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CODIFICATION OF KNOWLEDGE IN BUSINESS PROCESS IMPROVEMENT PROJECTS

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Abstract

In times of globalization, new technologies and high market transparency, companies search for ways to raise the efficiency of their business processes and achieve long-term customer relationships. Therefore enterprises are strongly devoted to business process improvement (BPI) initiatives. However, in times of globally spanning inter-organizational business processes, conducting BPI initiatives is particularly challenging due to the necessary diverse and distributed knowledge. Successful BPI projects require the participation of a variety of employees who are directly involved in a business process. The employees have tacit process knowledge that needs to be transformed into explicit knowledge to derive improvement opportunities in a BPI project. To reach this, a set of easy to understand and well-structured BPI techniques is required to encourage employees to participate in corresponding initiatives. Further, the codification of the results gained in such initiatives is decisive to enable their proper documentation, communication and processing.

The paper at hand introduces a BPI roadmap for coordinating the structured use of BPI techniques in a project. The roadmap is based upon a set of formal conceptual model types for codifying the results generated by each technique. In addition, reports are specified that process the model information and facilitate the communication and documentation of the results. The presented approach thus contributes to the systematic transformation of employees' tacit process knowledge to explicit knowledge in the course of BPI initiatives. By applying the roadmap in a use case, its benefits for BPI initiatives are illustrated.

Keywords: Business process improvement, knowledge codification, metamodel.

1 Introduction

Production as well as service enterprises undergo profound transformations these days (Gardner, 2013; Hamel and Prahalad, 2012; Davis, 2013). New technologies such as social media, or internet portals for product comparison provide market transparency, enabling customers to easily compare products and prices, write product reviews or share their experiences with other net users (cf. Kaplan and Haenlein, 2010; Mitic and Kapoulas, 2012; Sharma and Baoku, 2013). Consequently, long-term customer relationships are becoming hard to achieve these days (Lovelock and Wirtz, 2011). In addition, market and competitive pressure forces companies to reduce costs and raise the efficiency of their business processes (cf. Heckl et al., 2010; Davis, 2013). In this context, employees' individual knowledge is becoming decisive to face this development. Employees have tacit knowledge (e.g. on weaknesses in business processes, customer requirements, etc.) which is valuable for the whole company to optimize its services as well as its products offered (cf. Nonaka, 2007; Bhatt and Troutt, 2005; Anaby-Tavor et al., 2010). This knowledge unfolds and is attempted to be made explicit in corresponding business process improvement (BPI) projects that aim at increasing the efficiency and effectiveness of the business processes (Zellner, 2011; Wolf and Harmon, 2012; Davis, 2013).

However, the conduction of BPI initiatives is particularly challenging in modern enterprises due to globalization, complex inter-organizational business processes and high market transparency caused by new web technologies (cf. Kaplan and Haenlein, 2010). To exploit market opportunities, companies are increasingly engaged in cooperations with business partners, creating “value” (cf. Womack and Jones, 1996) in inter-organizational business processes (Feller et al., 2013; Telang and Singh, 2012). However, project members of a BPI initiative need to have a common understanding of the process to be improved which is especially demanding in such inter-organizational settings. Usually, employees’ process knowledge is limited to those partial processes that are performed within their own company or that they directly participate in. Thus, they lack an end-to-end perspective on the process (cf. Gijo and Rao, 2005; La Rosa et al., 2013). This implies the danger of arranging BPI workshops in which the participants focus on certain parts of the holistic process in a one-sided way. It is therefore required that employees from all business partners share their knowledge to enable systematic and successful improvements of business processes. This involves tremendous documentation, communication and coordination efforts across companies to exchange results and organize a business process improvement project.

Further, enterprises are faced with rapidly changing customer requirements (Sigala and Christou, 2006; Gijo and Rao, 2005). The aforementioned market transparency through new technologies is thereby a decisive factor. Consequently, BPI projects must be performed continuously to keep pace with dynamically shifting customer expectations. This forces companies to thoroughly investigate and document current and future customer needs, resulting in a high information demand. The sources to identify customer requirements can be diversified and comprise explicit knowledge, e.g. primary or secondary data such as customer surveys respectively complaints, or employees’ tacit knowledge gained in customer interactions for example. After all, tremendous knowledge, e.g. on customer requirements, process data, process performance, problem causes or possible solutions, is generated in BPI projects, which needs to be transformed into explicit process knowledge and shared among the parties involved (cf. Nonaka, 2007; Dalkir, 2005). BPI literature strongly focuses on the description of activities for improving business processes, e.g. “streamlining” (Harrington, 1991). However, it neglects techniques and solutions on how knowledge and results can be adequately captured, communicated and processed in BPI projects. This is surprising, since it has already been recognized that techniques of knowledge management can provide great value for the improvement of business processes (cf. Dalkir, 2005). This concerns both organizational approaches and the techniques originating from technology-oriented knowledge management (cf. Maier, 2004; Tochtermann and Maurer, 2002). Nevertheless their transfer to the BPI discipline has not been properly investigated yet.

We thus developed a roadmap, which is a well-suited technique for knowledge capturing (Dalkir, 2005), for the systematic conduction of BPI projects. In addition, we show how knowledge generated in BPI projects is codified through processable conceptual models and reports which can be spread throughout a company. We therefore contribute to BPI research in two ways. First, a roadmap and thus clear “guidelines” on how to conduct BPI projects in a goal-oriented way are provided. By that, employees’ tacit process knowledge is partially transformed into explicit process knowledge. Second, we introduce means to codify the explicit process knowledge using processable, formal model types and reports. These help to document, communicate and process the newly generated knowledge.

The paper is structured as follows: In the next section, we provide foundations on BPI and knowledge codification. Afterwards, we develop a BPI roadmap and introduce means to codify the knowledge generated in a BPI project (section 3). In section 4, we present a use case for the BPI roadmap to demonstrate its usability. The paper ends with a conclusion, limitations and an outlook.

2 Foundations

2.1 BPI – state of the art

In recent years, several approaches for BPI have been introduced in literature. For example, Harrington (1991) introduced a five-phase approach for improving business processes, which is to be considered as a fundamental work in the BPI discipline (cf. Zellner, 2011). The approach starts with the selection of critical processes and their visualization as conceptual models before improvements are developed in the "streamlining" phase (Harrington, 1991). The approach of Coskun et al. (2008) focuses on the "weak points" of a process and calculates improvement degrees for business processes. Adesola and Baines (2005) designed a "BPI methodology" that builds on existing BPI frameworks (cf. Harrington, 1991; Kettinger et al., 1997) and provides a seven-step procedure for process improvement. Lee and Chuah (2001) constructed a methodology that integrates ideas from "continuous process improvement", "business process reengineering" and "business process benchmarking" (cf. Teuteberg et al., 2013). The "Condor methodology" as introduced by Vakola and Rezgui (2000) puts special emphasis on organisational and human issues. Povey (1998) developed a best practice methodology by analysing existing approaches and combining their strengths into a unified approach.

Following Zellner (2011), existing BPI approaches lack a methodologically sound support for their users. Whereas the approaches discussed above mainly emphasize the procedural aspects of the methodologies, actual BPI techniques and their results are neglected in most cases (cf. Zellner, 2011). Some authors introduce or mention BPI techniques in their approaches, but do not assign techniques to all activities of the corresponding steps in the procedure (cf. Povey, 1998; Adesola and Baines, 2005). Others do not consider techniques as "guidelines" to follow, but rather introduce them as examples respectively suggestions only (cf. Lee and Chuah, 2001). Furthermore, the codification of the project participants' knowledge is not dealt with in the approaches (cf. Seethamraju and Marjanovic, 2009). These circumstances hamper the operationalization of the approaches for a concrete BPI project. Besides, frameworks from the enterprise modelling domain such as the ARIS-House of Business Engineering (cf. Scheer and Nüttgens, 2000) or the Business Engineering Model according to Österle (1995) respectively Winter (2001) exist. However, they are very extensive, aiming not only at the conceptual design of business processes but also at the IT landscape to implement them. The scope of these approaches is therefore too comprehensive for the majority of BPI initiatives.

In addition, collections of BPI techniques can be found in literature (cf. Hagemeyer et al., 2006; George et al., 2005; Kettinger et al., 1997). Some of these represent conceptual models, e.g. the Supplier-Input-Process-Output-Customer (SIPOC) Diagram or the Ishikawa Diagram (cf. George et al., 2005). However, decision makers are often overwhelmed by the quantity of existing techniques. Further, structured comparisons of the techniques are still missing (cf. Griesberger et al., 2011). As a result, project teams often do not know which techniques should be used for a BPI project to unfold participants' tacit knowledge. This usually leads to an unconsidered adaption of techniques found in literature which however do not meet the expectations of the users or require profound BPI expertise. Nevertheless, the majority of employees will not have this expert know-how regarding BPI. Since it is crucial for the success of a BPI project not only to involve a few experts but rather a variety of employees from different departments, the BPI techniques must be easy to understand and directly usable. Only then can the participants' knowledge be adequately captured and codified in corresponding BPI workshops (cf. Mineau et al., 2000; Dalkir, 2005).

2.2 Codification of knowledge using conceptual modelling methods

The current third and beginning fourth generation of knowledge management (KM) is characterized by a focus on collaborative and collective intelligence approaches. This also includes efforts towards a stronger impact of KM practices in business and society up to increasing attention on knowledge-based development and KM's contribution to improving business performance (Serenko, 2013; Schiuma, 2012). Recent analysis of KM call in particular for an amalgamation of technology-based and people-oriented practices as well as for detailed guidance for the practical implementation of KM practices (Ragab and Arisha, 2013). The acquisition, structuring and representation of knowledge from a technology-oriented perspective have been discussed in-depth in the field of knowledge engineering. In KM in contrast, it is investigated how to facilitate knowledge sharing and reuse on an individual and organizational level (Gavrilova and Andreeva, 2012). In both areas, the *codification* of knowledge plays a central role: it stands for the process of transforming knowledge into information including the definition of the codes themselves (Hall, 2006). This may be conducted on a technical or a human-oriented level. In this context of knowledge codification, a holistic view on people and technology can be facilitated by formal conceptual models such as concept maps, decision trees or knowledge taxonomies (Dalkir, 2005). The advantage of such models lies in their mutual suitability for technological knowledge engineering techniques, e.g. through automated processing of the taxonomies' contents, as well as for people-oriented communication and understanding (Mylopoulos, 1992).

From a more general perspective, conceptual modelling methods either come as general purpose modelling methods (GPMM) that provide generally applicable, generic concepts or as domain specific modelling methods (DSMM) which reconstruct technical concepts in the target domain and thus promote modelling productivity (cf. Frank, 2011). Modelling methods are composed of a modelling technique, which includes a modelling language and modelling procedures for applying this language, and mechanisms and algorithms (Karagiannis and Kühn 2002) – see Figure 1.

Thereby, a modelling language is itself composed of a syntax that defines the grammar of the language, a (visual) notation and semantics that specify the meaning of the elements in the modelling language. The mechanisms and algorithms are used in modelling procedures to conduct tasks such as analysis or simulations of the models created with the modelling language and in order to facilitate a smooth user interaction. In the past, a large number of domain specific modelling methods were developed for codifying specific types of knowledge related to business process improvement. Some recent examples include: the Horus method for codifying knowledge about business processes that ranges from a strategic perspective to the actual execution layer in terms of XML nets (Fill et al., 2013), the RiskM method (Strecker et al., 2011) for codifying knowledge about risks in business processes using the MEMO approach or the SeMFIS method for codifying and simulating risks in business processes using semantic annotations (Fill, 2012).

Looking at the BPI discipline, a handful of diagram types, such as the SIPOC Diagram, the Ishikawa Diagram or the Should-Be Process Map (cf. Griesberger et al., 2011) that capture and visualize partial results (e.g. on key problems, possible solution, etc.) of a BPI initiative as conceptual models are offered. Other techniques, e.g. "process simplification" (Harrington and Lomax, 2000), are not ascribed comparable presentation mechanisms (e.g. tables) in contrast. Much more they can be considered as collections of guidelines.

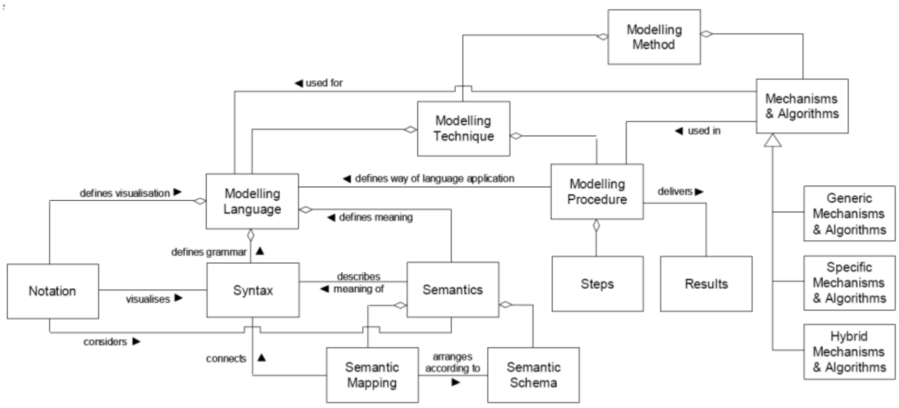

Figure 1. Components of modelling methods (Karagiannis and Kühn, 2002)

What is missing so far is an integration of BPI techniques with a focus on their structured use for the explication and dissemination of employees' tacit process knowledge using conceptual models. The shift of attention away from oversized approaches for process improvement to single BPI techniques is strongly emphasized in current practitioner-related surveys (cf. Davis, 2013). These techniques enable employees to focus on operational aspects of a BPI project – e.g. analysis of problem causes – whereas they are not kept busy with strategic or organizational questions. According to Nonaka (2007, p. 165) "tacit knowledge is highly personal" and difficult to formalize or communicate. Tacit knowledge builds on mental models, beliefs, perspectives, know-how and is rooted in an individual's way of acting and the commitment to a certain context (Nonaka, 2007). Whereas the conversion of tacit into explicit knowledge is a critical stage of KM (Nonaka, 2007) and may only succeed to a certain degree, it can be supported by corresponding techniques. An established technique for capturing tacit knowledge are "roadmaps", which are comparatively formal in nature since problem solutions are derived in a structured way, following an agenda (Dalkir, 2005). Therefore, roadmaps support the aforementioned conversion of tacit into explicit knowledge. We conceive a BPI roadmap as a logical and ordered sequence of BPI techniques. Such a roadmap helps to identify respectively to conceptualize partial results (Dalkir, 2005) within a BPI project, e.g. project goals, problem causes, customer requirements, etc., and to come to final solutions for improving process performance. The roadmap should cover all mandatory stages, i.e. the definition of project goals, measurement of process performance, analysis of problem causes, etc. of a BPI project (cf. Pande et al., 2000). To represent these techniques formally, conceptual model types are defined to document, communicate and process the results. In the following, we describe how we developed such a roadmap for BPI.

3 Identifying, Conceptualizing and Codifying Knowledge in BPI Projects: The BPI Roadmap

3.1 Development of a BPI roadmap

In the previous section, the deficiencies of existing BPI approaches were described. At the same time, BPI will be one of the major topics for CEOs in the years to come to face rising market transparency, changing customer requirements and heavily competitive markets (Davis, 2013; Wolf and Harmon, 2012). Therefore we developed a BPI roadmap to support the identification and conceptualization (cf. Dalkir, 2005) of employees' process knowledge to derive solutions for process improvement.

Our approach follows the research paradigm of design science in information systems (Hevner et al., 2004; March and Smith, 1995), respectively the principles of engineering (Royal Academy of Engineering, 2010; Österle et al., 2011). The goal of these research directions is to build purposeful IT artifacts that: a. address relevant problems in organizations; b. are built using rigorous methods and c. do not just permit to test hypotheses but permit to assess whether particular applications will actually work (Hevner et al., 2004; Lipton, 2010). The artifact considered in the research at hand is the BPI roadmap. Therefore, in the following we will describe in detail how we engineered the BPI roadmap based on a set of requirements derived from the relevant literature, how we integrated techniques for supporting the roadmap, how these techniques can be formally described using metamodels, and how the resulting artifact can be applied in a use case. In future evaluations, it will then be possible to technically implement the metamodels, assess the real-life behavior of the artifact and apply methods from behavioral research. The development of the roadmap followed a five-step approach (Figure 2).

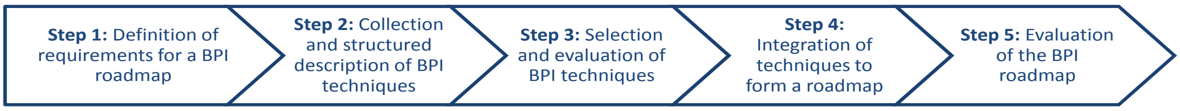

Figure 2. Approach for developing the BPI roadmap

Step 1 (definition of requirements): In literature, several requirements can be found regarding the use of BPI techniques for process improvement (cf. Johannsen et al., 2010). In particular, a vast majority of authors introduce requirements a technique should meet to be applied in corresponding projects. For example McQuater et al. (1995) present the criteria “understanding”, “importance”, “relevance” and “use”. A technique is suitable if it scores high in all these aspects. Thia et al. (2005) present so-called internal factors for technique use in product development that can be used for judging a technique’s suitability, e.g. “user-friendliness”. Further requirements, like “ease of learning”, are mentioned by Dale and McQuater (1998). In addition, a technique must deliver the results or partial results strived for at different stages of a BPI project (cf. Shamsuddin and Masjuki, 2003; Bamford and Greatbanks, 2005). Further, the ability of techniques to be integrated and combined with other techniques is emphasized (cf. Bruhn, 2010; Dale and McQuater, 1998). In the following, these suggestions are condensed to requirements on a BPI roadmap coordinating the systematic application of BPI techniques in a project. Besides, the project environment is focused to formulate criteria and requirements on the applicability of techniques (cf. Thia et al., 2005; Bunney and Dale, 1997). This refers to the “user expertise” or “management support” for certain techniques for example. However, most of these aspects might be useful for characterizing BPI project constellations, but they lack an operational nature for deriving requirements on a BPI roadmap to improve process performance. We thus only focus on those criteria that address techniques directly.

First, all stages of a BPI project must be considered by the BPI roadmap (cf. Shamsuddin and Masjuki, 2003; Bamford and Greatbanks, 2005). Due to its structuredness and completeness we chose the DMAIC cycle of the Six Sigma approach to define the stages of a BPI project (cf. Antony, 2006; Snee and Hoerl, 2003). It is necessary, that the roadmap offers BPI techniques to create results for all these phases *(requirement 1)*. However, it has to be acknowledged that the number of BPI techniques offered in the roadmap must be limited since employees refuse the use of too many different techniques (cf. Gijo and Rao, 2005). A set of 10-15 BPI techniques is considered as manageable (cf. Bamford and Greatbanks, 2005) *(requirement 2)*. To capture the knowledge of a vast majority of process participants, it is advisable to organize the project as a series of workshops (cf. Corbett et al., 1999; Ulrich et al., 2002). Therefore the BPI roadmap should consider techniques to stimulate group discussions and visualize the results generated *(requirement 3)*. Further requirements such as “understanding”, “user-friendliness”, “ease of learning” or “difficulties during use” (cf. McQuater et al., 1995; Thia et al., 2005; Dale and McQuater, 1998) refer to properties which ease or complicate the use of a BPI technique. Summarizing these aspects and transferring them to our purpose, the roadmap and its techniques must be easy to learn and highly understandable *(requirement 4)*. Only then is the roadmap directly applicable in workshops without extra training of the employees. This is further promoted in case the techniques are adaptable to specific user groups of a workshop, e.g. regarding the steps performed during the application. This aspect is referred to as “flexibility” in literature (cf. Thia et al., 2005) *(requirement 5)*. Aspects like "resources" or the "selection depending on intended aims" (cf. Shamsuddin and Masjuki, 2003; Thia et al., 2005) demand to consider only those BPI techniques that produce results directly, e.g. identified customer requirements, without the help of further techniques *(requirement 6)*. In current studies, the necessity for more operational approaches is strongly emphasized (cf. Davis, 2013). Therefore the BPI techniques of the roadmap should focus on the business process and not deal with strategic questions *(requirement 7)*. Across all stages of the BPI project, the techniques should support each other and thus have complementary interdependencies (cf. Bruhn, 2010) *(requirement 8)*. This means that the output of a technique serves as input for the subsequent technique. By that, the project produces consistent results. This is also referred to as a technique's ability of integration (cf. Dale and McQuater, 1998). A successive sequencing of the techniques (cf. Bruhn, 2010) within the roadmap supports their structured application *(requirement 9)*. The requirements are summarized in Table 1.

Requirements (Rq)	**Explanation**
Rq1: Support of all stages of the DMAIC cycle	The roadmap should consider BPI techniques to create results for all DMAIC phases.
Rq2: Manageable set of BPI techniques	The roadmap should only provide a limited set of BPI techniques.
Rq3: Consideration of team-oriented BPI techniques	The techniques must be suitable to stimulate group discussions and visualize the results generated.
Rq4: High understandability and learnability of the roadmap	The techniques of the roadmap must be easy to learn and directly usable in workshops, without extra training.
Rq5: Flexible handling	The BPI techniques should be adaptable for specific user groups.
Rq6: Autonomy of BPI techniques	Each technique should produce results directly (e.g. identified customer requirements).
Rq7: Operational character	The techniques should focus and work on the business process itself.
Rq8: Complementary interdependencies	The techniques of the roadmap should be logically dependent, so that the output of a technique serves as input to another technique.
Rq9: Successive sequencing of techniques	A clear order of techniques should be given.

Table 1. Requirements on the BPI roadmap

Step 2 (collection and description): Subsequently, techniques for process improvement were derived from literature (cf. Hagemeyer et al., 2006; Griesberger et al., 2011; John et al., 2008; George et al., 2005; Pande et al., 2000; Kettinger et al., 1997). Each technique was shortly described regarding the aspects "purpose of the technique", "steps during the application of the technique" as well as "pros and cons". As a result, we came up with a list of 107 BPI techniques.

Step 3 (selection and evaluation): In the third step, the BPI techniques were reviewed by six BPI experts of a German automotive bank the researchers had a long-term cooperation with. The employees came from the "organization" department and were chosen due to their BPI expertise based on long years' experience of conducting BPI projects as well as due to their responsibility for introducing companywide standards and approaches within the company. Each BPI technique was discussed and rated regarding its input for a BPI project (Rq1), suitability for teamwork in workshops (Rq3), ease of learning (Rq4), flexible handling (Rq5), autonomy (Rq6) and operational character (Rq7). The rating was based on the experience of the experts and the techniques' description (step 2). In case of strongly deviating ratings among the experts, a BPI technique was postponed and discussed once again separately. In such a situation, additional use cases and information on the particular technique were derived from literature. This was meant to support the finding of a consensus. Regarding the high number and scope of the techniques collected (see step 2) the discussion with a small group of experts was considered appropriate to assess the techniques' usability for the roadmap. Finally, 16 BPI techniques were selected that fulfilled the aforementioned requirements and were perceived to be the most suitable ones for the roadmap. The usability of these 16 techniques was then tested in several improvement projects within the automotive bank over a period of one year. Each BPI project was organized in the form of two to three full-day workshops. At the end of each workshop, a short discussion and feedback round on the BPI techniques was held. Participants were asked whether they perceived the BPI techniques used to be helpful and beneficial. In addition, they were encouraged to express what they liked or disliked, about the techniques. Further, the workshop moderators documented their impression of the techniques' usability. All this feedback was gathered by the researchers. Finally (in accordance with Rq2), a manageable set of eleven BPI techniques, considered to be the most beneficial ones, was chosen.

Step 4 (integration): In a fourth step, the BPI techniques were logically ordered guiding the sequential use (Rq9) of the techniques in a BPI project. It was taken care that the results (output) of one technique served as input to the following technique (Rq8 – complementary interdependencies), and the sequence of the BPI techniques logically covered all phases of the DMAIC procedure (Rq1).

Step 5 (evaluation of roadmap): Finally, the BPI roadmap was promoted via a Web-Based Training and evaluated in different BPI projects at the automotive bank (e.g. document management process, disturbance of contract process, etc.). Since the applicability of the techniques themselves had already been confirmed (step 3), the insights gained referred to the logical arrangement of the techniques within the roadmap. For example it proved suitable to create an Ishikawa Diagram (Ishikawa, 1982) after the process performance had been analyzed. By that, the participants were able to analyze problem causes very precisely, although it would be possible to establish the diagram at an earlier stage of the project. Figure 3 gives a brief overview of the BPI roadmap.

In the following, we describe the roadmap shortly (cf. John et al., 2008; George et al., 2005; Pande et al., 2000; Kettinger et al., 1997): The SIPOC Diagram is a simple technique to visualize a process in an abstract way. It is less complex than standard approaches to process modelling but can be linked to standard modelling techniques if necessary. The CTQ/CTB Matrix collects customers' as well as employees' requirements on the process. From these, so called "critical-to-quality (CTQ)" and "critical-to-business (CTB)" factors are derived which represent the project goals. Performance indicators are then defined to measure the process performance. In the Measurement Matrix, it is decided which performance indicators measure the achievement of project goals. By means of the Data Collection Plan it is determined how the performance indicators are to be measured and by whom. Histograms and scatterplots are used to visualize the process performance data. The Ishikawa Diagram helps to identify and categorize problem causes. Solutions to overcome these problems are developed with the help of the Affinity Diagram. The Reaction Plan captures defined actions to mitigate occurring process variances. Finally, control charts are used for a continuous process control.

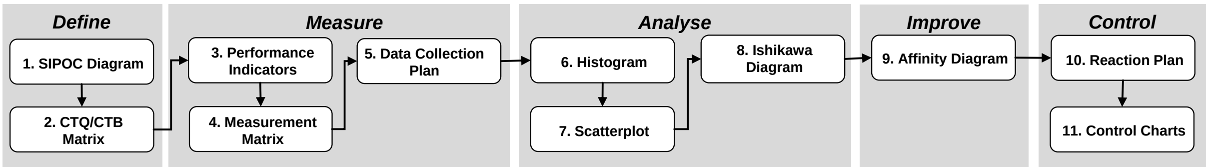

Figure 3. Overview of the BPI roadmap showing the five phases and the techniques

3.2 Metamodels of the BPI roadmap

The BPI roadmap described above supports its users to identify the key problems for lacking process performance and to conceptualize solutions to improve a process. A further major step lies in the codification (cf. Dalkir, 2005) of the explicit knowledge generated in BPI projects. In that context, formal conceptual models have been established as beneficial means for documentation and communication purposes in practice (Anaby-Tavor et al., 2010; Davies et al., 2006). We therefore developed model types for the BPI roadmap to document and visualize the results generated using the BPI techniques in a tangible form. The results can then be easily communicated throughout a company but also across company borders. Further, they can be processed and queried for creating reports.

To do so, the core concepts of each BPI technique (see Figure 3) were identified in a first step. This was done to conserve the BPI techniques' original functionality. For example, the SIPOC Diagram (cf. George et al., 2005) comprises the central concepts "supplier", "input", "process", "output" and "customer". For each concept of a BPI technique, a corresponding class was derived in a second step. Afterwards, it was analyzed in how far the core concepts of a technique (respectively classes) were related to one another. For example, in the "CTQ/CTB Matrix", the collected "Voice of the Customer" statements (which represent the verbally uttered customer requirements) are condensed to "core statements" from which "critical-to-quality factors" (CTQs), determining the project goals, are derived (John et al., 2008). Due to the interrelationships between the concepts, it was possible to define relations and thus relation classes (e.g. "condense" or "derive critical factor"). After the core concepts and relations had been defined, model types to cover the BPI roadmap and corresponding metamodels could be established. Figure 4 provides an overview of the metamodels regarding the model types as they have been defined. Since the BPI techniques of the roadmap logically build on each other (see Rq8 – Table 1), the model types have interrelations which are indicated by corresponding references (red arrows) in Figure 4. These interrelations are explained in Table 2 in more detail. The statistical diagrams have been considered in the "Statistic Interface Model" type.

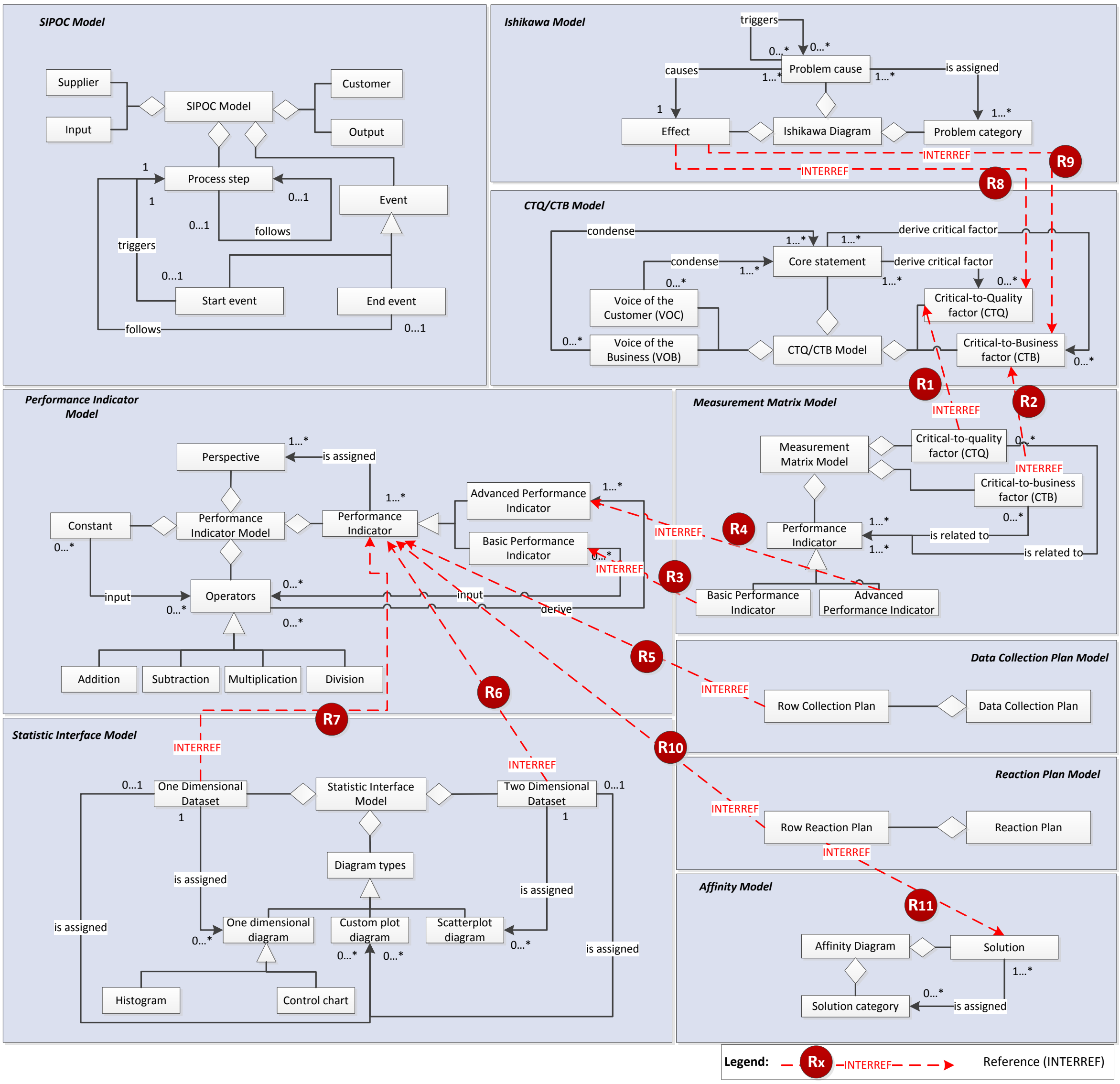

Figure 4. Metamodels of the techniques and their interrelations for generating reports

Reports that build on references (INTERREF) between model types			
Report	**Explanation**	**Required references**	**Key concepts (classes) involved**
Measurement of project goals from a customer perspective	Critical-to-quality (CTQ) factors capture the customers' requirements on a process. The report indicates which and how many performance indicators are used for measuring specific project goals (CTQs) derived from customer requirements (VOCs). By that, the goal realization level can be measured.	R_1, R_3, R_4	CTQ, Performance Indicator (Advanced/Basic)
Measurement of project goals from a business perspective	Critical-to-business (CTB) factors represent project goals from a business perspective. The report shows which and how many performance indicators are referred to for measuring certain project goals (CTBs) that are derived from business requirements (VOBs).	R_2, R_3, R_4	CTB, Performance Indicator (Advanced/Basic)
Organizational data collection report	Information on the performance indicators (e.g. on their operational definition) is referred to in the Data Collection Plan Model to organize the data collection. Thus, a report describing how, when and by whom a performance indicator is collected can be generated.	R_5	Row Collection Plan, Performance Indicator
Process performance report	The Statistic Interface Model serves the analysis of the process performance. Therefore, the performance indicators, as they have been defined, are referred to and they are assigned collected datasets. Reports, visualizing the process performance regarding the project goals, e.g. as histograms, can be generated that way.	R_6, R_7	Performance Indicator, One Dimensional Dataset, Two Dimensional Dataset
Process problem report	In case the process falls short of the project goals, the CTQs or/and CTBs are referred to in the Ishikawa Model to analyse problem causes. Reports, listing potential problem causes for not reaching certain project goals, can be easily generated that way.	R_8, R_9	CTQ, CTB, Effect
Process variance reaction report	The Reaction Plan Model enables a continuous control of the process performance. It is defined which measures are taken in case of unexpected process variance. Therefore, solutions that were highlighted in the Affinity Model to mitigate process performance variances are referred to as suggestions for immediate action.	R_{10}, R_{11}	Row Reaction Plan, Performance Indicator, Solution
Further reports			
Report	**Explanation**		**Key concepts (classes) involved**
Supplier and input report	The report is generated from a SIPOC Model and shows which process input (e.g. documents, etc.) is provided by a certain supplier (e.g. car dealer, etc.).		Supplier, Input
Customer and output report	This report is generated from the SIPOC Model as well and highlights which output is received by a specific customer (e.g. private customer, etc.).		Customer, Output
Project goal definition report	The report generated from the Measurement Matrix Model provides an overview which CTQs and CTBs cover the initial statements of the customer (VOCs) and the business (VOBs). Thus, a prioritization of project goals is facilitated.		CTQ, CTB, VOC, VOB
Performance indicator overview report	This report lists all performance indicators as defined and provides an overview regarding their operational definition and the corresponding data sources to retrieve the data.		Performance Indicator (Basic/Advanced)
Problem cause report	The report lists the defined problem categories of a process and shows which (and how many) causes have been assigned to each one of them.		Problem cause, Problem category
Solution report	A list of solution categories (e.g. IT, employees, etc.) and solutions (e.g. introduction of CRM-system, etc.) assigned to these are shown.		Solution, Solution category

Table 2. Overview of reports

The model types generated that way serve two purposes: First, they document the results and the explicit knowledge emerging in a BPI project (knowledge codification). This allows an easy communication, documentation and processing of the working results at low costs (Dalkir, 2005). The model types adopt the simple nature of the underlying BPI techniques, while each model type codifies the results at a certain stage of a BPI project (e.g. problem causes, etc.). Further, the model types support the homogeneous presentation of the results (as conceptual models) which facilitates the communication among employees (cf. Anaby-Tavor et al., 2010), especially in inter-organizational BPI projects. Besides the graphical representation of the results, the model types enable the generation of textual respectively tabular reports, which is a widely established form of knowledge codification as well (cf. Anaby-Tavor et al., 2010). This way the knowledge captured in a model type can be queried and easily analyzed. For example, a report generated from the "SIPOC Model" (see Figure 4) can highlight what process output (type of output, number of units, etc.) is received by a specific process customer. At this point, the major strength of the BPI roadmap, namely the complementary dependencies between the BPI techniques, becomes obvious. Therefore knowledge and results created using a certain model type are considered in the context of key aspects examined in other model types. This strongly supports the systematic derivation of consistent solutions within a BPI project. For example performance indicators, originally defined in the "Performance Indicator Model", are reflected against the CTQs and CTBs which stem from the "CTQ/CTB Model". It can thus be determined which performance indicators are most suitable for measuring the project goals. This benefit is enabled by corresponding references between logically interrelated classes across model types. The impact of these references on reports is explained more detailed in Table 2.

As a second purpose, the model types are the base for establishing teaching material for employees. The teaching material serves two major aims: First, the material allows to efficiently communicate knowledge on the BPI discipline. Since the model types adopt the simple nature of the underlying BPI techniques, they enable an easy communication of the basic principles of BPI projects. Examples of real BPI projects can be depicted as corresponding models facilitating the teaching of certain project constellations and how to deal with them. Second, instances of these model types that are created in a BPI project foster the internalization (cf. Nonaka, 2007) of process knowledge within the workforce leading to a better understanding for a company's business processes and value-creation.

In summary, the BPI roadmap facilitates the transformation of employees' tacit knowledge into explicit company knowledge on business processes to derive solutions for process improvement. The model types and reports support the combination, communication and processing of the explicit knowledge but also its internalization among the employees (cf. Nonaka, 2007). Table 2 gives a summary on project relevant reports based on the BPI roadmap. A special emphasis is laid on those reports that build on references between classes of different model types (Figure 4 – R_1-R_{11}). The reports help to analyze key results of a BPI project and understand how these build on each other. Additional reports are possible. However, the selection as presented is based on the feedback gained during using the BPI roadmap in manifold BPI projects at the aforementioned automotive bank over a period of two years. The reports listed covered all information that was required during that time.

4 A Use Case for the BPI Roadmap

As mentioned in section 3.1, the BPI roadmap was evaluated and applied in several different project settings. We exemplarily focus on the case of the "end of leasing contract (EOT)" process which is to be considered as one of the most complex and central business processes of the aforementioned automotive bank. The process is triggered as soon as a customer's leasing contract ends and the car is returned to the car dealer. At the car dealer, the car value is assessed by an external partner for vehicle inspection. The results are documented and transferred to the automotive bank to calculate the final customer bill. The process ends as soon as the bill has been settled. Several parties are involved in the process and a lot of information is exchanged. At the time of the project, no integrated information system to support the process existed and a lot of information was exchanged between the process participants in a paper-based manner. Customers repetitively complained about long cycle times and errors in the calculation of the final bill, so that the management set up a BPI project to improve the process. The BPI roadmap is currently being implemented using the ADOxx metamodelling platform (Fill and Karagiannis, 2013). Correspondingly, Figure 5 shows four model excerpts and two excerpts from reports of the BPI roadmap using data from the BPI project. In the "CTQ/CTB Model", the verbally uttered "Voice of the Customer (VOC)" is condensed to core statements and critical-to-quality factors (CTQs) are derived thereafter. For example, the customers complained about how long it was taking to bill the leasing contract. This statement referred to the long cycle time of the process (core statement). Therefore, a CTQ to reduce the cycle time of the holistic process was defined as one of the major project goals. Afterwards, performance indicators to measure goal achievement were defined. The excerpt from the "Performance Indicator Model" exemplarily shows those performance indicators defined to assess the process cycle time, e.g. "cycle time EOT".

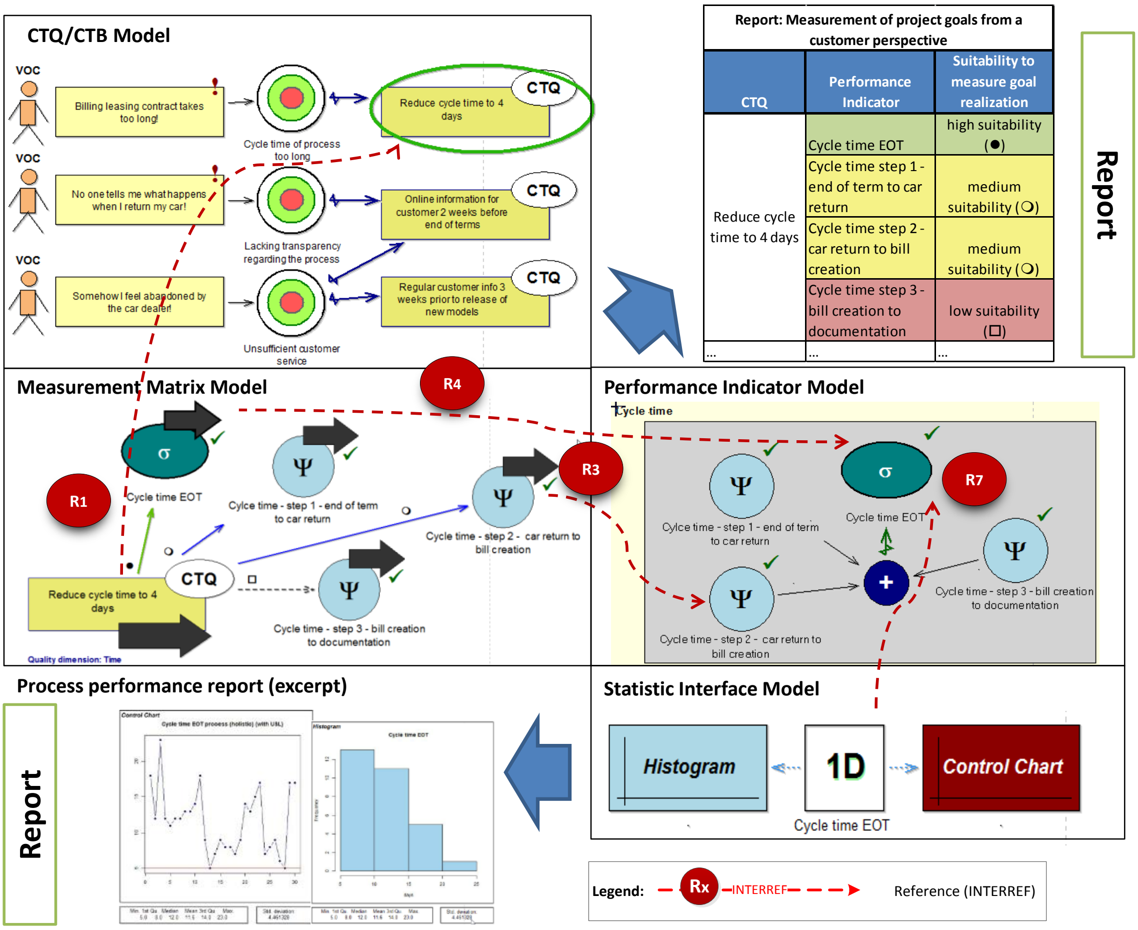

Figure 5. *Excerpts from a BPI project at an automotive bank*

The performance indicator "cycle time EOT" was decomposed into three performance indicators focusing on parts of the actual process. Then, using the "Measurement Matrix Model", the performance indicators were assigned to the CTQs defined previously. This was possible, since there are references (interfaces) between the three model types as mentioned (see Table 3 – R_1, R_3, R_4). In general, each performance indicator requires a judgment whether it is suitable for measuring the goal achievement regarding a specific CTQ or not. Thus, a report can be generated, supporting the focus on those performance indicators measuring the degree of goal achievement ("Measurement of project goals from a customer perspective"). The collection of data for the performance indicators was organized via the Data Collection Plan Model. Once the performance indicators had been measured, they were analyzed using statistical diagrams (via the Statistic Interface Model), resulting in the "Process performance report" (see Figure 5). By that, it was possible to locate those process steps responsible for the delays in billing the leasing contract for example. This facilitated the systematic identification of problem causes using the Ishikawa Model. The Affinity Model helped to develop and prioritize solutions to mitigate the problem causes. It was proposed to introduce Tablet PCs for the vehicle inspectors for example to transfer their inspection results to the bank automatically and to avoid media discontinuity. Control charts helped to control the process performance after the solutions had been implemented. In summary, the project led to a tremendous reduction of the process cycle times and customer complaints. In addition, cost savings of several million euros were achieved.

5 Conclusion and Lessons Learned

In our paper, we suggest a solution to overcome a major weakness of current BPI approaches: the codification of knowledge generated within process improvement projects. We developed a BPI roadmap that supports the goal-oriented accomplishment of BPI projects. By emphasizing BPI techniques and their sequential application, the BPI roadmap meets practitioners' current expectations on operational and technique-oriented BPI methodologies (cf. Davis, 2013). The BPI techniques of the roadmap were converted into corresponding model types for codifying the knowledge generated.

The benefits of this research for practice are the following: First, we provide practitioners with means to systematically conduct BPI projects using an easy to learn, understandable and proven BPI roadmap. Second, we introduce model types which do not only serve for documentation purposes but also enable an easy processing and querying of the results in the form of reports. Further, teaching material for employees can be generated from it (see section 3.2). By that, the systematic and goal-oriented conduction of BPI projects is supported. Third, the metamodels shown will serve as a basis for implementing the roadmap using the ADOxx metamodelling platform (cf. Fill and Karagiannis, 2013). By that, a software prototype supporting BPI initiatives based on the BPI roadmap is generated. Our results contribute to research equally: First, we show that metamodels are an effective means to identify the interrelationships between different BPI techniques (see Figure 4). By that, it is possible to systematically analyze which BPI techniques can be combined in a value-adding manner and how a certain BPI technique may facilitate the use of another one (e.g. the Ishikawa Model refers to the results of the CTQ/CTB Model). Second, the BPI roadmap transfers ideas from KM to the BPI discipline and provides a solution on how to manage knowledge in BPI projects appropriately. The roadmap thus extends current BPI research, since the aspect of managing knowledge has not explicitly been dealt with in established BPI approaches yet.

However, there are limitations. First, the requirements were derived from a literature review. Requirements found that were similar to each other were condensed correspondingly (e.g. "understanding", "user-friendliness", etc.). However, completeness of the requirements regarding all the specific demands of a practitioner cannot be guaranteed. Further, the selection and evaluation of the collected BPI techniques were performed in cooperation with six practitioners. While interrater-agreement was achieved, subjectivity cannot be completely excluded. Whereas more reports are possible (see section 3.2), the selected ones were found appropriate for satisfying employees' information demand in BPI projects. The BPI roadmap in its current state has been tested in several BPI projects at an automotive bank. Further evaluations with small-and-medium sized cooperation partners across different branches (e.g. textile industry, service industry, etc.) are currently performed. Contrary to approaches that were developed for a certain branch only, e.g. the Poka Yoke technique for defect avoidance (John et al., 2008) in production companies, the BPI techniques of the BPI roadmap do not functionally depend on the inherent characteristics of service or production processes (e.g. intangibility of products, machine equipment, etc.) (Hensley and Dobie, 2005). That means the BPI roadmap does not underlie a branch-specific imprint. Considering this, the intersectoral usability of the roadmap is very likely. Whereas the evaluation at companies of different size is still ongoing, the feedback we received so far is promising and confirms the general applicability of the BPI roadmap hitherto.

From the research conducted we learned that one of the main success factors for a project is to catch peoples' process knowledge. It is not the mere presence of few BPI experts but the commitment of a vast majority of process participants making a BPI initiative a success. Therefore, easy to handle BPI techniques are preferred to highly analytical but often complicated techniques by employees. The BPI roadmap is currently implemented using the ADOxx metamodelling platform. In future work, the implementation of the BPI roadmap as a software tool will be evaluated in practice. By that, not only insights on the usability of the roadmap but also on its handling in the form of a tool will be gained.

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