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ORIGINAL PAPER

Integration of business process management and knowledge management: state of the art, current research and future prospects

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Abstract The integration of business process management (BPM) and knowledge management (KM) helps companies to improve temporal, qualitative and cost aspects of the provision of goods and services and to increase their innovative capacities. There are numerous publications in German and English that deal with the integration of both of these management approaches. By means of a comprehensive examination of this literature, the present article evaluates the state of knowledge and identifies additional research needs. More specifically, the volume of the publications examined is evaluated and classified by means of appropriate and carefully defined criteria. Moreover, the contents of the classes thus defined will be elucidated and then critically discussed. Finally, this article provides a general review of current approaches and their specific merits, and it will demonstrate the current deficits and spheres of activity in relation to the integration of BPM and KM.

Keywords Business process management (BPM) · Cumulative review · Knowledge management (KM) · State of the art

JEL Classification L20 · M10

1 Initial position and aims

The pressure of competition in every branch of the business world is increasing across the board. The growing demands on temporal, qualitative and cost aspects of

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the provision of goods and services as well as on innovative strengths represent an on-going challenge. A significant step in meeting these demands is the renunciation of functional orientation in favour of process orientation. After the beginning of this development several decades ago (compare Gaitanides 1983, p. 60) a management approach with methods and tools was developed that represented the prolegomenon to the current wide-spread concept of *business process management* (BPM) (compare Bullinger et al. 1995, pp. 7ff.). As a parallel process the insight gained ground that the classic value creation factors work, capital, and land were losing significance while knowledge had become a growth commodity. From this insight a more conscious handling of knowledge developed, which is the essence of *knowledge management* (KM) (compare North 2011, pp. 9–23). In the course of time the two management approaches, BPM and KM, began to close in on each other. While in the area of KM, process-oriented approaches developed and became established, in BPM knowledge was not only understood as an important resource but also as a product. It is essential in the design and regulation of processes to concentrate on both aspects. Both management approaches intersect at many points and depend upon and complement each other. An integration of BPM and KM exists only when the basic elements of both management approaches are mutually employed. In the process knowledge assumes priority in business processes, and KM elements focus on the improvements of these business processes. It is essential to increase the value creation in companies and organisations whose provision of products and services are more than ever based on knowledge and whose products and services increasingly include knowledge. The integration of BPM and KM and the exploitation of the resulting potentials have been for some time the subject of scholarly activity and practical experience. There are with respect to both points a multitude of publications that in part differ widely in content, scope and focus. Nevertheless, in practice there is still a great deal of uncertainty in the handling of knowledge. On the one hand, companies are well aware that there is a need for action, but, on the other hand, matters often remain on the level of perception without any measures being agreed upon and implemented (compare Lehner 2008, p. 283f.). The integration of BPM and KM is ideally qualified to dispel this uncertainty. But integration alone promises neither sufficient orientation nor any increase in the creation of value. To date (too) many KM initiatives do not lead to the desired results and are in part discontinued (compare Meier and Weller 2012, p. 115). An important reason for this failure is the lack of understanding on the part of businesses and organisations of their own KM requirements. There is up to the present scarcely any practical and fundamental understanding of demand for KM that is derived from individual exigencies. Without this condition, however, meaningful, systematic and supportive handling of knowledge that creates value is not possible.

The goal of this article is, on the basis of a current and broad summary of the up-to-date publications in German and English on the integration of BPM and KM, to provide an evaluation of the state of scholarly work as well as to identify additional research needs. To this end in the following chapter a common

conceptual ground for BPM and KM will be developed as well as the procedure in evaluating research and its results sketched. Following this discussion Sect. 3 presents the search results and begins with a survey of the publications encountered. On the basis of suitable and previously described characterising criteria, these publications are then evaluated and classified. An elucidation and critical discussion of the contents of the resulting classes follow. The last chapter, Sect. 4, contains a summary of the results as well as the identification of additional research needs.

2 Foundations and procedure

At the beginning of this chapter the terms BPM and KM are defined and their relationship sketched. The common conceptual foundation is the basis in the present article for classifying the listed and categorically arranged publications on the integration of BPM and KM and for being able to understand their contents. The procedure in implementing the systematic review of the literature is oriented on the recommended principles from the phase description for a systematic review by Jesson et al. (2011).

Accordingly, the investigation of the integration of BPM and KM is carried out with the aid of a targeted and delimited search whose object is described in Sect. 1 and its procedure in Sect. 2.2. In accordance with an additional principle of Jesson et al. (2011, p. 108), Sect. 2.2 discusses how extensively the search is carried out. How the principle of data extraction is complied with follows from in the description of the procedure in the evaluation of the results in Sect. 2.3. The purposes discussed there and the detailed criteria for the characterisation of the considered search results are used for the realisation of additional principles in accordance with Jesson et al. (2011). These are the principles of *evaluation quality*, *synthesis* and *summary and the lucid presentation of the results*. The appropriate implementation of these principles can be found at the end of Sect. 2. An evaluation of quality occurs especially in the framework of the substantiated exclusion of various search results in Sect. 3.1, and a synthesis as well as a summary and a transparent presentation of the results in Sect. 3.2 'Classification and Explanation of Relevant Search Results' and Sect. 3.3 'Critical Discussion of Relevant Search Results'.

2.1 Definitions relevant to business process management and knowledge management

The definitions forming the basis of this article and illustrated in the following remarks are intentionally broadly formulated in order to permit the inclusion of the diverse conceptual variations found in the publications of the literature search.

A business process is a chain of value creating, functional and interorganisational activities that generate output from a series of inputs (compare Schmelzer and Sesselmann 2010, p. 62). A business process ought to fulfil the goals derived from a corporate strategy and in this context produce outputs that satisfy the wishes of

customers. Building on this notion BPM is understood as '… an integrated concept of management, organisation and monitoring of the business processes whose goal is the increase of the effectiveness and efficiency of the company' (Schmelzer 2004, p. 25).

Knowledge can be defined as '… the total of the information and skills that individuals apply for the solution to problems' (Probst et al. 1999, p. 46). Knowledge management is the conscious and systematic handling of this resource and deals with its target-oriented application in organisations (compare Reinmann-Rothmeier and Mandl 2000, p. 9). It comprises '… the choice, implementation and control of suitable KM strategies, deploys instruments on many varying intervention levels in order to improve on the individual and collective level the handling of knowledge whose purpose is finally achieving by means of the strategies specified by KM.. the [goals of effectiveness and efficiency]' (Remus 2002, p. 26). BPM and KM are linked, on the one hand, by the fact that knowledge is part and parcel of the business process, that it is created as a product or a secondary product and that it is necessary for process control and design; on the other hand, BPM and KM are linked by the common objective of achieving increased effectiveness and efficiency for the company (compare Bucher and Ohlhausen 2001, p. 41).

2.2 The research procedure

In order to obtain a current, comprehensive and up-to-date general view of the publications in German and English on the integration of BPM and KM, the search for and thus a suitable choice and combination of search terms is decisive. In Table 1 the terms used for the search and the corresponding combination variants are illustrated.

For the search the so-called 'free search' (German *freie Suche*) belonging to the search portal InfoGuide with access to Gateway Bayern (Bavarian Union

Table 1 Choice and combination of search terms

No	Combination of search terms	
1	Geschäftsprozessmanagement	Wissensmanagement
2	Prozessmanagement	Wissensmanagement
3	Process management	Knowledge management
4	Geschäftsprozessorientiertes	Wissensmanagement
5	Prozessorientiertes	Wissensmanagement
6	Process based	Knowledge management
7	Process-based	Knowledge management
8	Process oriented	Knowledge management
9	Process-oriented	Knowledge management
10	Geschäftsprozessmanagement	Wissen
11	Prozessmanagement	Wissen
12	Process management	Knowledge

Catalogue) was used.[1] Here a full-text search was not conducted, but rather all the stored information, such as titles or catch words, is included. A full-text search was carried out in Google Books (*Google Bücher*). With the exception of two term combinations, a full-text search was also carried out in the portal WISO with the modules *Economics* and *Social Sciences*.[2] For term combinations 10 and 11 a full-text search, however, delivered unclear results with very limited relevance for the hits.[3] Therefore, the search for these two term-combinations was limited to journal titles. The search was carried out in all media so that all hits with the particular combinations of the terms—that means both entered search terms are included—are displayed. The search depth was defined individually for each medium and determined in dependence upon the relevance of the displayed hits. This determination occurred on the basis of an evaluation that was a component of the hit sighting and that depended upon the thematic relationship of the hit to the integration of BPM and KM. The sighting of the articles resulting from a term combination in a medium was at the end of a displayed hit page discontinued as soon as the sighted articles no longer showed any thematic relevance.

Publications in books were first searched for in the search portal InfoGuide. With respect to the search depth the examination of the hits was exhaustively performed; this means that each displayed hit was subjected to a first rough examination as to the thematic relevance. Then the search in the medium Google Books was carried out. Thereby the hits for the term combination 1 were exhaustively examined. The hits for the term combination 3 were examined up to and including hit number 80 and for all the other combinations up to and including hit number 150. Only those titles available via the Bavarian Union Catalogue (*Bayerischer Verbundkatalog Gateway Bayern*) were included in the search.

Publications in journals were researched in the portal WISO. The search of the journal articles was made exhaustively including all titles that are available either via the modules *Economics* and *Social Sciences* of the WISO portal or the Electronic Journals Library of the Universität der Bundeswehr München.[4]

On the one hand, the literature search aims at a plausibly generated and comprehensive result that takes into consideration German and English language

[1] Gateway Bayern is the web portal of the Bavarian Library Network (German BVB). The B3Kat - Cooperative Union Catalogue of BVB and KOBV [Cooperative Library Union Catalogue of Berlin-Brandenburg] contains over 23 million bibliographic data sets from the university libraries and additional libraries in Bavaria and Berlin and Brandenburg. In: http://www.bib-bvb.de [online-access as of 28.12.2011].

[2] WISO is a web portal that is suited for the search of electronic journal articles. With the modules Economics and Social Sciences it contains about 7.4 million literature references. The search was carried out with the access rights of the Universität der Bundeswehr München, with the status of December 2011. In: http://www.wiso-net.de.

[3] The limited thematic relevance of the displayed search hits in a full-text search resulted from the fact that the difference between the substantive 'knowledge' (Wissen) and the verb 'to know' (wissen) could not be indicated.

[4] The Electronic Journals Library of the Universität der Bundeswehr München is a web portal that is suited for the search of journals. The search was carried out with the access rights of the Universität der Bundeswehr München, with the status of December 2011. In: http://ezb.uni-regensburg.de/fl.phtml?bibid=UBWM&colors=7&lang=de.

publications as well as one that does justice to the cross section of expertise of BPM and KM. On the other hand, a claim to completeness cannot nor should not be made. The choice of the search media used, especially the portal WISO (in association with the Elektronische Zeitschriftenbibliothek [Electronic Journals Library]), should be understood as a compromise made to achieve the search goals listed and to manage the scope of the search.

The search began in October, 2011, and was concluded in February, 2012. Spread over all the search media used, a total of 3,239 source references[5] altogether were carried out in a first rough screening for thematic relevance.

2.3 Procedure in evaluating results

Based on the searches concluded at the beginning of 2012 and the concurrent screening, the search hits are comprehensively examined and, in so far as they deal with the integration of the BPM and KM, are in each case characterised by means of suitable criteria.

The search results showed a large diversity. In a first step a sighting of the articles occurred that aimed at an evaluation of the contextual orientation. Different emphases in the objectives suitable for a classification arose. The hits of the search are distinguished in three different types of emphasis: *planning, analysis and implementation*; *system utilisation*; and *system evolution*. In the case of *planning, analysis and implementation* the business processes are the point of departure for the KM. With respect to *system utilisation* the main theme is KM during the process execution, that is, the operative utilisation of a process-oriented KM system or KM tools. However, if a systematic identification, evaluation or exploitation of the potential for improvement during the system's running time is paramount in the publication, it is assigned to *system evolution* (compare Abecker et al. 2002, pp. 4–7).

In a second step a detailed investigation of the articles leading to the identification of numerous criteria occurs. These criteria can be assigned to the four dimensions *application*, *object of observation, methodological procedure, design*. Figure 1 provides a summary.

Within the dimension *application* a subdivision between 'Reference' and 'Maturity' can be made. With regard to the 'Reference' of the *application* there is always the possibility that with respect to a search hit a basic discussion is meant, a concept/model is explained and/or concrete methods/tools of the process-oriented KM are included. Moreover, a differing 'Maturity' of the *application* can be determined that ranges from a commercial/ready-for-use product up to a non-applied/unfinished prototype.

The various publications can be aimed at the total process organisation as an *object of observation*. Additional possibilities for the *object of observation* are business processes/subprocesses in general. The focus can, however, be placed on business processes in a particular branch or on a concrete business process type. With regard to the *object of observation*, moreover, two kinds of knowledge can be

[5] The 3,239 source references are distributed as follows among the search media: InfoGuide 481, Google Books (Google Bücher) 1,567, WISO 1,191.

distinguished, explicit and implicit knowledge, which in the approaches described can be taken into consideration. Explicit knowledge here means that the knowledge is on the basis of information articulated, codified and stored. In contrast, implicit knowledge is that knowledge that is not explainable or not yet explicit (A part of implicit knowledge is not explainable and is termed 'tacit knowledge'.) (compare Gronau 2009, p. 5).

In the case of the *methodological procedure* of the publications a criteria spectrum in detail is available from the comprehensive survey, the interview or the workshop, the case study or the case example and the prototype description up to the literature search.

The dimension *design* consists of the 'Management Level' and the 'Intervention Level'. The 'Management Level' of an approach is designated as strategic if long-term and path-breaking aspects are dealt with. Tactical components are spoken of if the temporal and contextual reference is medium-term and not purely concerned with day-to-day operations. Operative-oriented titles, in contrast, include components that can be applied and implemented within the short-term. With respect to their 'Intervention Level' the search hits are classified according to the *design* dimensions technology, organisation, and personnel (compare Bullinger et al. 1998, pp. 21–39) as well as by means of the eight various KM building blocks in accordance with Probst (compare Probst et al. 1999, pp. 56–58).

The represented criteria further the description and discussion of the different search hits. For the generation of significant results in relation to the objective formulated at the beginning of the present article, however, merely the 'Reference' from the dimension *application* is suitable as an indication of an additional classification of the results in subclasses. In the framework of the generated classes and subclasses the other criteria are enlisted as needed in order to support a systematic explication, evaluation and critical discussion of the search results as well as the derivation of the additional research needs.

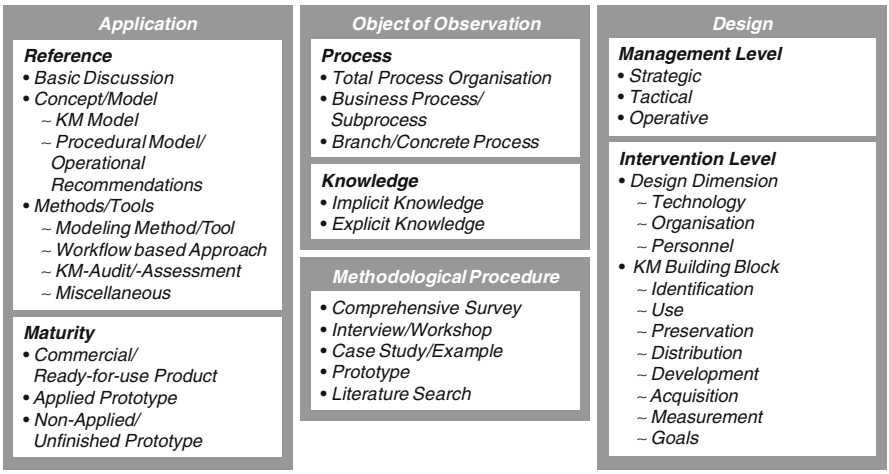

Fig. 1 Detail criteria for the characterisation of search results

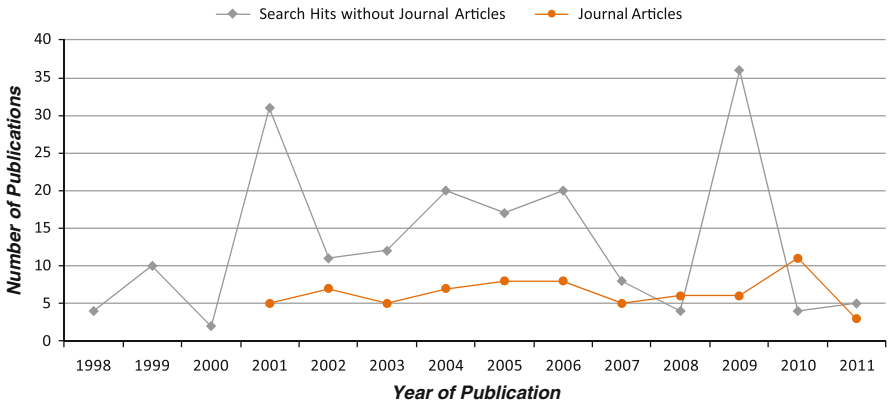

Fig. 2 General view of the year of publication of the search results

For a better understanding of the search results explained in the following chapter, it is necessary to point out that the criteria represented in Fig. 1 are used because of their fitness for the achieving of the purpose of this article and cannot be separated accurately.

3 Search results

In this chapter a review of the search results is undertaken. Thereafter a classification and explanation as well as a critical discussion of the relevant search hits is effected.

3.1 A general view of the search results

The search results include altogether 255 publications on the integration of BPM and KM. Over 75 % of them are in German and almost 25 % are in English. 90 of the publications are articles in anthologies, 52 are conference papers (available in conference volumes or accessible online), 42 are monographs[6] and 71 are journal articles. A general view of the year of publication of all the publications located is presented in Fig. 2.

In 19 of the 255 publications no original approaches are developed, no existing approaches enhanced and no other contributions to the integration of BPM and KM rendered. They comprise merely market surveys of methods and tools or the presentations of contents and categories of approach that either are based exclusively on existing literature and/or contribute nothing to the achievement of the purpose formulated in Sect. 1. Despite their potential pragmatic added value in certain contexts (for example, an engaged company wishing to gain an oversight of

[6] In this article the distinction between monographs and dissertations is not made. The list of monographs also includes dissertations.

Table 2 Summary of the search results not further examined

No	Title	Author(s) (year)	Type of Article
1	Prozessmanagement und Wissensmanagement	Kohl and Orth (2010)	Anthology article
2	Anwendungen und Systeme für das Wissensmanagement - Ein aktueller Überblick	Bahrs et al. (2009)	Anthology article
3	Wissensmanagement - Grundlagen, Methoden und Technische Unterstützung	Lehner (2008)	Monograph
4	Prozess- und Wissensmanagement - Ansätze zur Integration von Prozess- und Wissensmanagement	Donleitner (2006)	Monograph
5	Strategien zur Bewahrung von Wissen - Zur Sicherung nachhaltiger Wettbewerbsvorteile	Trojan (2006)	Monograph
6	Modeling and Analysis of Knowledge Intensive Business Processes	Bahrs and Müller (2005)	Conference paper
7	Marktüberblick: Anwendungen und Systeme für das Wissensmanagement	Gronau (2005)	Journal article
8	Erweiterte Funktionalität bei Softwarewerkzeugen zur Geschäftsprozessmodellierung	Haak and Eekhoff (2002)	Journal article
9	Integrierte Wissensmanagement-Systeme: Architektur und praktische Anwendung	Riempp (2004)	Monograph
10	Knowledge Management Tools	Alwert and Hoffmann (2003)	Anthology article
11	Integrationspotentiale für Geschäftsprozesse und Wissensmanagement	Abecker et al. (2002)	Anthology article
12	Integrating Knowledge Modeling in Business Process Management	Papavassiliou (2002)	Conference paper
13	Anforderungen an Geschäftsprozessmanagement-Werkzeuge	Kopperger (2001)	Anthology article
14	Unterstützung des Wissensmanagement durch Geschäftsprozessmanagement-Werkzeuge	Kopperger et al. (2001)	Anthology article
15	Knowledge meets Process - eine Zusammenfassung	Kunsmann and The (2001)	Anthology article
16	Workshop “Geschäftsprozessorientiertes Wissensmanagement”	Müller et al. (2001)	Conference paper
17	Ergänzende Unterstützung durch wissensbasierte Informationssysteme	Müller (2001a, b)	Anthology article
18	Grenzen der Geschäftsprozessmanagement-Werkzeuge	Müller and Nägele (2001)	Anthology article
19	Herausforderung Wissen und Prozesse managen	Schreiner (2001)	Anthology article
20	Wissensmanagement - Von der computerzentrierten zur anwendungsorientierten Kommunikationstechnologie	Petkoff (1998)	Monograph

available modeling software), they provide no relevant content for the integration of BPM and KM that is not already covered by other titles contained in the search results—for these are identical with the relevant primary sources.

A publication by Abecker et al. (2002) represents a special case. In a basic discussion it offers a possibility for differentiating approaches that deal with the integration of BPM and KM. It concerns essentially the differentiation made use of in the present article of the main focus types concerning the purpose of the sighted search hits. Thus the publication by Abecker et al. itself contains the three classes established in the first step as explained in Sect. 2.3. For this reason this title cannot be assigned.

In Table 2 the 20 of the 255 located publications are listed that for the reasons stated above are not additionally part of the examination.

Thus remaining are 235 publications on the integration of BPM and KM that in the further course of this chapter are classified, explained and finally critically discussed.

3.2 Classification and explanation of relevant search hits

For the generation of the most comprehensive and, at the same time, the clearest summary as well as for the evaluation and critical discussion of the state of the art, the 235 search hits will be classified. Here, on the one hand, the three different objective target types are enlisted and, on the other hand, the relation of the *application* from Fig. 1 is an appropriate point of reference.

Depending on the objective, in the following remarks a clear assignment of the 235 relevant search hits to the classes *planning, analysis and implementation* or *system utilisation* or *system evolution* will be carried out. These three classes represent altogether an analogical life cycle in which the various publications on the integration of BPM and KM can be arranged. The assignment is decided on the basis of the main priorities within the articles under examination. If, for example, a workflow based solution is under consideration—which is assigned to the second class—it does not necessarily follow that the implementation of the respective solution does not play any role in the title examined.

In the two goal-setting Classes I and II the setting up of subclasses seems appropriate. In this connection the exploitation of the 'Reference' of the *application* promises to deliver sound results that relate to the solution of practical problems and thus fulfil the purpose of the present article. In the course of the evaluation and classification of all relevant search hits in accordance with the variety of the criteria established in Fig. 1, a corresponding consideration of the 'Reference' of the *application* turned out as possible and suitable for six of seven subclasses. On the other hand, in one subclass the titles that deal with the KM approach of the Fraunhofer-Gesellschaft are summarised independently of the 'Reference' of the *application*. The articles in the classes and subclasses are sorted in reverse chronological order within the same year of publication in alphabetical order according to author.

In the framework of the following explanation of the individual classes and subclasses the criteria from Fig. 1 according to need—and as far as useful—are used. Especially when specific criteria patterns[7] for a (sub)class stand out, they will

[7] A pattern of criteria appears when a criterion from Fig. 1 applies without exception to all, or to almost all, titles of a (sub)class. The exceptions are indicated.

Table 3 Summary of the Search results of subclass IA

Class	No	Title	Author(s) (year)	Type of Article
Class IA	1	New Product Development Based on Knowledge Creation and Technology Education	Papoutsakis (2011)	Anthology article
Class IA	2	A Knowledge Framework Underlying Process Management	Linderman et al. (2010)	Journal article
Class IA	3	Role of process knowledge in business process improvement methodology: a case study	Seethamraju and Marjanovic (2009)	Journal article
Class IA	4	Prozessorientiertes Wissensmanagent	Erzer (2007)	Journal article
Class IA	5	Studienbuch Wissensmanagement – Grundlagen der Wissensarbeit in Wirtschafts-, …	Hasler Roumois (2007)	Monograph
Class IA	6	Developing new products in a network with efficiency and innovation	Lee et al. (2007a)	Journal article
Class IA	7	Knowledge Management Systems: Information and Communication Technologies for …	Maier (2001)	Monograph
Class IA	8	Integrated Modeling	Hädrich and Maier (2006)	Anthology article
Class IA	9	Integrierte Führungssysteme weisen den Weg	Katz and Koller (2006)	Journal article
Class IA	10	Prozessorientiertes Wissensmanagement in mittelständischen Maschinenbau-Unternehmen	Mühlbradt (2005)	Journal article
Class IA	11	Überlegungen zur organisationalen Wissensbasis von Dienstleistungsunternehmen: …	Welter (2005)	Conference paper
Class IA	12	Das Know-how der Kunden nutzen	Nohr (2004)	Journal article
Class IA	13	Von den Grundlagen zu einer Architektur für Customer Knowledge Management	Riempp (2003)	Anthology article
Class IA	14	On managerial incentives for process knowledge capture and use	Krishnamurthy and Balasubramaniam (2001)	Conference paper
Class IA	15	Towards a Framework for Knowledge Management Strategies: Process Orientation as …	Maier and Remus (2001)	Conference paper

be discussed in detail. Finally, the criteria patterns identified in the generated classes and subclasses are summarised by means of an overview display.

3.2.1 Search results of class I: planning, analysis and implementation

A total of 133 of the 235 relevant publications are included in this main class. On the basis of the individual evaluations conducted as well as especially with regard to the different 'Reference' of the *application*, Class I can be subdivided into four distinct subclasses (Classes IA to ID). In Table 3 the first Subclass IA is represented.

The publications in Subclass IA contain without exception basic discussions and take into consideration both implicit and explicit knowledge. With the exception of

Table 4 Summary of the search results of subclass IB

Class	No	Title	Author(s) (year)	Type of Article
Class IB	16	Kreativität und Wissensarbeit in SERIOUS PLAY Workshops – Nutzen für Planungsprozesse	Müller and Tröger (2011)	Conference paper
Class IB	17	Modellierung RFID-gestützter wissensintensiver Prozesse	Münchow et al. (2011)	Journal article
Class IB	18	Wissensmanagement für kleine und mittlere Unternehmen - Ein …	Wiesner et al. (2011)	Journal article
Class IB	19	Geschäftsprozessanalyse und Wissensmanagement mit Hilfe Sozialer Netzwerke	Weber and Scharff (2010)	Journal article
Class IB	20	Systemische Wissensbewirtschaftung - Teil 1: Wissensorientierte Modellierung von …	Wenzel et al. (2009a)	Journal article
Class IB	21	Systemische Wissensbewirtschaftung - Teil 2: Nutzung von Wechselwirkungen für die …	Wenzel et al. (2009b)	Journal article
Class IB	22	Research on a Knowledge Management Paradigma of Tightly Coupling the Business …	Yao (2008)	Anthology article
Class IB	23	Auditing and Mapping the Knowledge Assets of Business Processes - An Empirical Study	Lee et al. (2007b)	Conference paper
Class IB	24	Systemanalyse im Wissensmanagement	Trier and Bobrik (2007)	Anthology article
Class IB	25	Prozessorientiertes Wissensmanagement – Das ziel heisst: Prozesse optimieren	Erzer (2006)	Journal article
Class IB	26	Prozessorientiertes Wissensmanagement im TransAction Banking der Comerzbank AG: …	Grum et al. (2006)	Anthology article
Class IB	27	Auf dem Weg zu einem "Wissens-basierten und Prozess-orientierten …	Vogel and Hemmje (2006)	Conference paper
Class IB	28	Prozessoptimierung mit Wissensmanagement – Strategischer Einsatz von Methoden in …	Abele et al. (2005)	Journal article
Class IB	29	Improving performance of customer-processes with knowledge management	Bueren et al. (2005)	Journal article
Class IB	30	B-KIDE: A Framework and a Tool for Business Process Oriented Knowledge Infrastructure …	Strohmaier (2005)	Monograph
Class IB	31	Wissensinfrastrukturen – die optimale Unterstützung Ihrer Geschäftsprozesse	Tochtermann and Lindstaed (2005)	Journal article
Class IB	32	Werkzeugkasten für Wissensmanagement in KMU – Für jeden Mittelständler den …	Abele and Kuhn (2004)	Journal article
Class IB	33	Vorsprung durch Wissen – Mit optimierten Wissensprozessen in Forschung und …	Dückert (2004)	Journal article
Class IB	34	Wissensorientierte Optimierung von Geschäftsprozessen	Mühlbradt (2004)	Anthology article
Class IB	35	Designing Participatory Processes	Röder and Tautges (2004)	Conference paper
Class IB	36	Towards a Systematic Approach for Capturing Knowledge-Intensive Business Processes	Trier and Müller (2004)	Conference paper
Class IB	37	Basislager Qualitätsmanagement – mit Vorsprung zum Wissensgipfel	Vollmar (2004)	Journal article
Class IB	38	Developing a Multidisciplinary Approach of Concurrent Engineering	Zhang and Chen (2004)	Conference paper

Table 4 continued

Class	No	Title	Author(s) (year)	Type of Article
Class IB	39	Experiences from knowledge management implementations in companies of the …	Apostolou and Mentzas (2003)	Journal article
Class IB	40	Wissensorientierung im CRM bei der Helsana Versicherungen AG	Gronever et al. (2003)	Anthology article
Class IB	41	Wissensmanagement in der integrierten Produkt- und Prozessgestaltung - …	Klabunde (2003)	Monograph
Class IB	42	Knowledge Asset Management - Beyond the Process-centred and Product-centred …	Mentzas et al. (2003)	Monograph
Class IB	43	Prozeßorientiertes Wissensmanagement - Leitfaden zur Einführung und Anwendung in …	Bodrow et al. (2002)	Monograph
Class IB	44	Prozessorientiertes Wissensmanagement zur Verbesserung der Prozess- und..	Hanel (2002)	Monograph
Class IB	45	Prozessorientiertes Wissensmanagement	Lenz (2002)	Journal article
Class IB	46	Wissensmanagement-Projekte mit dem SIZ-Leitfaden zum Erfolg führen	Zimmer (2002b)	Journal article
Class IB	47	SIZ-Leitfaden – Wissensmanagement erfolgreich einführen	Zimmer (2002a)	Journal article
Class IB	48	Eine prozeßorientierte Mikro-Logik für praxisnahe Wissensmanagement-Projekte: …	Bettoni et al. (2001)	Conference paper
Class IB	49	Wissensmanagement im Projektgeschäft	Brunk and Schneider (2001)	Conference paper
Class IB	50	Vorgehensmodell für Wissensplattformen - Referenzrahmen und Wissensdienste	Seifried (2001)	Monograph
Class IB	51	Prozessorientiertes Wissensmanagement - Konzepte, Methode, Fallbeispiele	Thiesse (2001)	Monograph
Class IB	52	Business Knowlegde Management: Wertschöpfung durch Wissensportale	Bach (2000)	Anthology article
Class IB	53	Business Knowledge Management: von der Vision zur Wirklichkeit	Bach (1999)	Anthology article
Class IB	54	Wissensmanagement: eine unternehmerische Perspektive	Bach and Österle (1999)	Anthology article
Class IB	55	PROMET I-NET: Methode für Intranet-basiertes Wissensmanagent	Kaiser and Vogler (2000)	Anthology article
Class IB	56	Knowledge Engineering and Management - The CommonKADS Methodology	Schreiber et al. (1999)	Monograph
Class IB	57	Knowledge Asset Road Maps	Macintosh et al. (1998)	Conference paper

title 4 they are based on a literature search. In title 4 no bibliographic references were made. Titles 7, 13 and 15 consist of KM models. In title 13 KM in connection with customer relationship management receives special treatment, likewise in title 12. Title 12 as well as title 1, 6 and 14 contain large surveys. Title 2 deals thematically with KM in connection with Six Sigma, titles 5 and 9 with KM in connection with quality management. Title 3 is concerned with the process of

Table 5 Summary of the search results of subclass IC or IC*

Class	No	Title	Author(s) (year)	Type of article
Class IC	58	Verwaltungsmodellierung – Entwicklung und Evaluation einer Methode zur verteilten …	Baacke (2010)	Monograph
Class IC	59	Fuzzy-Prozessmodellierung - Identifikation, Externalisierung und Repräsentation …	Maihoff (2007)	Monograph
Class IC	60	A knowledge centred framework for collaborative business process modelling	Adamides and Karacapilidis (2006)	Journal article
Class IC	61	Qualität im Wissensmanagement - Modellierung und Bewertung von Wissensprozessen	Paulzen (2006)	Monograph
Class IC	62	Modellierung eines prozessorientierten Wissensmanagementkonzepts im …	Neumann (2004)	Monograph
Class IC	63	Wissensintensive Geschäftsprozesse partizipativ kostengünstig erheben, strukturiert …	Rumpfhuber (2004)	Anthology article
Class IC	64	Prozeßorientiertes Wissensmanagement - Konzepte und Modellierung	Remus (2002)	Monograph
Class IC	65	Integrierte Prozeß- und Kommunikationsmodellierung als Ausgangspunkt für die …	Remus (2001)	Conference paper
Class IC	66	Wissensmanagement mit ARIS-Modellen	Allweyer and Scheer (1999)	Anthology article
Class IC*	67	Wissen prozessorientiert managen - Methode und Werkzeuge für die Nutzung des …	Gronau (2009)	Monograph
Class IC*	68	ITIL & Co.: Der Faktor Wissen - ein oft vernachlässigter Aspekt	Schmid (2009)	Journal article
Class IC*	69	Software Engineering durch Modellierung wissensintensiver Entwicklungsprozesse	Freund (2006)	Monograph
Class IC*	70	Grundlagen zum Themenkomplex des Projektes M-WISE	Gronau et al. (2006d)	Anthology article
Class IC*	71	Modellbasierte Analyse interorganisationaler Wissensflüsse	Kratzke (2007)	Monograph
Class IC*	72	Wissensintensive Abläufe gestalten mit dem K-Modeler - Humanfaktor	Sultanow (2007)	Journal article
Class IC*	73	Einleitung - Motivation, Ziele Ergebnisse	Bahrs (2006)	Anthology article
Class IC*	74	Die KMDL-SE als UML-Erweiterung	Bischofs et al. (2006)	Anthology article
Class IC*	75	Methodenhandbuch KMDL-SE	Gronau et al. (2006a)	Anthology article
Class IC*	76	Technische Dokumentation K-Modeler	Gronau et al. (2006b)	Anthology article
Class IC*	77	KMDL - Eine semiformale Beschreibungssprache zur Modellierung von Wissenskonversionen	Gronau and Fröming (2006)	Journal article
Class IC*	78	Modellierung und Analyse wissensintensiver Aktivitäten in einem Geschäftsprozess …	Gronau et al. (2006c)	Anthology article
Class IC*	79	Von der Kommunikationsstrukturanalyse zur Knowledge Modeling and Description Language	Gronau and Müller (2006)	Anthology article

Table 5 continued

Class	No	Title	Author(s) (year)	Type of article
Class IC*	80	Management of Knowledge Intensive Business Processes with KMDL v2.0	Korf and Fröming (2006)	Conference paper
Class IC*	81	Modellierung, Analyse und Gestaltung wissensintensiver Geschäftsprozesse am …	Bahrs and Gronau (2005)	Journal article
Class IC*	82	Management von wissensintensiven Geschäftsprozessen mit KMDL	Bogen and Korf (2005)	Journal article
Class IC*	83	Prozessorientiertes Wissensmanagement	Gronau and Bahrs (2005)	Anthology article
Class IC*	84	Modellierung und Analyse wissensintensiver Prozesse mit KMDL v2.0	Gronau et al. (2005)	Anthology article
Class IC*	85	Analyse wissensintensiver Verwaltungsprozesse mit der Beschreibungssprache KMDL	Gronau and Weber (2005)	Anthology article
Class IC*	86	Aufbau einer Wissensorganisation für den betrieb komplexer ERP-Systeme	Schmid et al. (2005)	Journal article
Class IC*	87	The KMDL Knowledge Management Approach: Integrating Knowledge Conversions …	Gronau et al. (2004)	Conference paper
Class IC*	88	Management of Knowledge Intensive Business Processes	Gronau and Weber (2004)	Conference paper
Class IC*	89	Sprache zur Modellierung wissensintensiver Geschäftsprozesse	Gronau (2003)	Journal article

business process analysis and optimisation and the necessary knowledge for the process, title 8 with the demands for the modeling of knowledge work, title 10 with KM in medium-sized mechanical engineering companies and title 11 with the role of knowledge in service companies. The depth of the content and thematic breadth of these publications differ strongly.

The illustrated Subclass IB in Table 4 comprises 42 search hits that likewise on the basis of their 'Reference' of the *application* are jointly represented and described.

The titles of this subclass contain without exception procedural models or operational recommendations.[8] In titles 16 and 52 through 54 the operational recommendations are not explicitly implemented. They can be drawn from the description contained in title 16 of a concept of role-playing for the application of factory planning processes. In titles 52 through 54, which also contain a KM model, they can be drawn from the illustrated case studies/examples. Titles 36, 41 and 44 likewise describe KM models. In ten articles (titles 20, 21 23, 28, 32, 34, 39, 42, 44 and 56), moreover, KM audits/assessments are addressed. With the exception of title 16, which without exception considers implicit knowledge, in all the other publications explicit knowledge is taken into consideration. And with the exception of titles 19 and 57, which are tactically or strategically oriented, all the articles have an operational focus. In detail it can be ascertained that the objectives within

[8] Since the boundary between a procedural model and operational recommendations is fluid, the separation between procedural model and operational recommendations is not consistently possible.

Table 6 Summary of the search results of subclass ID

Class	No	Title	Author(s) (year)	Type of article
Class ID	90	BEYERS - Die richtigen Grundlagen schaffen: Motivation und Wissensteilung	Beyers and Salgado (2009)	Anthology article
Class ID	91	PLATH - den Wettbewerb im Visier	Brüggman et al. (2009)	Anthology article
Class ID	92	DESMA - Transparenz über Prozesse und Methoden	Decker and Orth (2009)	Anthology article
Class ID	93	PM-Automotive GmbH - Verantwortung durch Qualifizierung übergeben	Döhler (2009)	Anthology article
Class ID	94	Einführung von Wissensmanagent	Finke (2009b)	Anthology article
Class ID	95	Den Status Quo im Umgang mit Wissen erkennen	Finke (2009a)	Anthology article
Class ID	96	Schnittstellenworkshops und soziale Netzwerkanalyse	Finke (2009c)	Anthology article
Class ID	97	Prozessorientiertes Wissensmanagement bei einem mittelständischen Maschinenbauer	Gruhn (2009a)	Conference paper
Class ID	98	Krautzberger - 100 Jahre Wissen	Gruhn (2009b)	Anthology article
Class ID	99	Ein Referenzmodell für Wissensmanagent	Mertins et al. (2009a)	Anthology article
Class ID	100	Wissensorientierte Analyse und Gestaltung von Geschäftsprozessen	Mertins and Orth (2009b)	Anthology article
Class ID	101	Der WM-Prozessassistent	Mertins and Orth (2009a)	Anthology article
Class ID	102	Wissensbilanz	Mertins et al. (2009b)	Anthology article
Class ID	103	Dr.-Ing. Meywald GmbH & Co. KG. - Überzeugungsarbeit mit Augenmaß	Meywald (2009)	Anthology article
Class ID	104	Kristronics - Wissensmanagement als Kompass in stürmischer See	Molter (2009)	Anthology article
Class ID	105	Wissensmanagement mit Wiki-Systemen	Orth (2009)	Anthology article
Class ID	106	Wie Wissen wandert - der Fall STELCO	von Pechmann and von Hahn (2009)	Anthology article
Class ID	107	Lti DRiVES GmbH - aus Erfahrungen lernen und Irrwege vermeiden	Rühl (2009)	Anthology article
Class ID	108	Terrawatt Planungsgesellschaft mbH - Effektive Nutzung windiger Zeiten	Schneider (2009)	Anthology article
Class ID	109	BMA AG - Der süße Geschmack des Wissensmanagements	Stolte et al. (2009)	Anthology article
Class ID	110	AUCOTEAM - Ingenieurwissen effektiv managen	Thierse (2009)	Anthology article
Class ID	111	Schmalz - Wikipedia für den unternehmerischen Einsatz	Ulmer (2009)	Anthology article
Class ID	112	Wissensmanagement-Lösungen auswählen	Voigt (2009b)	Anthology article

Table 6 continued

Class	No	Title	Author(s) (year)	Type of article
Class ID	113	Selbsterklärende Ordnerstrukturen	Voigt (2009a)	Anthology article
Class ID	114	Fazit aus 15 mittelständischen Fallstudien	Voigt et al. (2009b)	Anthology article
Class ID	115	Ausblick auf Forschungsbedarf im Wissensmanagement für KMU	Voigt et al. (2009a)	Anthology article
Class ID	116	Einleitung	Voigt and Seidel (2009a)	Anthology article
Class ID	117	Herausforderung für Unternehmen	Voigt and Seidel (2009b)	Anthology article
Class ID	118	Erfahrungssicherungsworkshops	Voigt and von Garrel (2009)	Anthology article
Class ID	119	Würth Elektronik ICS - Wiki-Lösungen: Wer die Wahl hat, hat die Qual	Wartenberg (2009)	Anthology article
Class ID	120	GWB - Wissen sichern und nutzbar machen mittels Datenbanken	Würstl and Würstl (2009)	Anthology article
Class ID	121	Wissensmanagementpraxis im Maschinenbau - Von der Strategie bis zur Lösung	Mertins et al. (2008)	Journal article
Class ID	122	Prozessorientiertes Wissensmanagement in produzierenden Unternehmen - Einfach, …	Voigt et al. (2008)	Journal article
Class ID	123	Prozessorientiertes Wissensmanagement in KMU	Mertins et al. (2007)	Journal article
Class ID	124	Prozessorientiertes Wissensmanagement in kleinen und mittelständischen Unternehmen - …	Finke et al. (2006)	Conference paper
Class ID	125	Nutzen statt Kosten – Wissensmanagement in KMU	Staiger and Kilian (2006)	Journal article
Class ID	126	Integration von Wissensmanagement in Geschäftsprozesse	Heisig (2005a)	Monograph
Class ID	127	Integration von Wissensmanagement in Geschäftsprozesse	Heisig (2005b)	Anthology article
Class ID	128	Business Process Oriented Knowledge Management	Heisig (2003)	Anthology article
Class ID	129	Wissensmanagement in industriellen Geschäftsprozessen	Mertins and Heisig (2003)	Journal article
Class ID	130	Introduction	Mertins et al. (2003)	Anthology article
Class ID	131	Methode des geschäftsprozessorientierten Wissensmanagements - Die Methode GPO-WM	Heisig (2002)	Anthology article
Class ID	132	Wissenstransparenz als Wettbewerbsvorteil - Einstiegsmethode und -werkzeuge in das …	Dämmig et al. (2001)	Conference paper
Class ID	133	Business Process Oriented Knowledge Management - Methode zur Verknüpfung von …	Heisig (2001)	Conference paper

Table 7 Summary of the search results of subclass IIA

Class	No	Title	Author(s) (year)	Type of article
Class IIA	1	Wikis als integrierende Plattform für prozessorientierte Wissensarbeit zwischen …	Voigt (2011)	Conference paper
Class IIA	2	Bleibt alles anders: Ad-hoc-Prozesse - und wie IT sie unterstützen kann	Böhringer and Gerlach (2010)	Journal article
Class IIA	3	Wissensmanagement - Unterstützung für die Entwicklung und Nutzung von …	Prilla (2010)	Monograph
Class IIA	4	Prozessmanagement - Interaktiv mit Wiki	Schmitt and Behrens (2010)	Journal article
Class IIA	5	Prozessleitstände für verteilte und nicht planbare Organisationsprozesse	Sultanow and Weber (2010)	Journal article
Class IIA	6	Ein Referenzmodell zur Unterstützung wissensintensiver Prozesse im …	Lütke Entrup (2009)	Monograph
Class IIA	7	Integriertes prozessorientiertes Wissensportal der CREDIT SUISSE IT	Meili (2009)	Conference paper
Class IIA	8	Erfolgreich IT-Anwendungen entwickeln - Wissensmanagement hilft	Rodé et al. (2009)	Journal article
Class IIA	9	"Ganzheitliches Informations-, Prozess- und Wissensmanagement aus der industriellen …	Bentele (2006)	Conference paper
Class IIA	10	Taba Workstation: Supporting Technical Solution Through Knowledge Management of …	Figueiredo et al. (2006)	Conference paper
Class IIA	11	Prozessorientiertes Wissensmanagement bei Siemens Medical Solutions	Winkler (2005)	Anthology article
Class IIA	12	Vom Kundenwunsch zum Produkt – das praktizierte Prozess-, Wissens- und …	Pohl and Steinmann (2004)	Journal article
Class IIA	13	Prozess- und Wissensmanagement - Praktische Ansätze zur Integration	Redling and Traunfellner (2004)	Anthology article
Class IIA	14	Hybrides Änderungsmanagement im Serienanlauf	Scholz-Reiter et al. (2002)	Journal article
Class IIA	15	Globale HR Prozesse als Herausforderung – Kommunikation von HR Prozesswissen …	Winkelmann-Ackermann and Thoma (2004)	Anthology article
Class IIA	16	Methodology of Integrated Knowledge Management in Lifecycle of Product …	Zhong et al. (2004)	Conference paper
Class IIA	17	Projektportal bei der Winterthur Versicherungen	Kremer and Riempp (2003)	Anthology article
Class IIA	18	Just-In-Time-Informationskonzept befähigt die Kooperation in Produktionsnetzwerken	Dombrowski and Zeisig (2002a)	Journal article
Class IIA	19	Wenn Unwissenheit die Qualität gefährdet – Integrierte Prozess-, Qualitäts- und …	Dombrowski and Zeisig (2002b)	Journal article
Class IIA	20	PRomisE2 - Recording and Displaying Situated Process Information in Knowledge …	Hoffmann et al. (2002)	Conference paper
Class IIA	21	Managing Knowledge in Weakly-Structured Administrative Processes	Papavassiliou et al. (2002)	Conference paper
Class IIA	22	Wissensmanagement mit Portalen	Borowsky and Scheer (2001)	Journal article

Table 7 continued

Class	No	Title	Author(s) (year)	Type of article
Class IIA	23	Integrating Business Process Descriptions and Lessons Learned with an Experience Factory	Decker et al. (2001)	Conference paper
Class IIA	24	Management von Geschäftsprozesswissen – IT-basierte Systeme und Architektur	Habermann (2001)	Monograph
Class IIA	25	Process Oriented Knowledge Management	Jablonski et al. (2001)	Conference paper
Class IIA	26	Prozessorientiertes Web Content Management	Möllering and Scheube (2001)	Journal article
Class IIA	27	Prozessorientiertes Wissensmanagement mit CognoVision	Müller and Herterich (2001)	Conference paper
Class IIA	28	Management von Prozesswissen in Fahrzeugentwicklungsprojekten	Rupprecht et al. (2001)	Conference paper
Class IIA	29	Kontextintensive Bereitstellung und Visualisierung von Unternehmensinformationen	Spath et al. (2001)	Journal article
Class IIA	30	Improving Knowledge Intensive Processes through an Enterprise Knowledge Medium	Eppler et al. (1999)	Conference paper
Class IIA	31	SAP R/3 - Prozeßanalyse mit Knowledge Maps	Teufel et al. (1999)	Monograph

Subclass IB differ. They range from planning and implementation of process oriented KM through planning and implementation of concrete KM solutions that for the most part are IT based.

The 'Reference' of the *application* of the 32 search hits that are represented in Table 5 resemble with respect to their main focus, which is the modeling of processes and knowledge.

In Subclass IC the publications are summarised that in reference to modeling have different emphases and explain various notations and tools. Title 58 contains a modeling method that was developed for the integrative observation of business processes and knowledge in public administration. In addition, known process modeling languages and tools are treated, such as the Petri net (title 61) or the EPC (event driven process chain) realised in ARIS (titles 59, 62, 64, and 66) that are extended to include knowledge. In addition, in title 63 the picture postcard method for software independent process- and knowledge-retention is introduced, and in titles 64 and 65 the process modeling in connection with communication modeling is presented.

All titles listed under IC* are devoted specially to the notation Knowledge Modeling and Description Language (KMDL) and, with the exception of title 71, also the associated tool K-Modeler. With this special notation and the associated tool the modeling of business processes together with the options of the illustration and analysis of knowledge flows and transformations are pointed out. The publications deal with the application of the KMDL and the K-Modeler to different business process types. Titles 69, 70, 73, 74, 75 and 76 deal, for example, with the

Table 8 Summary of the search results of subclass IIB

Class	No	Title	Author(s) (year)	Type of article
Class IIB	32	Industrialisation of the Knowledge Work: The Knowledge Conveyor Belt Approach	Karagiannis et al. (2011)	Anthology article
Class IIB	33	Heterogenen Wissenständen gerecht werden - mit personalisierten Informationen	Mutschler (2011)	Journal article
Class IIB	34	Service-oriented Business Process Systems for Knowledge Work – Architecture, …	Leyking (2010)	Monograph
Class IIB	35	Ontologiebildung und semantische Suchpfade zur Wissensgenerierung und Repräsentation	Binner (2009)	Journal article
Class IIB	36	Ganzheitliches Wissenskonzept - Wissensframework - Zur Gestaltung und …	Binner (2008a)	Journal article
Class IIB	37	Pragmatisches prozessorientiertes Wissensmanagement	Binner (2008b)	Monograph
Class IIB	38	Prozessorientiertes Wissensmanagement unterstützt erfolgreiches …	Binner (2008c)	Journal article
Class IIB	39	Systematische Wissensentwicklung in der Organisation	Binner (2008d)	Journal article
Class IIB	40	Workflow Systems and Knowledge Management	Berztiss (2006)	Anthology article
Class IIB	41	Activation of Knowledge in an Integrated Business Process Support/Knowledge …	Bider et al. (2006)	Conference paper
Class IIB	42	Wissensbasiertes Prozessmanagement sichert den Unternehmenserfolg	Binner (2006)	Journal article
Class IIB	43	Concurrent Engineering	Busch and Gardoni (2006)	Journal article
Class IIB	44	Business Process Support as a Basis for Computerized Knowledge Management	Andersson et al. (2005)	Conference paper
Class IIB	45	Prozessorientiertes Wissensmanagement durch kontextualisierte …	Böhm and Härtwig (2005)	Anthology article
Class IIB	46	A Process for Delivering Information Just in Time	Fenstermacher (2005)	Conference paper
Class IIB	47	Ein Beitrag für ein selbstlernendes Anwendungssystem zur kontinuierlichen …	Grein (2005)	Monograph
Class IIB	48	Der Elektronische Akt (ELAK) als Grundlage für Wissensbasiertes Prozessmanagement	Grimm and Müller (2005)	Anthology article
Class IIB	49	MAKO-PM: Just-in-Time Process Modell	Morikawa and Kerschberg (2005)	Conference paper
Class IIB	50	Paradigmenwechsel bei der Gestaltung von E-Government Prozessen? GEVER - Ein …	Schaffroth (2005)	Anthology article
Class IIB	51	Towards the Agile Management of Business Processes	Weber and Wild (2005)	Conference paper
Class IIB	52	Business-Process Oriented Knowledge Management: Concepts, Methods, and Tools	Abecker (2004)	Monograph
Class IIB	53	Research on Cooperative Workflow Management Systems	Cui and Wang (2004)	Conference paper

Table 8 continued

Class	No	Title	Author(s) (year)	Type of article
Class IIB	54	Effective Elements of Integrated Software Development Process Supported Platform	Fang et al. (2004)	Conference paper
Class IIB	55	Wissensmanagement in IT-Unternehmensberatungen	Hofmann (2004)	Monograph
Class IIB	56	Wissensmanagement: Wissensversorgung und kontextuelle Kollaboration bei …	Huang (2004)	Monograph
Class IIB	57	Knowledge-based process management – an approach to handling adaptive workflow	Chung et al. (2003)	Journal article
Class IIB	58	e-R&D: Effectively Managing and Using R&D Knowledge	Ebert et al. (2003)	Anthology article
Class IIB	59	Möglichkeiten und Grenzen der wissensbasierten Vertriebsunterstützung für …	Hartmann (2003)	Monograph
Class IIB	60	Process-Based Knowledge Management Support for Software Engineering	Holz (2003)	Monograph
Class IIB	61	A framework for designing a workflow-based knowledge map	Kang et al. (2003)	Journal article
Class IIB	62	Kontextbasiertes Wissensmanagement in der Produktentwicklung als Grundlage für …	Apitz et al. (2002)	Journal article
Class IIB	63	Rechnergestütztes Organisationsframework ermöglicht systematische …	Binner (2002)	Journal article
Class IIB	64	Ein Ansatz zur Unterstützung wissensintensiver Prozesse durch …	Goesmann (2002)	Monograph
Class IIB	65	The PROMOTE approach: Modelling Knowledge Management Processes to describe …	Karagiannis and Woitsch (2002)	Anthology article
Class IIB	66	Workflow and Knowledge Management: Approaching an Integration	Lai and Fan (2002)	Conference paper
Class IIB	67	The DECOR Toolbox for Workflow-Embedded Organizational Memory Access	Abecker et al. (2001a)	Conference paper
Class IIB	68	Prozesswissen als Gegenstand des Wissensmanagements in der öffentlichen Verwaltung	Engel (2001)	Conference paper
Class IIB	69	Wissens-Ko-Produktion und dynamische Netze: Kooperative Wissenserzeugung und …	Fuchs-Kittowski (2001)	Conference paper
Class IIB	70	Vernetztes Wissen als Unternehmensstrategie	Gentner (2001)	Journal article
Class IIB	71	Wissensmanagement und Geschäftsprozeßunterstützung - am Beispiel des Workflow …	Goesmann and Herrmann (2001)	Anthology article
Class IIB	72	GroupProcess: Using Process Knowledge from the Participative Design and Partical …	Huth et al. (2001)	Conference paper
Class IIB	73	Wissensbasierte Informationssysteme	Müller (2001b)	Anthology article
Class IIB	74	Anforderungen an die Workflow-Unterstützung für wissensintensive Geschäftsprozesse	Schwarz et al. (2001)	Conference paper
Class IIB	75	Distribution of Workflow Process Knowledge in Organizations	Smolnik et al. (2001)	Anthology article

Table 8 continued

Class	No	Title	Author(s) (year)	Type of article
Class IIB	76	Knowledge Management Concepts and Tools: The PROMOTE Project	Telesko et al. (2001)	Anthology article
Class IIB	77	The EU-Project PROMOTE: A Process-oriented Approach for Knowledge Management	Karagiannis and Telesko (2000)	Conference paper
Class IIB	78	ICMS KnowledgeBase, New Zealand – Gold Award, Document/Knowledge Management, …	Fischer 1999	Anthology article
Class IIB	79	Wissensmanagement für die Schadenbearbeitung in Versicherungsunternehmen	Jara et al. (2000)	Anthology article
Class IIB	80	Process-Oriented Knowledge Management	Kwan (1999)	Monograph
Class IIB	81	Unterstützung des Wissensmanagement durch Informations- und …	Wolf et al. (1999)	Anthology article
Class IIB	82	Ein Beitrag zur Integration von Workflow- und Wissensmanagement unter besonderer …	Wargitsch (1998)	Monograph

Table 9 Summary of the search results of subclass IIC

Class	No	Title	Author(s) (year)	Type of article
Class IIC	83	How to integrate technology-enhanced learning with business process management	Capuano et al. (2008)	Journal article
Class IIC	84	Wissen im Fluss - Prozeßorientierung im Wissensmanagement unter Verwendung …	Pook (2003)	Monograph
Class IIC	85	Software-Unterstützung für das Geschäftsprozessorientierte Wissensmanagement	Abecker et al. (2001b)	Conference paper
Class IIC	86	Geschäftsprozesse und Wissensmanagement – vom Umgang mit erfolgskritischem …	Pook and Starkloff (2011)	Journal article

development and application of an adapted form of KMDL and the K-Modeler for the use in software engineering. In relation to the 'Intervention Level' the dimensions technology, organisation and personnel are taken into account in Subclass IC*.

In addition to the 'Reference' of the *application* all the titles in Class IC and IC* have in common that they refer not to the total process organisation but throughout to the business process/subprocess generally or to a branch/concrete process. With the exception of titles 59, 66 and 72 that focus only on explicit knowledge, all the others take into account implicit and explicit knowledge. All of the articles are based on literature searches. Furthermore, with the exception of the tactical title 68, all the articles are operatively oriented. The content of title 71 has operative and tactical constituents.

The 44 publications in Subclass ID that are represented in Table 6 provide either a summary of the KM approach of the Fraunhofer-Gesellschaft or they explain its

components and describe their application. This approach covers a majority of the criteria from Fig. 1; this means also numerous different criteria from the area of the 'Reference' of the *application.* Therefore, the assignment of the individual articles dealing with this one comprehensive KM application to the other subclasses is not reasonably possible. Here the setting up of an individual subclass is appropriate. The following explanation refers to the total approach of the Fraunhofer-Gesellschaft, because its components described in the individual titles in large part build upon each other and together account for a concept consisting of extensive planning, analysis and implementation of process oriented KM in small and medium-sized companies.

With the exception of the criterion basic discussion, the KM approach of the Frauenhofer-Gesellschaft covers all the criteria from the 'Reference' of the *application*. With regard to 'Maturity' the main point is a commercial/ready-for-use product. The approach aims at business processes/subprocesses, and implicit and explicit knowledge are taken into consideration. The description is based upon literature searches and case studies/case examples. The approach includes components with both operative and tactical foci that together cover all KM building blocks. The use of interviews, surveys and workshops is described. For the modeling and analysis of business processes the Integrated Enterprise Modeling (IEM) method is used that is implemented by means of the software tool Method for Object-Oriented Business Process Optimization (MO^2GO), which has been developed for this purpose. For the support of the decision in the choice of the existing KM methods and tools, ProWis-Shop is introduced, an online tool available free of charge based upon the principle of helping people to help themselves and is aimed especially at medium-sized companies.

3.2.2 Search results of class II: system utilisation

In Class II a total of 86 of the 235 closely handled publications are grouped. On the basis of the individual evaluations carried out and especially because of the differences within the 'Reference' of the *application*, this class can also be divided into subclasses.

In Table 7 the represented Subclass IIA differs chiefly in its 'Reference' of the *application* but also regarding the system complexity and use of context, it is distinguished from the Subclass IIB.

All the publications that with reference to the criterion methods/tools belong to the category miscellaneous are classified in IIA. In this subclass, processes as a structuring foundation are used to organise archives (compare Abecker et al. 2001b, p. 40f.). Explicit knowledge is always taken into consideration. An operative orientation can be ascertained without exception. Moreover, all titles deal with the design dimension technology as well as the KM building blocks use, preservation and distribution. The titles 14, 22 and 30 contain the basis for portal solutions that use processes as a structuring foundation. Solutions with, in part, comprehensive search functions are provided in titles 1 through 4, 6 through 13, 16, 17, 20, 21, 23 through 25, 27, 29 and 31. Titles 15, 18, 19 and 26 integrate directories of experts or building blocks from the area *computer supported cooperative work* (CSCW)

(compare Abecker et al. 2002, p. 15). Examples of this are virtual conference rooms or web based question portals. In addition, in title 28, for the application case motor vehicle development, the possibility of a process modeling on a graphic interface's being realised parallel to process implementation is described. Title 5 represents a special feature in whose presented solution the process and knowledge representation occurs three-dimensionally by means of the utilisation of virtual space.

In Table 8 the represented Subclass IIB contains the workflow based research results that range from a pure workflow-triggered information logistics to the use of dynamic and extended process contexts (compare Abecker et al. 2001b, p. 40f.).

The titles of this subclass, which are without exception workflow based, refer without exception to the business process/subprocess or a branch/concrete process. All take into account explicit knowledge and are operatively oriented. With the exception of title 46 in which the just-in-time information supply is purely theoretically presented, the articles look at the 'Intervention Level' technology. In addition, all the publications take into account the KM building blocks use, preservation and distribution. Beside title 46 the titles 40 and 43 also contain foundations for workflow based solutions. The majority of these publications offer solutions in which the purely workflow based information logistics are paramount and are suitable for the use of processes that can be structured and standardised. In titles 56 and 60, on the other hand, flexibly and dynamically adaptable workflow solutions for the use in so-called ad hoc processes (compare Abecker et al. 2002, p. 19) are explained. The integration of process contexts as a possibility of an improved information supply is used (ibid., p. 16). In title 56 as well as in title 73, moreover, solution-building blocks from the area CSCW are used.

In the following Table 9 the titles of the Subclass IIC are represented.

The Subclass IIC contains without exception basic discussions. All the publications refer to business processes/subprocesses and take into consideration implicit and explicit knowledge. They are based on a literature search and are operationally oriented. In each title the KM building blocks preservation and distribution are considered. The first title of this subclass deals with the potentialities of the integration of E-learning, skill management and BPM, for which a prototypical system solution is developed. The two titles 84 and 86 deal with the potentialities and benefits of a tight coupling of BPM and KM, where especially in title 84 the suitability of process models for the transfer of knowledge is gone into. Title 85 offers the chance for the differentiation of approaches that relates to their system complexity and contextual utilisation. This possibility of differentiation was drawn upon in the framework of the present article in order to construct the two Subclasses IIA and IIB as well as to differentiate the workflow publication types within the Subclass IIB.

3.2.3 Search results of class III: system evolution

The focus Class III represented in Table 10 is with a total of 16 publications the most clearly comprehensible. For this reason an additional subdivision will here not be made.

Table 10 Summary of the search results of class III

Class	No	Title	Author(s) (year)	Type of article
Class III	1	Qualitätsmanagement für wissensintensive Geschäftsprozesse	Gronau and Heinze (2011)	Conference paper
Class III	2	Gefahr Wissensweitergabe - eine Knowledge Firewall schützt	Bahrs and Vladova (2010)	Journal article
Class III	3	Mit Wissensflussmanagement Produktpiraterie unterbinden - Koordinierte Geheimhaltung in …	Bahrs et al. (2010)	Journal article
Class III	4	Reifegradmessung als Ansatz zur Verbesserung von wissensintensiven Geschäftsprozessen	Geers et al. (2010a)	Journal article
Class III	5	Qualität in wissensintensiven Geschäftsprozessen - Ein neuer Ansatz für die Qualitätsmessung	Geers et al. (2010b)	Journal article
Class III	6	Qualität in wissensintensiven Geschäftsprozessen - Ein neuer Ansatz für die Qualitätsmessung	Jochem and Geers (2010)	Journal article
Class III	7	Wissenskapital identifizieren und bewerten - ein 4-Stufen-Modell	Soelberg (2010)	Journal article
Class III	8	Ein Konzept zur Simulation wissensintensiver Aktivitäten in Geschäftsprozessen	Fröming (2009)	Monograph
Class III	9	Preserving Substantial Knowledge in the Organizational Memory Using Process Modelling …	Saad (2008)	Anthology article
Class III	10	A framework for the improvement of knowledge-intensive business processes	Dalmaris et al. (2007)	Journal article
Class III	11	Knowledge, Information and the Business Process – Revolutionary Thinking or Common Sense?	Taylor (2007)	Monograph
Class III	12	Wirtschaftlichkeitsanalyse bei der Einführung und Gestaltung von …	Blodig et al. (2006)	Conference paper
Class III	13	Strategische Unternehmensentwicklung auf Basis von Kompetenzprofilen – Ein Ansatz zum …	Nedeß et al. (2006)	Journal article
Class III	14	Die Kombination von Wissens- und Prozessmanagent - Herausforderung für die Unternehmen …	Engelhardt (2004)	Anthology article
Class III	15	Heterogenes Wissen über Prozesse als Grundlage für die Geschäftsprozessoptimierung	Hrastnik et al. (2004)	Anthology article
Class III	16	Einflussfaktoren des Wissenstransfers – Ergebnisse einer explorativen empirischen Studie	Werner (2004)	Anthology article

All of the articles in this class consider implicit and explicit knowledge. They depend upon a literature search and take into consideration with respect to the 'Intervention Level' the dimension organisation and the KM building block preservation. In the titles 7, 9, 11, 13 and 15 the evaluation of identified and relevant knowledge is of major importance. The titles 12 and 14, on the other hand, deal with the evaluation of KM applications. The goal of the simulation concept from the monograph of title 8, which was developed on the basis of the KMDL-notation, is likewise an evaluation. Thereby, for example, the efficiency of business processes in reference to their use, preservation and development of knowledge can be analysed and evaluated. Likewise with reference to KMDL-notation—at least as a possible option—in titles 2 and 3 the protection of critical knowledge is gone into. The

	Planning, Analysis and Implementation				*System Utilisation*			*System Evolution*
	IA (15 titles)	*IB* (42 titles)	*IC(*)* (32 titles)	*ID* (44 titles)	*IIA* (31 titles)	*IIB* (51 titles)	*IIC* (4 titles)	*III* (16 titles)
Application	**Reference** Basic Discussion A	**Reference** Procedural Model/ Operational Recommen-dations A	**Reference** Modeling Method/Tool A	**Reference** Every criterion A (except for Basic Discussion) **Maturity** Commercial/ Ready-for-use Product A	**Reference** Miscellaneous A	**Reference** Workflow based Approach A	**Reference** Basic Discussion A	
Object of Observation	**Knowledge** Implicit A and explicit A	**Knowledge** Explicit A (except for title 16)	**Process** Total Process Organisation K **Knowledge** Implicit A (except for titles 59, 66 and 72) and explicit A	**Process** Business Process/ Subprocess A **Knowledge** Implicit A and explicit A	**Knowledge** Explicit A	**Process** Total Process Organisation K **Knowledge** Explicit A	**Process** Business Process/ Subprocess A **Knowledge** Implicit A and explicit A	**Knowledge** Implicit A and explicit A
Methodological Procedure	Literature Search A (except for title 4)		Literature Search A	Literature Search A and Case Study/ Example A			Literature Search A	Literature Search A
Design		**Management Level** Operative A (except for titles 19 and 57)	**Management Level** Operative A (except for title 68) **Intervention Level** Technology A*, Organisation A* and Personnel A*	**Management Level** Strategic K **Intervention Level** Each KM Building Block A	**Management Level** Operative A **Intervention Level** Technology A; KM Building Blocks Use, Preservation and Distribution A	**Management Level** Operative A **Intervention Level** Technology A (except for title 46); KM Building Blocks Use, Preservation and Distribution A	**Management Level** Operative A **Intervention Level** KM Building Blocks Preservation and Distribution A	**Intervention Level** Organisation A; KM Building Block Measurement A

Key: A = applies to all articles; A* = applies to all articles in IC*; K = applies to none of the articles

Fig. 3 Summary of the identified criteria patterns in (sub)classes

foundation for this protection is the analysis and evaluation of critical process interfaces. Title 10 contains a framework for a systematic improvement of business processes, whereas in title 16 an empirical study of the barriers of knowledge transfer is introduced. Titles 1, 4, 5, and 6, on the other hand, explain a maturity model for the systematic analysis and evaluation of BPM and KM. Thereby the integrative implementation of both disciplines can be tactically measured and regulated.

3.2.4 Summary of the explanation of relevant search results

In the following diagram the criteria patterns explained in Sect. 3.2 are summarised (Fig. 3).

Despite the heterogeneity of the publications considered, their evaluation and classification aim at making general statements by means of the criteria described in Sect. 2.3. The view of the criteria patterns shows that there are fundamentally different possibilities for the creation of subclasses. The decision to use the 'Reference' of the *application* for the formation of Subclass IA, IB, IC$^{(*)}$, IIA, IIB and IIC is based on the intention to obtain meaningful results in the sense of the formulated objective.

3.3 Critical discussion of relevant search results

In Sect. 3.1 and on the basis of an initial evaluation of the results, 20 of the 255 search hits were not further examined. The 235 remaining publications were by means of a taxonomy divided into Classes I, II and III, which in part contain additional subclasses, and explained.

A critical discussion of the relevant search results follows as well as a review of what these up to now have achieved and where there are still deficits. This discussion is oriented on the constituted classes. The established criteria from Fig. 1, insofar as appropriate, are used there.

3.3.1 Critical discussion of class I: planning, analysis and implementation

In Class I the concept of *planning, analysis and implementation* is paramount. The contents aim at process oriented KM approaches, concrete KM systems or individual-solution building blocks. Included in the class are basic discussions and KM models, procedural models and operational recommendations as well as numerous commercial/ready-for-use methods and tools.

Discussions of fundamentals and KM models are prerequisites for concrete approaches. Therein KM elements are named and connections explained. They are important for the generation of understanding, but they alone do not offer sufficiently concrete support for the realization of *planning, analysis and implementation.* Decisive for the success of relevant initiatives is the existence of a clearly and concretely formulated goal in the form of a target KM requirement. Procedural models and operational recommendations contain sweeping indications as to what constitutes a 'good' KM, what is to be observed in *planning, analysis and*

implementation and what is best avoided. The individual demand for KM of a company or an organisation plays scarcely any role in this process. With KM audits/assessments an actual evaluation can be carried out. Under the premise of a repeated application, a before-and-after comparison can thus be drawn. In addition, individual questions as to the application of methods and tools imply aspects of a sweeping target status. A systematic ascertainment of a clearly formulated and individual target status is, however, not intended. With the aid of a process modeling expanded by knowledge an actual state can likewise be established from the handling of knowledge and KM. For a systematic evaluation, however, a sound understanding of the concrete demand for KM of a company or an organisation is lacking and thus left without a goal, namely the target status. With the online solution ProWis-Shop of the Fraunhofer–Gesellschaft a guided selection of KM solution-building blocks can basically be made. In the framework of this selection, however, KM methods and tools on the basis of the orientation of the application to small and medium-sized companies are suggested, which are chiefly sweeping and conventional as well as quick and easily applicable. More demanding or more expensive solutions—also the heavily IT or workflow based solutions from Class II—are not part of the suggestion. The online solution is based on a self-assessment. In combination with selection rules that are oriented on the type of knowledge (implicit or explicit) and specific KM building blocks, there is at least an initial consideration of the decisive interdependency between demand for KM and the choice of the appropriate solution.

The full potential that a systematic procedure in view of the individual demand for KM of a company or an organisation promises is, however, not used in any one of the articles in this class.

3.3.2 Critical discussion of class II: system utilisation

In the publications of Class II approaches with process oriented archive organisation or a workflow based solution are introduced that are well qualified for the providing of employees with explicit knowledge. Depending on the approach a more or less automated and role-specific support is possible. In addition, the possibilities of the networking of experts across organisational and spatial boundaries are demonstrated. A few of the fundamentals of the *system utilisation* as well as the numerous solutions are introduced that are suitable especially for a concrete operating range and a specific branch or applications that can be appropriately adapted. The numerous case examples speak for the practical suitability of many methods of resolution that describe both their functionality and the application of their methods in practice.

In the titles in Class II it is assumed that the solutions therein described cover the existing demand for KM. None of these publications satisfactorily take into consideration in advance whether these solutions actually cover demand for KM nor does an appropriate evaluation take place after their implementation. This does not come as a surprise here inasmuch as the emphasis of the applications of this class is not on analysis or planning. Nevertheless there exists, without sufficient sensitivity to the suitable purpose of the KM solutions, the danger, on the one hand, that they

do not do sufficient justice to the existing functional requirements or that thus the proverbial cannon is used to kill mosquitos. On the other hand, the risk exists, for example, that the corporate culture and the acceptance of the solution will be neglected by the employees. Only with a better understanding of the existing demand for KM of a company or an organisation can the accuracy of fit in the choice of a solution be ensured. Only thus can the approaches described in Class II develop their full potential in the application.

3.3.3 Critical discussion of class III: system evolution

In the articles in Class III the main interest is in the systematic identification, evaluation and exploitation of improvement potential in the framework of process oriented KM. Besides various barriers, analysis approaches and maturity models are introduced. The publications in this class are relatively recent. Obviously, this essential theme has been receiving attention only for a short time. The search resulted chiefly in hits on individual and special solutions that are only briefly described and thus in part could not be extensively evaluated. Since 2010 the publications reveal a tendency towards increasing interest in knowledge protection and the process oriented measurement and control of knowledge and KM by means of maturity models.

An understanding of potential barriers is important, but by itself does not permit an analysis and evaluation of the handling of knowledge and KM in companies or organisations. The analytical methods basically provide the opportunity for an evaluation of an actual state. Without a concrete target state, however, neither an evaluation nor a target oriented handling is thus possible. Maturity models contain formulated target states in the form of levels of maturity structured on top of each other. The placement in a specific level of maturity conforms to the ascertained actual state. The higher levels are potential target states. The main point in the process is not the individual target states that are established for companies or organisations or business processes/subprocesses, but rather the sweeping indications. The individual demand for KM of companies and organisations is ignored. A meaningful evaluation, however, can be carried out only by means of the individual demand for KM. This evaluation is the requirement for a sound decision on the suitability, the choice and the application of measure, methods and tools.

4 Summary and evaluation

On the basis of a current and the most extensive general view possible of the up-to-date publications in German and English on the integration of BPM and KM, the goal of this article is to provide an evaluation of the state of scholarship as well as to identify additional research needs. This goal has been achieved by means of a comprehensive literature search whose execution is represented clearly and whose result is evaluated and classified through the use of appropriate criteria. Moreover, the contents of the classes and subclasses are explained and critically discussed as well as the potentialities and limitations of the included approaches described.

It is clear that in the majority of the previous publications the emphasis lies on *planning, analysis and implementation.* With respect to this emphasis, publications on some redy-for-use methods and tools exist. There are numerous publications especially on the extensive and proven approach of the Fraunhofer-Gesellschaft for the *planning, analysis and implementation* of process oriented KM. Many of the established characterising criteria apply to this approach, which aims at easily implemented KM solutions for small and medium-sized companies.

In addition, *system utilisation* is of chief importance in many research results. They chiefly deal with basic approaches and solutions that either use processes as a structuring foundation to organise archives or are workflow based. In the current titles flexible and adaptive workflow approaches and solutions are introduced that are suitable for an application of processes that are difficult to plan and standardise.

The gains from the discovered research results with the emphasis *system evolution* in relation to their number, scope and application maturity are the least valuable. As a reaction to the existing need for action in reference to knowledge protection and maturity models, an increasing tendency in the publications for this theme stands out.

In summary, it was shown in the present article that there are already numerous solutions and, in part, proven methods and tools for *planning, analysis and implementation* as well as for *system utilisation* in which BPM and KM are integrated. In contrast, there are up to now few publications with the emphasis *system evolution* that chiefly deal with the challenges inherent in the evaluation of knowledge as well as with the evaluation of its handling. Moreover, the approaches dealt with in them are not fully developed.

From all three classes with the thematically relevant hits in the literature search, additional research needs pertaining to the theme of demand for KM can be derived. There are up to now no suitable approaches that both permit a sound choice of BPM and KM solutions and do justice to the individual demand for KM of companies and organisations. A tailor-made and successful application of KM solutions is to the greatest extent left to chance. The missing operationalisation of demand for KM constitutes a deficit. It is imperative to establish criteria by means of which demand for KM can be described. An additional deficit is the poor understanding of factors of influence. On the one hand, the influences on the individual demand for KM of companies and organisations must be identified. On the other, what this influence looks like must also be explained. Only the describable character of demand for KM, the awareness of the factors of influence and the clarity of the appropriate interdependence will permit that justice to the specific challenges of companies and organisations will be done.

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