and/or expectations towards usability.

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