Business Process Evaluation in Agile Business Process Management Using Quality Models

Michael Gebhart
iteratec GmbH
Stuttgart, Germany
michael.gebhart@iteratec.de

Marco Mevius, Peter Wiedmann
HTWG Konstanz
Constance, Germany
mmevius/pewiedma@htwg-konstanz.de

***Abstract*—Agile business process management is an adaptation of the agile methodology, which is well-known in the area of software development. It supports the tight and efficient collaboration between customer and process analysts when designing processes. However, this methodology requires a governance approach that ensures the high quality of the processes. This article shows the usage of quality models to evaluate business processes in agile business process management environments and its specific challenges. To illustrate the approach, an existing quality model is reused and formalized. Afterwards, a business process in the context of offer management is captured and evaluated by means of this quality model.**

Keywords-business process; design; quality; agile; business process management; ISO 25000.

I. INTRODUCTION

This article is an extended version of [1]. Fast and efficient adaptability to business processes becomes an increasingly important competitive factor for organization [2]. For that reason, high business process flexibility is an important requirement for organizations, such as administration sections within companies, to counter current challenges. Among other things, explicit knowledge about the structure and functionality of business processes is essential for the understanding of organizational sequences [3]. For example, business processes, in which citizens and experts of public administration participate together, should be accessible for both sides easily. For that purpose, a targeted enhancement of Business Process Management (BPM) with the help of agile advantages generates new significant potential for the automation, modeling, interaction, and optimization of business processes. The idea of agility is described as the ability to balance flexibility and structure [4] and to minimize risks for instance by conforming project changes rapidly [5].

In the past, different (agile) approaches have been developed. One approach that is also chosen in this article is BPM(N)$^{Easy1.2}$ [6][7]. It describes a combination of Business Process Management and Business Process Model and Notation (BPMN) with the ambition of making BPM easier. In reference to the agile software engineering, which is already well-known and used in a lot of organizations and projects, the agile BPM method adapts aspects from it. The approach extents and supports the interaction between every participant with focus on more coherency without confronting them with unneeded complexity. Furthermore, it follows an empirical, incremental and iterative concept to increase predictability of the process quality and to reduce project risks [6]. For instance, the efficiency and effectiveness of capturing a business process can be enhanced significantly.

However, within the prediction and control phase of the business process quality, the participants have to know what constitutes a good process and how to evaluate processes [8]. Today, there are no general rules, which define what a good business process is. The literature suggests aspects, such as the customer value, process standardization, and the employee well-being to measure quality [9]. But this information is not sufficient to perform a systematic or even automatic quality analysis of business processes. Aggravating this situation, contradictory constraints and needs – for instance speed and quality – generate the need to focus on the delivering value [10].

To enable a systematic quality assurance in agile BPM from a functional point of view, this article introduces the application of quality gates and quality models. Quality gates define a specific point within a project to evaluate determined maturity and sustainability [11]. These quality gates appear frequently during the application of an agile BPM approach, such as BPM(N)$^{Easy1.2}$ and ensure the synchronization and acceptance of all participants. For instance, an automated business process has to correspond with all predefined requirements and expectations. The quality gates considered in this article are supposed to close the gap especially at the beginning and during the business process modeling step. The requirements and expectations are represented by quality models that enable a systematic evaluation of business processes. In this article, existing work in the context of business process evaluation is reused. I.e., existing quality models are evaluated and the preferred one is adapted [12] for applying and measuring it in BPM environments. Especially agile environments with short iterations and high interaction are suited for the continuous monitoring and improving of the business process quality.

The article is organized as follows: Section II analyses relevant literature regarding business process modeling. Furthermore, quality models for BPM and their application for agile BPM are discussed. Section III introduces the BPM(N)$^{Easy1.2}$ method and demonstrates where and how quality models can be applied within an agile approach. In Section IV, the application of a certain business process quality model in agile BPM is evaluated by means of a scenario from offer management. Section V introduces the tools, which have been applied during the evaluation. Especially, the internals of the quality analysis tool are revealed. Section VI presents the conclusion and discusses future research work.

II. BACKGROUND

This section describes the fundamental terms and existing work in the context of modeling and evaluating business processes. Regarding the quality of business processes, work that targets the quality from both a functional and a technical point of view is considered. Furthermore, this work is examined in detail regarding its applicability in agile BPM environments. As the approach chosen in this article was already applied in related disciplines, the according results are presented.

A. Modeling of Business Processes

In the following, work in the context of modeling business processes with focus on agile BPM is presented. The introduced approaches address especially the involvement of all participants within modeling business processes.

The process of continuous improvement and involvement of stakeholders is well-known in the area of quality management. Total cycle time or Six Sigma are examples cf. [13]. A variant of Six Sigma, the Lean Sigma approach, represents the combination of Lean and Six Sigma. This approach helps to improve the product and process quality on the one hand, and on the other hand it increases process performance. Audits, which are conducted internally or externally, are used to interview the user directly and to draw from the interview results conclusions about possible improvements in quality. These improvements lead not only to, e.g., an increased quality of business process activities execution, moreover, through the interviews the understanding of business processes can be enhanced.

In the context of BPM, Cheng et al. describe [14] the problem, which exists between the connection of business rules and business models. For instance, business rules can have compulsory possibilities of a sequence. These possibilities depend on business rules, which in the first step are often formulated in common language, e.g., "The customer is not allowed to order articles without logging in". Cheng et al. suggest a framework, which supports the mapping of business rules and business processes and assists the stakeholders in identifying inconsistencies. Hereby, the usage of this framework simplifies the "connections" of business rules and models, but takes not account of their quality itself explicitly.

Antunes et al. [15] focus on the integration of end users. They developed an approach and tool to support business process modeling from the perspective of end-users. For this purpose, Antunes et al. use concepts of representation and visual composition. In contrast to other approaches, there is not only a common language support, e.g., by adding annotations to a business process activity. The approach extends these annotations by adding pictures to a business process element. This additional illustration leads to a higher understanding of the modeled business processes.

The approach of Bittmann [16] adds additional information as natural language artefacts to business processes. Every business process activity can be described more in detail by adding a written text. Within this text, the identifier label of a business process activity, such as "entering data", has to be mentioned and linked. The approach fosters the higher integration of employees, especially of the operative business (non IT specialists).

B. Quality of Business Processes

In this section, work regarding the quality of business processes is introduced. This work is considered from both a functional and technical point of view. Furthermore, the applicability in agile BPM as introduced in the section before is examined.

The International Organization for Standardization (ISO) and the International Electro technical Commission (IEC) have created standards regarding the quality of software products. Both ISO/IEC 9126 [17] and the successor ISO/IEC 25000 ff. [18] define relevant terms for software product quality. Furthermore, they describe quality characteristics, their subcharacteristics, and their final quality measure elements. They hereby provide a wide overview of measuring the quality of software products. In order to apply these standards on business processes, the term "business process" has to be distinguished from "business process model". As the standards refer to software products, they can only be directly applied on business process models as software artifacts. Also, in this case, only a subset of described characteristics is applicable. Heinrich et al. [19], Sánchez-González et al. [20], and YeongSeok et al. [21] show the adaptation of these standards on business process models. However, according to the introduction, we focus on the quality of business processes and their content instead of the models as software artifacts and their syntactical correctness etc. For that reason, the standards cannot be applied. Nevertheless, they give hints about characteristics that might be important for business processes as well.

Further standards regarding quality management focus on quality management systems. Examples are ISO 9000 ff. [22], or branch-specific manifestations, such as the European Norm (EN) 9100 for aerospace. There also exist standards for the quality management in projects, such as ISO 10006. Even though they consider the quality in business domains and in some cases also describe business processes, the quality of the business processes themselves is not explained in detail. This is also the case when choosing Capability Maturity Model Integration (CMMI) or IT Infrastructure Library (ITIL).

In [9], Krogstie describes criteria for so-called good processes. He introduces dimensions of value that is valid for most customer groups. Furthermore, he summarizes heuristics for good business processes. Even though no metrics are provided, these heuristics can be good starting points to derive more concrete quality aspects that again enable a systematic and automatic evaluation of business processes. In addition, this work helps to understand the purpose of business processes and why it is important to have good processes. Thus, it forms the framework for a quality model as it focuses on the motivation and strategic goals of business processes.

In order to enable a more systematic quality analysis of business processes, Kneuper created the quality model Gokyo Ri based on existing standards, such as ISO 9000, CMMI, and ITIL [23]. It refines the quality of business processes so that their quality can be determined. Even though this quality model focuses on business processes and their content, the quality model is still too abstract to be used in agile business process management environments. In agile projects the quality has to be determined in short intervals best automated based on modeled business processes. Thus, Gokyo Ri has to be further refined until at least a subset of the quality attributes can be determined automatically or with short user interaction intervals.

Similarly, Lohrmann et al. introduce quality attributes for business processes [8]. Also, in this case the quality attributes are derived from business-related quality concerns and focus on the content of the business process and not the artifact. Lohrmann et al. distinguish between the efficacy and efficiency of business processes that can be either determined on basis of business process models and running instances. Former is called business process design and implement efficacy and efficiency. Latter is called business process enactment efficacy and efficiency. Even though Lohrmann et al. do not describe an entire quality model, they introduce quality attributes that are relevant for the business process quality as considered in this article. Nevertheless, similar to the quality model introduced by Kneuper the quality attributes are still too abstract to be applied in an agile environment. They first have to be refined so that they can be determined either based on business process models or by answering simple questions.

Regarding a more technical point of view, Suarez et al. [24] describe best practices for modeling business processes using certain languages, such as the Business Process Model and Notation (BPMN). Even though this article also focuses on BPMN as modeling language, these best practices mostly consider syntactical correctness of created models or related issues. The content of the processes and their quality from a functional point of view is not considered. The described best practices are also not aligned with a holistic quality model. So, the impact of these best practices on abstract quality characteristics is not obvious. The best practices can increase the quality of modeled business processes. They are also applicable in agile BPM environments as they can be easily determined or can be even measured automatically by tools. Nevertheless, they do not target the kind of business process quality considered in this article.

C. Related Application in Service-Oriented Architectures

The approach chosen in this article has already been successfully applied in other areas. One example is the evaluation of web services in service-oriented architectures: Today, a lot of best practices exist that describe how to design web services so that they fulfill wide-spread quality attributes, such as loose coupling and autonomy. For example, Erl [25][26], Cohen [27], and Josuttis [28] describe such best practices. Whenever the IT architect or a developer has to decide, how to design a web service, these best practices should be considered. However, due to the increasing complexity of architectures, it is nearly impossible to consider them all without mistakes. Sometimes, the best practices require an understanding of the entire architecture of the considered system. And in addition, in some cases, they refer to technical details that have to be completely understood to apply the best practices successfully. Furthermore, similar to the quality models for business processes, these best practices are described informally and require interpretation effort. This hampers their efficient application in real-world projects. IT architects and developers have to map the textually described best practices onto the technology used in the concrete project. This again may result in wrong applications of the best practices.

For that reason, in [28], Gebhart et al. introduced metrics that reuse the mentioned work of Erl et al. to evaluate web services regarding the introduced best practices in a comprehensible and repeatable manner. These metrics are formalized so that they can be systematically measured on web services described using the Service oriented architecture Modeling Language (SoaML) [29] as profile for the Unified Modeling Language (UML) [30]. By means of these metrics, IT architects and developers know exactly, what elements of the modeled architecture have to be considered to evaluate a service. Based on mapping rules introduced by Gebhart et al. in [31], the metrics could be mapped to concrete implementation artifacts. This enables the systematic evaluation of implemented web services using Web Services Description Language (WSDL) [32] to describe the service interface, XML Schema Definition (XSD) [33] for the data types, and Service Component Architecture (SCA) [34] to implement the internal logic. The application of the metrics is demonstrated for a geographical information system by Gebhart et al. in [35]. Also, in this case, existing abstract quality attributes were refined to enable a fully or partially automated quality assurance. As result, a solution was created to ensure the systematical creation of a flexible and maintainable architecture [36].

D. Summary and Need for Action

The overview shows that there exists a lot of work in the context of modeling and evaluating business processes as required in this article. However, some work focuses on best practices or quality attributes from a functional point of view that are too abstract to be measured directly and especially too heavyweight to be determined in agile environments. Other work considers fine-grained quality aspects, such as syntactical correctness that can be easily determined, however does not provide value for the quality of business

process from a functional point of view. This article shows how to fill this gap by reusing existing quality models that focus on quality attributes from a functional point of view and breaking these quality attributes down into aspects that can be either directly measured on business process models or easily answered by process analysts. The approach has already been successfully applied in the context of service-oriented architectures. For that reason, the methodology to derive measurable quality aspects from quality models was reused. Furthermore, when evaluating the approach, the same quality analysis has been applied.

III. Business Process Evaluation in Agile Business Process Management Using Quality Models

In order to evaluate business processes in an agile BPM project, on the one hand, the point of time when an evaluation of the business process is possible and useful has to be determined. For that purpose, the approach of agile BPM has to be examined in detail. On the other hand, an appropriate quality model has to be identified and adapted so that the quality of the business process can be determined in a systematic and repeatable manner.

A. Agile BPM

As mentioned before, there exist different approaches of agile BPM. To identify the point of time, when to apply a quality model in an agile BPM project, these approaches have to be analyzed in detail. For instance, Meziani [37] introduces a method called AGILIPO. This method describes an approach, which focuses especially on the integration of software systems and organizational knowledge. To automate business processes, the method uses concepts as used in agile software engineering. In addition, AGILIPO suggests the usage of social media tools to interact with all stakeholders. For example, the stakeholders can write comments (common language) on existing business process models. This feedback can be used to optimize current models in a next iteration.

Another approach is provided by Schnabel et al. [38]. They outline the Lightweight Process Modelling process and the Language for Lightweight Process Modelling (LLPM). The formal semantic of LLPM is focused on a simple graphical form. LLPM "introduces goals as unbound activities that are bound to a particular service either at design time or at runtime by composition tools" [38]. As a result, business process models can be maintained more flexible and agile.

In the following, the agile approach BPM(N)$^{Easy1.2}$ [6] is used to show when (time of application) during the methodology the quality model is expected to be applied. This approach has been chosen, because of this holistic concept behind. BPM(N)$^{Easy1.2}$ enables highly sophisticated agile BPM. It covers all aspects of BPM – from process design and process execution to process controlling with focus on the integration of all process participants. The following Fig. 1 provides an overview of the approach and the including quality gates. Latter are displayed as stars:

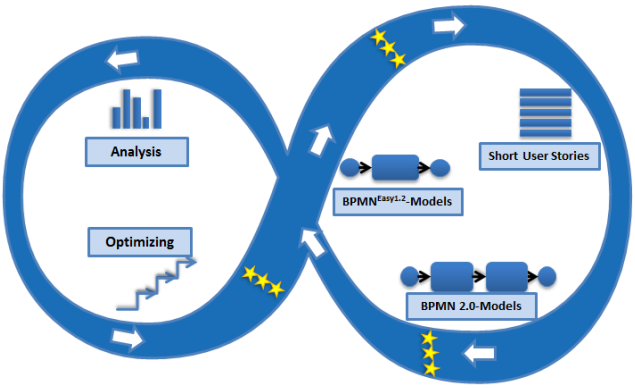

Figure 1. Illustration of the BPM(N)$^{Easy1.2}$ approach.

The approach consists of two connected cycles. One cycle is used to capture new BPMN$^{Easy1.2}$ models and short user stories. BPMN$^{Easy1.2}$ represents the modeling language of BPM(N)$^{Easy1.2}$ and a subset of BPMN. Both BPMN$^{Easy1.2}$ models and short user stories formulate the requirements of the activities within a business process. The models are used to design the flow in general and set up a first model very easily. The short user stories describe further information, e.g., additional business rules. The formulated requirements are the basis for the modeling and implementation of an enriched BPMN 2.0 business process. For the enrichment, a BPMN$^{Easy1.2}$ model and a number of user stories are selected to work on. Furthermore, the business process is modeled on the business user's point of view. In addition, in consultation with a business user, an IT expert is able to use the business process model to automate the process. Once the modeling and implementation stages are completed, the resulting BPMN 2.0 models are transferred to a final control. Within this control all participants assure that the result, e.g., an automated business process corresponds with the BPMN$^{Easy1.2}$ models and formulated short user stories (synchronization and acceptance).

Immediately after the acceptance, new requirements can be taken and transformed into a business process model or implementation. If defined key performance indicators show optimization potential (analysis and optimizing cycle), new BPMN$^{Easy1.2}$ models or short user stories will be generated. The several iteration and high collaboration between every participant allows the continuous monitoring of the business process quality [6].

However, in general there are still different weak points in agile methods. Mohammad [39] says that short response times and high interaction during the agile development do not require the writing of documents which can lead to a reduced quality of documentation. Furthermore, Mohammad [39] mentions the increased collaboration time of the participants. But in fact, in some circumstances there is not enough time for the required coordination or the participants are not at the same (physical) location [39]. In [40], agile methods are described as a risk of large or complex projects. The magnitude of uncertainty is increased. Therefore, agile

methods are mistrusted in most organizations. To counteract these disadvantages and related lack of quality, it is required to introduce quality checks during the application of an agile approach. In [41], quality checks are suggested to be applied to different steps of agile approaches.

According to [41] and with the assumption that software engineering has the same goals as BPM, e.g., cost reduction and collaboration enhancement, the quality gates listed in Table I are suggested for agile BPM approaches:

TABLE I. QUALITY GATES

Quality Gate	Time of Application	Comment
1	Formulation of user stories	Continuous feedback and collaboration between every participant
2	Modeling of business process	
3	Automation of business process	Test of process application
4	Acceptance testing	

Today, some of the quality gates have already been implemented to assure the determined quality. For instance, the quality gate 1 can be applied by a continuous feedback process between every participant or by means of standard assurance tests of the process application [42]. For quality gates 1, 3 and 4, methods already exist, which can be used to assess the quality, e.g., real tests of a process applications.

Therefore, in this article, the quality gate number 2 that is applied during the modeling of business process is considered to improve and guarantee the expected quality.

B. Quality Model Choice and Adaptation

In the previous section, quality gates during an agile methodology have been identified. One quality gate considers the quality of modeled business process. This section shows how this quality gate can be supported by IT.

In order to support this quality assurance, an appropriate quality model has to be prepared. For that purpose, first the most appropriate existing quality model has to be identified. Afterwards, its direct applicability has to be verified. As described in Section II, appropriate quality models are those introduced by Lohrmann et al. [8] and Kneuper [23]. However, in both cases, the introduced quality attributes have to be adapted for requirements in agile environments: As mentioned before, the quality of business processes has to be determined in short intervals, which again requires a quality analysis to be easy and lightweight. This requirement cannot be fulfilled by these existing quality models and the contained quality attributes. They are not formalized using metrics which hampers their automatic determination based on business process models. Furthermore, the informal description requires interpretation effort that can result in misunderstandings and wrong measures. This is a typical issue when performing quality analyses and has already been identified for other domains, such as the quality analysis of service-oriented architectures by Gebhart et al. [43].

Thus, after choosing a certain quality model, the quality attributes have to be refined if necessary until more fine-grained and comprehensible quality attributes are identified so that no interpretation is necessary any longer. They are called quality indicators, formalized as metric, and return a measure. It is not necessary that a quality indicator can be fully automatically measured on process models. If this is not possible as they require further knowledge, such as domain knowledge, the only condition is that it is possible to formulate unambiguous questions that can be answered by experts and do not require interpretation. Summarized, for every function and variable used within a metric, the criteria listed in Table II have to be fulfilled.

TABLE II. CRITERIA FOR FUNCTIONS AND VARIABLES IN METRICS

Criterion	Description
Technology Representation *for variables and functions*	A variable or function represents a certain aspect within the considered technologies, i.e., business process models in this case. This enables an automatic measurement.
Comprehensible Question *for variables and functions*	If Technology Reflection is not fulfilled, for example if expert knowledge is necessary, a comprehensible and unamabigious question can be formulated that can be answered by experts and does not require interpretation.
Composition *for functions*	If the previous criteria are not fulfilled, the considered function is composed of other functions using automatically measurable operators.

IV. EVALUATION

In this section, the methodology introduced in the previous section is applied and evaluated by means of a real-world example. For that purpose, first, the scenario is introduced. Afterwards, the quality criteria for business processes are exemplarily derived from a quality model. They constitute the basis for the business process analysis. In a next step, the business process is modeled. Finally, this business process is analyzed and revised using the criteria established before. The approach is shown in Fig. 2.

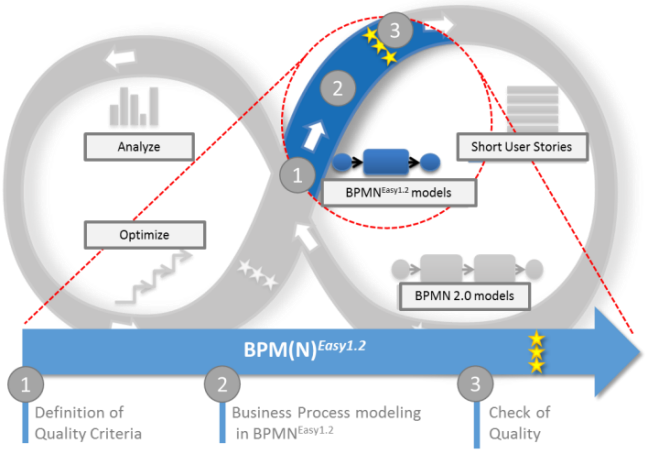

Figure 2: Quality gate and evaluation approach.

A. Scenario

The considered scenario "offer creation" originates from one of our industry partners. The activities in this scenario describe how to create a new offer. Participating roles are Sales, Accounting, and Calculation.

The corresponding business process is expected to be modeled with BPMN$^{Easy1.2}$. Besides the agile BPM methodology BPM(N)$^{Easy1.}$, BPMN$^{Easy1.2}$ is also an appropriate business process modeling language which uses BPMN 2.0 [44] but reduces its complexity so that it fits an agile BPM approach. After modeling the process using BPMN$^{Easy1.2}$, the resulting model can be enhanced, e.g., to create a model for business process automation.

To verify the correctness of the business process model, participants interacted with each other closely. All definitions were moderated and monitored by a BPM expert. If for example the IT experts had some understanding issues, these could be dealt with by direct dialog with the other participants.

B. Quality Criteria

To ensure the high quality of the business process model that is expected to be created for the scenario, first, the quality criteria have to be defined. These criteria constitute the basis for the evaluation. As described before, an existing quality model should be reused when possible. Based on this model, quality indicators should be derived as exactly formalized measures. Furthermore, for each quality indicator the expected target value has to be determined. The combination of quality indicators and target values represent the quality criteria.

In this article, the quality model and its attributes introduced by Lohrmann et al. [8] are chosen. In the following, two quality attributes and their correlating quality predicates are refined to derive quality indicators and target values.

1) Controlled resource consumption in activities: According to Lohrmann et al. [8], a business process fulfills this predicate when activities within the process are designed to avoid materials waste and capacity waste. This information is too abstract to be comprehensible on a certain business process model as it is not explained how this waste is reflected in process design. For that reason, the predicate and its quality attribute have to be refined into quality indicators.

For this purpose, best practices that could be identified in earlier projects are tested for their suitability to represent the considered predicate and its quality attribute. One best practice suitable in this case is that for each role at least two persons have to be available. This ensures that in case of a person being absent still another person can continue the work and other persons do not have to wait and to be idle, which represents a capacity waste. As the predicate refers to the business process as a whole, also the refinement has to be measured on the entire process. Thus, the indicator measures the degree to which the participating roles have more than one person assigned. This indicator can be formalized as metric (1) similar to the ones introduced by Gebhart et al. in [45]. Table III describes the used elements.

$$PAR(bp) = \frac{|F(R(bp),r,HSP(r))|}{|R(bp)|} \quad (1)$$

TABLE III. VARIABLES AND FUNCTIONS USED FOR PAR (1)

Element	Description
PAR(bp)	*Person Availability of Roles:* Degree to which roles in business process bp have more than one person assigned
R(bp)	*Role of Business Process:* roles used in business process bp
F(e, v, c)	*Filter:* filter the elements e by condition c that uses the variable v as iterator
HSP(r)	*Role Has Several Persons:* true if role r has more than one person

TABLE IV. FULFILLED CRITERIA FOR PAR (1)

Element	Fulfilled Criteria
bp	Technology Representation: The considered business process is represented by the BPMN process file
PAR(bp)	Composition: This function is composed of other functions and all operations can be automated.
R(bp)	Technology Representation: The roles are represented by the pools and lanes within the BPMN business process model
F(e, v, c)	Composition: This function is requires other functions as input and the filter operation can be automatically performed.
HSP(r)	Comprehensible Question: This aspect is not measurable on standard BPMN 2.0 artifacts. Thus, it has to be answered by an expert, but the question is easily to understand, unambigious and comprehensible: "Are more than one person assigned to role r?" As input, a boolean value is expected.

Based on the quality indicator, Table V can be derived, which shows the possible values of the quality indicators and their interpretation. The value 1 is the desired one as it represents the case that all roles within the business process are filled with at least two persons. Thus, 1 is the target value for the quality indicator PAR.

TABLE V. INTERPRETATION OF VALUES FOR PAR (1)

Value	Interpretation
0	No role within the business process is filled with at least two persons
Between 0 and 1	Some roles are filled with less than two persons
1	All roles within the business process are filled with at least two persons

In order to prove the suitability of this quality indicator as quality indicator in an agile environment, in Table IV for each element used in the formalization the criteria introduced in Table II are checked. The table shows that for each element the criteria are fulfilled. Thus, the quality indicator is a valid indicator for an agile environment. As mentioned before, we assume business process models using BPMN 2.0 [44], respectively the reduced language BPMN$^{Easy1.2}$.

Another best practice mentioned by Lohrmann et al. [8] that influences the controlled resource consumption is the usage of work item lists for all user groups. We assume that the user groups are represented by the roles participating in the business process. Therefore, the variables and functions applied for the previous metric PAR (1) can be partially reused. For each participating role, the usage of work item lists has to be requested. In a modeled business process, this cannot be recognized. This is the reason, why this information has to be answered by an expert.

$$WILU(bp) = \frac{|\,F(R(bp),r,UWIL(r))\,|}{|\,R(bp)\,|} \quad (2)$$

TABLE VI. VARIABLES AND FUNCTIONS USED FOR WILU (2)

Element	Description
WILU(bp)	*Work Item List Usage:* Degree to which roles within the business process bp use work item lists
UWIL(r)	*Role Uses Work Item List:* true if role r uses work item list

The used functions fulfill the criteria described in Table II as WILU is a composition of other functions and UWIL can be answered by a business analyst. Based on this quality indicator, Table VII shows the interpretation of values for WILU. According to this table, a value of 1 represents the case that all roles within the business process use work item lists. Thus, this value is the desired one.

TABLE VII. INTERPRETATION OF VALUES FOR WILU (2)

Value	Interpretation
0	No role within the business process uses work item lists
Between 0 and 1	Some roles use work item lists
1	All roles within the business process use work item lists

2) Controlled skill employment: A business process can only be efficiently performed when skill employment is controlled. According to Lohrmann et al. [8], this quality attribute or predicate is fulfilled when all activities are documented and trained. This refinement can be used as measurement. In BPMN, these activities are represented by manual tasks or tasks that are not further specified yet.

$$CSE(bp) = \frac{DT(bp)+TT(bp)}{2} \quad (3)$$

$$DT(bp) = \frac{|\,F(MT(bp),t,D(t))\,|}{|\,MT(bp)\,|} \quad (4)$$

$$TT(bp) = \frac{|\,F(MT(bp),t,T(t))\,|}{|\,MT(bp)\,|} \quad (5)$$

Also, in this case, all used functions and variables are described in Table VIII. They fulfill the required criteria defined in Table II as the manual tasks represent certain aspects within the technology and the other functions are either composed of others or comprehensible questions can be formulated as for D(t) and T(t).

TABLE VIII. VARIABLES AND FUNCTIONS USED FOR CSE (3, 4, 5)

Element	Description
CSE(bp)	*Controlled Skill Employment:* Degree to which skill employment is controlled in business process bp
DT(bp)	*Documentation of Tasks:* Degree to which manual tasks in business process bp are documented
D(t)	*Documentation:* true if task t is documented
TT(bp)	*Training of Tasks:* Degree to which manual tasks in business process bp are trained
T(t)	*Training:* true if task t is trained

According to Table IX, all manual tasks within the business process are documented and trained, when CSE (3) returns the value 1. Thus, this value is the desired and expected one.

TABLE IX. INTERPRETATION OF VALUES FOR CSE (3)

Value	Interpretation
0	No manual task within the business process is documented or trained
Between 0 and 1	Some manual tasks within the business process are documented and trained
1	All manual tasks within the business process are documented and trained.

In this article, we focus on this best practice as solely quality indicator for the considered predicate. If further best practices, standards, or guidelines can be identified as influencing quality indicators, they can be added later and have to be weighted.

Thus, in this article, four quality indicators with appropriate quality criteria are exemplarily identified. These concrete and partially automatically measurable quality indicators again influence more abstract quality attributes. Fig. 3 shows the derived quality model.

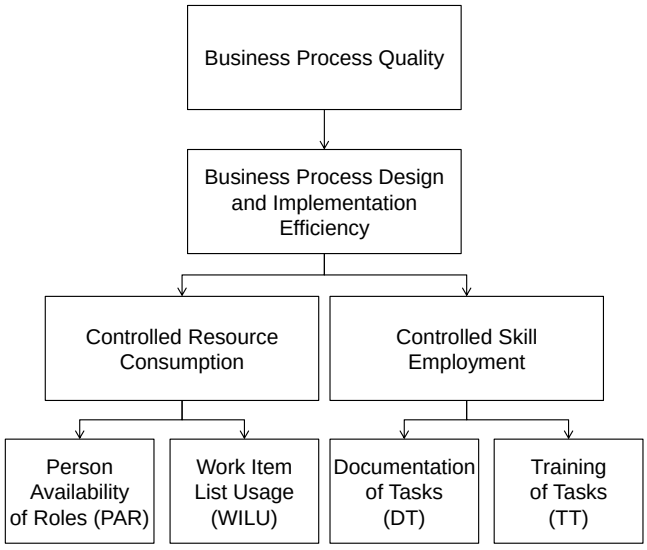

Figure 3. Derived quality model.

C. Business Process Modeling

After defining the quality criteria for the business process, in a next step, the business process can be modeled. The business process has been captured using the mobile application BPM Touch [46] (see more details in Section V). The mobile application supports agile BPM approaches by help of new information input concepts, e.g., the capturing of business process activities such as "Enter Offering" (c.f. fig. 4) can be done by audio recording instead of losing time writing this information down. The core of the user interface paradigm focuses on a simple touch technique. The modeling of business processes is carried out exclusively by touching a mobile device such as smartphone or tablet. For recording audio files participants can use built-in features such as the camera function or microphone of their mobile devices. Applying this mobile tool, a first draft of the business process has been modeled from the start event to end event. Fig. 4 shows the business process model.

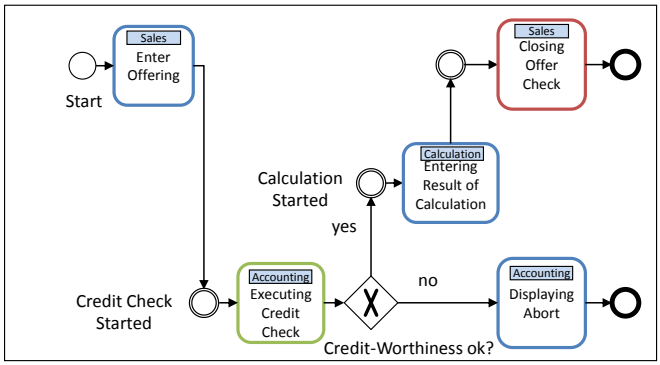

Figure 4. Offer creation business process.

The business process requires three roles: Sales, Calculation and Accounting and follows two different paths. In case of a successful credit check, the Sales can finalize the offer otherwise the business process will be aborted. During the scenario, the first draft of the business process model has been designed. BPMN$^{Easy1.2}$ provides three different activity types: manual (green form), semi-automated (blue form) and automated (red form). For instance, the "Enter Offering" activity is computer-aided and can be defined as a semi-automated activity. In addition, the required user stories have been described according to an agile methodology.

D. Analysis

When the business process is modeled, it can be analyzed regarding the prior defined quality criteria. For that purpose, the identified quality indicators are applied on the business process model and the results are compared to the expected and desired target values. To analyze the business processes, we adapted and applied the QA82 Analyzer to calculate the metrics. Furthermore, this tool enables to create questions for metrics that cannot be calculation but have to be answered by business analysts. Details about this analysis tool are provided in Section V.

1) Controlled resource consumption in activities: Applied on the modeled business process, the metric PAR (1) returns a value less than 1 as we realized by means of interviews that not every role is filled by at least two persons yet, i.e., HSP(r) is not true for all roles. Table V shows how to interpret this value. In order to fulfill the predicate of controlled resource consumption in activities, the metric is expected to return 1 as desired value. Thus, the business analyst is made aware to ensure that some further persons have to be assigned to roles with only one person. Even though if this is not possible, the business analyst gets the information that this fact represents a critical point for the efficiency of the business process.

Furthermore, in our scenario, only the Accounting uses with work item lists. This is the reason, why the second quality indicator WILU also returns a value less than 1. As described before, a value of 1 is the desired one. Thus, the business analyst is also made aware, how the controlled resource consumption and thus the business process design and implementation efficiency as part of the business process quality can be increased.

2) Controlled skill employment: In our scenario, all tasks represent manual tasks as automation has not been specified yet. When the metric is calculated, the business analyst has to answer, whether all of these tasks are documented and trained. In our scenario, the business analyst realized that this is not the case. Only some tasks are documented and trained. Thus, the metric returns a value less than 1. The interpretation of this value is shown in Table IX.

By applying the refined metrics, the business analyst is made aware that the documentation and training is important for the efficiency of the business process. If the metric returns a value less than 1, the analyst gets the information that further documentation and training effort is necessary.

E. Revision

Based on the analysis results, the business analyst can revise the business process. In our scenario, the business analyst was made aware that in some cases only one person is responsible for a certain task, that more work item lists should be used, and that not all tasks are documented and trained. By means of this information, the business analyst can revise the business process and the organization of the company.

In our scenario, the application of formalized quality indicators enabled the business analyst to systematically increase the quality of the business process. Furthermore, by means of the exact formalization, misunderstandings and interpretation effort could be avoided. The time for evaluating the business process could be reduced and the analysis is repeatable which enables a comparison of results over time. By applying appropriate tools, the efficiency of the evaluation could be further increased. The business process could be modeled in a lightweight manner and the analysis tool guided the business process through the entire evaluation by asking necessary questions. For that reason, in the next section, the applied tools are further described.

V. TOOL SUPPORT

This section describes the functionality of the used tools in detail. During the evaluation two tools have been applied: BPM Touch [46] and QA82 Analyzer [47].

A. Modeling Business Processes

Existing solutions mainly represent a transformation of existing desktop BPM tools on mobile devices. In contrast, the described mobile application implements innovative concepts. The application implements user-friendly features and potentials of mobile devices were consistently emphasized.
Fig. 5 shows the main screen for modeling a BPMN$^{Easy1.2}$ business process.

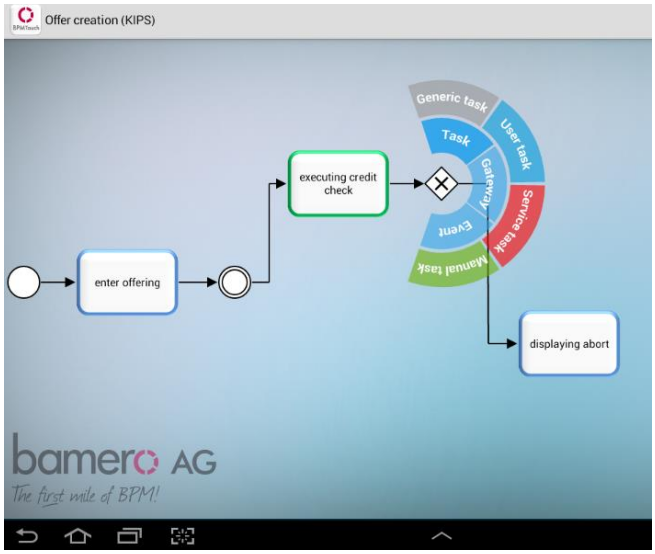

Figure 5. BPM Touch to model business process mobile

After a business process has been selected by a simple click on the sidebar, the business process model appears on the screen. The sidebar (on the left) contains all stored processes and allows a quick navigation between the business processes. The menu bar on the top provides basic functions to, for instance, create or save a new business process. In addition, a "share"-button allows the direct distribution of BPMN$^{Easy1.2}$ models to other participants. For example, business process models can be shared via e-mail, cloud service or automatically generated PowerPoint slides. The menu bar changes automatically in an "edit mode" if a business process item is touched. Furthermore, the handling of the canvas is very intuitive. For example, the start of each business process is already defined by a default start event. In addition, a "long touch" calls a highly innovative pie menu. This menu offers all possible elements of BPMN$^{Easy1.2}$.

All these functions of the mobile application address and support every activity during the agile BPM approach. For instance, BPMN$^{Easy1.2}$ models can be modeled directly from every participant without losing a great deal of time on training or coaching.

B. Quality of Business Processes

In order to increase the efficiency of quality analyses especially in agile environments, an appropriate tool support is necessary. For that purpose the already existing QA82 Analyzer [47] (Fig. 6) was applied. It is suited for agile environments and hybrid quality indicators that combine full-automated analyses and questions that have to be answered by the user for the following reasons: First, it supports the integration of custom quality models and combines the measure of model elements with questions that can be answered by experts, i.e., process analysts in this case. Second, the QA82 Analyzer can be integrated in business process modeling tools, such as BPMN$^{Easy1.2}$, using web services. This enables the display of quality analysis results directly in existing environments. Finally, the QA82 Analyzer allows the provisions of advices about how to improve the quality. As result, process analysts can model business processes using their modeling tool and directly get hints about how to design the process to improve their quality based on the custom quality model.

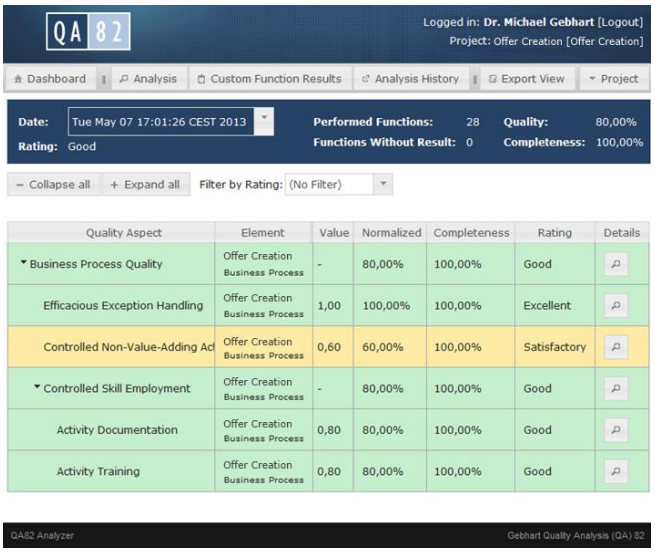

Figure 6. QA82 Analyzer to analyze business process.

To adapt the QA82 Analyzer for the evaluation of business processes in agile BPM, the quality model based on the quality attributes of Lohrmann et al. and the derived quality indicators were formalized and integrated into the QA82 Analyzer. This includes the mapping of functions to technology, i.e., to BPMN 2.0 artifacts, and the formulation of appropriate questions if necessary.

The QA82 Analyzer uses the concept of a query-based static analysis introduced by Gebhart in [48]. For that purpose, so-called information providers are utilized. When the user wants to query the quality of a certain business process, this information need is sent to the Analyzer component of the QA82 Analyzer. This component then tries to satisfy this information need. For that purpose, it looks up and queries available information providers. An information provider is a software component that is able to receive and to possibly answer a query. The concept of an information

provider is further refined into technology providers and refinement providers. A technology provider on the one hand is able to answer the query directly by means of technical information. For example, a BPMN technology provider is able to answer queries like "Return the number of tasks within the business process" or "Return all manual tasks within the business process". There might further technology providers exist. In the context of the evaluation of services in service-oriented architectures, a WSDL technology provider and SCA technology provider have been developed. These information providers are able to answer queries like "Return all provided operations of a certain service". A refinement provider on the other hand is able to refine a query into several sub-queries and to compose the answers of the sub-queries to the answer for the original query. For example, when the roles performing manual tasks are required, first, the manual tasks of the business process are queried. Afterwards, for each manual task returned by the BPMN technology provider, the performing roles are queried. This is again answered by the BPMN technology provider. The approach is illustrated in Fig. 7

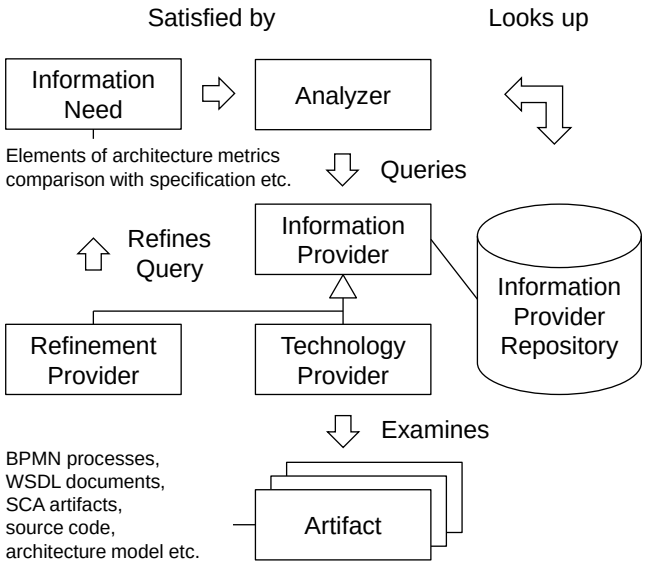

Figure 7. Query-based analysis approach.

The advantage of this approach is that with minimal effort new technologies and queries can be supported. To support the quality model introduced in this article, a BPMN technology provider was developed. Furthermore, to implement the quality model, a BPM refinement provider was developed that represents the quality attributes of the quality model. For example, the quality indicator Controlled Skill Employment (CSE) described in Table VI is contained by this refinement provider. If the Controlled Skill Employment is queried for a certain business process, the Analyzer sends the query to all information providers. The information providers try to answer the query, but there is only the refinement provider representing the quality model that is able to answer it. The refinement provider knows that to answer the query it first has to get the results for Documentation of Tasks and Trainings of Tasks for the considered business process. Thus, it sends these queries sequentially to the Analyzer component. The Analyzer component again tries to answer the queries by sending it to all available information providers. In this case, again the refinement provider is able to understand and answer the query. For Documentation of Tasks it knows that it has to find out how many of the manual tasks within the business process have been documented. For that purpose, the refinement provider first sends a query to the Analyzer component to receive all manual tasks in the business process. The Analyzer component tries to answer this query by asking all available information providers. In this case, the BPMN technology provider is able to answer the query. It returns all manual tasks in the process. Next, the Analyzer component returns this result to the refinement provider. Now, the refinement provider tries to answer the Documentation for each returned manual task. Thus, for each of the manual tasks, a query is sent to the Analyzer component. Once again, this component tries to answer the queries. However, in this case, there is no information provider able to answer the query. If this is the case, the Analyzer component does something special: It creates a question for the analyst to answer this query manually. Thus, in this case, for each manual task, the analyst is asked whether this one is documented or not. The same happens to the query about the training of the manual tasks. For each task, a question is generated and the analyst has to answer whether the task is trained or not. When the analyst has answered these questions, the analysis can be started again. This time, the answers are considered within the analysis. This means, when the Analyzer component tries to answer the queries Documentation and Training for each manual task, the answers of the analyst are returned as result. These results are used by the refinement provider to create the answer for the original query Controlled Skill Employment. Fig. 8 illustrates the interaction between the Analyzer component and the BPM information provider.

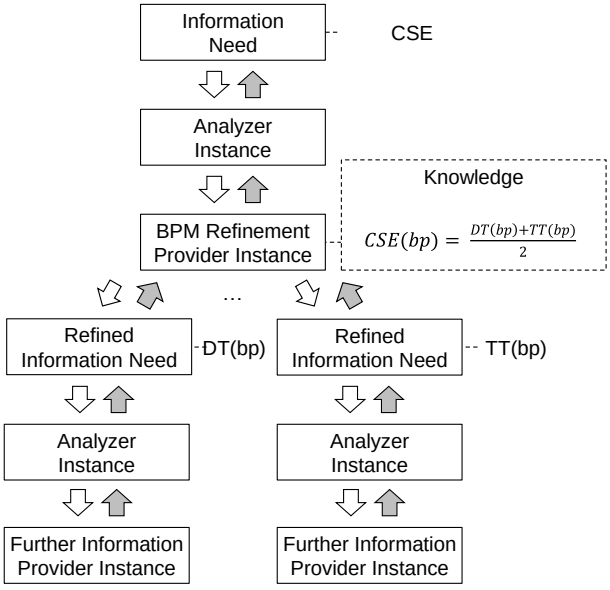

Figure 8. Interaction between Analyzer and BPM refinement provider.

As result, the QA82 Analyzer can be used to apply the identified quality indicators on any BPMN 2.0 or BPMN$^{Easy1.2}$ compliant business process. The concept of business process quality is step-by-step refined until information can be automatically measured on concrete business process elements, such as BPMN tasks, or a concrete question can be asked. The answers for these questions are stored and considered during the next quality analysis iteration. By this means, the business analyst does not have to answer the questions again and again. Only the first time certain information has to be added manually, the question has to be answered. This increases the efficiency of the evaluation and reduces the effort. Furthermore, the QA82 Analyzer stores the analysis results. This enables a comparison of results over time as previous results are accessible.

VI. Conclusion and Outlook

In this article, we demonstrated the application of business process quality models to support agile business process management (BPM) and to assure a high quality of created business process (applications). For that purpose, we provided a literature overview and described the general connections between quality assurance and agile BPM. Furthermore, we chose the agile BPM method BPM(N)$^{Easy1.2}$ and the quality model introduced by Lohrmann et al. [8] exemplarily. After the identification of the challenges, e.g., the degree of employee skills, we have shown how to address them.

First, the application of business quality models was aligned with an agile methodology. As essential deficit, the abstraction of available quality attributes was identified. To solve this issue, we demonstrated how these quality attributes can be refined to be applicable in agile environments. Hereby, we focused on the end users mainly and explicated how common language can be used to generate higher quality easily. Finally, we illustrated necessary tool support to increase the efficiency of quality analyses.

To illustrate our work, an evaluation in the context of a real business process was chosen. We described the scenario, the specification of quality criteria, the modeling of the business process, and finally the analysis and revision of the created business process model. The refined quality attributes enabled the systematic analysis of this process and the results helped the process analysts to revise the process and its environment in a quality-oriented manner. Even though the quality of a business process includes a lot of further aspects not covered in this article, the application of a fine-grained quality model increases the awareness of relevant aspects and supports the creation of high-quality business processes.

Thus, our approach enables companies and their analysts to increase the quality of created business processes whilst reducing at the same time effort and costs for quality assurance. All participants, such as business analysts, can create business process models using their preferred modeling tool and manually analyze created models in a systematic manner. When integrating the quality model and appropriate quality analysis methods into the tools, the analysts can even receive feedback about the quality of created models directly. Finally, derived advices could be shown and help the analysts to improve the created business models with regard to quality attributes that influence business-related goals.

Next, we will consider further quality attributes and derive appropriate quality indicators to enhance the created quality model. As described in this article, we will focus on reuse of existing quality attributes. In addition, we will investigate how all participants can communicate and interact more efficiently to increase the quality continuously during the entire business process lifecycle.

Also, the used tools will be investigated more in detail focusing on improving and extending the tools itself. For instance, the integration with existing modeling tools has to be enhanced. Finally, the approach is expected to be applied in further business process management projects to identify advantages and also weaknesses that have to be examined.

References

[1] M. Gebhart, M. Mevius, and P. Wiedmann, "Application of business process quality models in agile business process management," The Sixth International Conference on Information, Process, and Knowledge Management (eKNOW), 2014, pp. 152-158, ISBN: 978-1-61208-329-2.

[2] T.M. Bekele and Z. Weihua, "Towards collaborative business process management development current and future approaches," in Communication Software and Networks (ICCSN), 2011 IEEE 3rd International Conference, 2011, pp. 458-462.

[3] J. Eder and H.Pichler, "Business Process Modeling and Workflow Design," in D.W. Embley and B. Thalheim (eds), Handbook of Conceptual Modeling, Springer, 2011, pp. 259-286.

[4] J. Highsmith, "Agile software development ecosystems," Pearson Education, 2002, pp. 26-34.

[5] Agile Manifesto, http://agilemanifesto.org. [accessed: May 21, 2013]

[6] M. Mevius, R. Stephan, and P. Wiedmann, "Innovative approach for agile bpm," The Fifth International Conference on Information, Process, and Knowledge Management (eKNOW), 2013, ISBN 978-1-61208-254-7.

[7] M. Mevius and P. Wiedmann, „BPM(N)$^{Easy1.2}$ – Gebrauchssprachliche gestaltung IT-basierter prozesse," 8. Workshop „Bewertungsaspekte service- und cloudbasierter Achitekturen (BSOA)" der GI Fachgruppe „Software-Messung und -Bewertung", 2013, pp. 31-46.

[8] M. Lohrmann and M. Reichert, "Understanding business process quality," in Business Process Management - Theory and Applications, Springer, 2013, pp. 41-73.

[9] J. Krogstie, "Model-Based development and evolution of information systems – a quality approach," Springer-Verlag, London, 2012.

[10] J. Highsmith, "Agile project management – creating innovative products," Addison-Wesley Professional, 2009, pp. 15-16.

[11] F. Salger, M. Bennicke, G. Engels, and C. Lewerentz, "Comprehensive architecture evaluation and management in large software-systems," Fourth International Conference on the Quality of Software Architectures, 2008, pp. 205-219.

[12] E. Mnkandla and B. Dwolatzky, "Defining agile software quality assurance," International Conference on Software Engineering Advances, IEEE 0-7695-2703-5/06, 2006.

[13] J. vom Brocke and M. Rossmann, "Handbook on business process management 1: introduction, methods, and information systems", Springer Verlag, Heidelberg, 2010.

[14] R. Cheng, S. Sadiq, and M. Indulska, "Framework for business process and rule integration: a case of BPMN and SBVR," Business

Information Systems Lecture Notes in Business Information Processing Volume 87, 2011, pp. 13-24.

[15] P. Antunes, D. Simões, L. Carriço, and J. A. Pino, "An end-user approach to business process modeling," Journal of Network and Computer Applications 36 (2013), pp. 1466 -1479, 2013.

[16] S. Bittmann, D. Metzger, M. Fellmann, and O. Thomas, "Additional information in business processes: a pattern-based integration of natural language artefacts," Lecture Notes in Informatics, Modellierung 2014, ISBN 978-388579-619-0, pp. 137-152.

[17] International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC), ISO/IEC Standard No. 9126: Software Engineering – Product Quality; Parts 1-4.

[18] International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC), ISO/IEC Standard No. 25000: Software Engineering – Software Product Quality Requirements and Evaluation (SQuaRE) - Guide to SQuaRE.

[19] R. Heinrich and B. Paech, "Defining the quality of business processes," in Lecture Notes in Informatics Vol. P-161, 2010, pp. 133-148.

[20] L. Sánchez-González, F. Ruiz, F. García, and M. Piattini, "Improving quality of business process models," in Evaluation of Novel Approaches to Software Engineering, 2013, pp. 130-144.

[21] L. YeongSeok, B. JungHyun, and S. Seokkoo, "Development of quality evaluation metrics for BPM (business process management) system," in Proceedings of the Fourth Annual ACIS International Conference on Computer and Information Science, 2005, pp. 424-429.

[22] International Organization for Standardization (ISO), ISO Standard No. 9000: Quality Management Systems – Fundamentals and Vocabulary.

[23] R. Kneuper, „Gokyo ri: messung und bewertung der qualität von entwicklungsprozessen am beispiel des v-modell xt," in O. Linssen, M. Kuhrmann (Eds.): Qualitätsmanagement und Vorgehensmodelle, Shaker, 2012, pp. 25-34.

[24] G. N. Suarez, J. Freund, and M. Schrepfer, "Best practice guidelines for BPMN 2.0," in BPMN 2.0 Handbook, 2011, pp. 153-165.

[25] T. Erl, SOA – Principles of Service Design, Prentice Hall, 2008. ISBN 978-0-13-234482-1.

[26] T. Erl, "SOA – Design Patterns", Prentice Hall, 2008. ISBN 978-0-13-613516-6.

[27] S. Cohen, "Ontology and Taxonomy of Services in a Service-Oriented Architecture," Microsoft Architecture Journal, 2007.

[28] N. Josuttis, SOA in Practice – The Art of Distributed System Design, O'Reilly & Associates, 2007. ISBN 978-0-596-52955-0.

[29] OMG, "Service oriented architecture modeling language (SoaML) – specification for the uml profile and metamodel for services (UPMS)," Version 1.0.1, 2012.

[30] OMG, "Unified modeling language (UML), superstructure," Version 2.4.1, 2011.

[31] M. Gebhart and J. Bouras, "Derivation of web service implementation artifacts from service designs based on soaml," International Journal on Advances in Software, 6(1&2), 2013, pp. 170-180.

[32] W3C, "Web Services Description Language (WSDL)," Version 1.1, 2001.

[33] W3C, "XML Schema Part 0: Primer Second Edition," 2004.

[34] Open SOA (OSOA), "Service component architecture (SCA), SCA assembly model V1.00," http://osoa.org/download/attachments/35/SCA_AssemblyModel_V100.pdf, 2009. [accessed: January 04, 2011]

[35] M. Gebhart and S. Sejdovic, "Quality-oriented design of software services in geographical information systems," International Journal on Advances in Software, 5(3&4), 2012, pp. 293-307.

[36] M. Gebhart, "Service identification and specification with SoaML," in Migrating Legacy Applications: Challenges in Service Oriented Architecture and Cloud Computing Environments, Vol. I, A. D. Ionita, M. Litoiu, and G. Lewis, Eds. 2012. IGI Global. ISBN 978-1-46662488-7.

[37] R. Meziani and I. Saleh, "Towards a collaborative business process management methodology," International Conference on Multimedia Computing and Systems (ICMCS), 2011.

[38] F. Schnabel, Y. Gorronogoitia, M. Radzimski, F. Lecue, N. Mehandjiev, and G. Ripa, "Empowering business users to model and execute business processes," BPM 2010 Workshops, Springer, 2011, pp. 433-448.

[39] A. H. Mohammad, T. Alwada'n, and J. Adabneh, "Agile software methodologies: strength and weakness," International Journal of Engineering Science and Technology, 2013, ISSN : 0975-5462, pp. 455-459.

[40] J. Barlow, J. Giboney, M. Keith, D. Wilson, R. Schuetzler, P. Lowry, and A. Vance, "Overview and guidance on agile development in large organization," Communications of the Association for Information Systems, Vol. 29, No. 2, 2011, pp. 25-44.

[41] M. Huo, J. Verner, L. Zhu, and M. Babar, "Software quality and agile methods," 28th Annual International Computer Software and Applications Conference, IEEE 0730-3157/04, 2004.

[42] A. Janus, A. Schmietendorf, R. Dumke, and J. Jäger, "The 3C approach for agile quality assurance," Emerging Trends in Software Metrics (WETSoM), 2012 3rd International Workshop, 2012.

[43] M. Gebhart and S. Abeck, "Quality-oriented design of services," International Journal on Advances in Software, 4(1&2), 2011, pp. 144-157.

[44] OMG, "Business process model and notation (BPMN)", Version 2.0, 2011.

[45] M. Gebhart and S. Abeck, "Metrics for evaluating service designs based on soaml," International Journal on Advances in Software, 4(1&2), 2011, pp. 61-75.

[46] bamero AG, "BPM Touch® - The Revolution," http://www.bamero.de., accessed on 08/05/2014.

[47] Gebhart Quality Analysis (QA) 82 GmbH, QA82 Analyzer, http://www.qa82.com. [accessed: May 21, 2013]

[48] M. Gebhart, "Query-based static analysis of web services in service-oriented architectures," International Journal on Advances in Software, 7(1&2), 2014, pp. 136-147.