Towards Understanding Quality-Related Characteristics in Knowledge-Intensive Processes - A Systematic Literature Review

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Abstract. *Context* Contemporary process management systems have been supporting users during the execution of repetitive, predefined business processes. Many business processes are no longer limited to explicit business rules as processes can be unpredictable, knowledge-driven and emergent. In recent years, knowledge-intensive processes (KIPs) have become more important for many businesses. However, quality-related aspects of these processes are still scarce. Therefore, it is hard to evaluate these types of processes in terms of their quality. *Objective*: In this paper, we present a Systematic Literature Review aiming at investigating and reporting quality-related aspects of KIPs. *Results*: We identified in the selected studies the characteristics and methods related to KIPs. Although several papers present quality aspects of processes, literature still lacks papers with directions on the quality-related approaches in KIPs.

Keywords: Knowledge-intensive processes · Knowledge Intensive Business Process · Process flexibility · KIP Quality

1 Introduction

In recent years, many changes have been observed in the approaches of business processes. In many cases, business processes are flexible, unpredictable, adaptable and knowledge-driven. The characteristics of these processes also vary in organizations. Hence, knowing these characteristics could potentially aid the understanding of the mechanisms for improving these types of processes.

Moreover, the quality aspects of Knowledge-Intensive Processes (KIPs) are an important source of competitive advantages for contemporary companies. The quality-related characteristics have been carried out in the literature in several ways. Although several papers present some relation with quality aspects, there is a lack of studies that focus on quality-related characteristics in KIPs.

The importance and complexity of KIPs were exposed as hardly predefined, and compliance can be ensured only at run-time [7]. Therefore, the application of traditional Business Process Management (BPM) practices is difficult to implement in KIP environments and new ways to handle KIP processes need to be researched.

In this paper, we present a Systematic Literature Review on quality-related characteristics of KIPs to address the lack of literature on the topic. We contribute by exposing the lack of studies that present quality aspects for KIPs, as well as suggest avenues for defining quality metrics for KIPs.

The structure of this article is as follows. We start by laying an introduction to the topic. Then, in Section 2, we present the Related Work. Section 3 presents the protocol of the Systematic Literature Review, as well as the results of the study. Following, Section 4 discusses the threats of this research and Section 5 concludes the paper with our main considerations.

2 Related Work

Some quality metrics of business process models are used to evaluate a traditional process (prescriptive) model such as the number of elements, the complexity of the flow control, the immersion of the depth decision, the degree of clarity and the complexity of interconnections [25]. However, in the context of KIPs, these metrics are not fully applicable.

During our studies, we did not find specific treatments that address quality in knowledge-intensive processes. However, analyzing the state of the art we observed that many works address the characteristics that are related and repeated even in various contexts.

We highlight four papers that present important studies in knowledge-intensive processes: Di Ciccio et al., 2015 [10]; Isik et al., 2012 [38]; Marjanovic and Freeze, 2012 [22]; Sarnikar and Deokar, 2010 [29]. KIPs are often associated with Adaptive Case Management (ACM). Pillaerds et al. (2017) [26] assesses the characteristics cited by Di Ciccio et al. (2015) in four different Business Process Support Systems (BPSS) as ACM and others.

Observing these characteristics is fundamental for the development of future works that evaluate the quality of the KIPS.

3 Systematic Literature Review

The Systematic Literature Review presented in this paper is based on the methodology proposed by Kitchenham et. al [19]. This methodology was conceived with a particular emphasis on Systematic Literature Review (SLR) conducted within the software engineering domain. Kitchenham's methodology is structured according to the following three steps, which have to be performed one after the other, as presented in Figure 1.

Each of the three presented steps is described next.

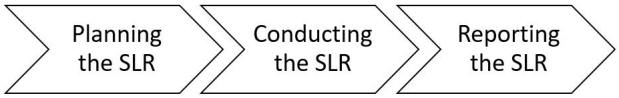

Fig. 1. SLR Methodology Steps [19].

- **Planning** - In the first step, we lay the objectives and needs for this review. We have defined the set of research questions and the review protocol.

- **Conduction** - In this second step, we have defined a search strategy to select a set of relevant research studies. The search was done according to the protocol established. This step has executed by two researchers, using a pair review strategy. This refinement step was quite critical since we had the opportunity to compare results. Finally, for each selected research work, the data extraction is performed and classified according to its relevant characteristics.

- **Reporting** - In this last step, we present the results and answers to the defined research questions.

Next, we present the details of each step of the systematic study.

3.1 Planning

In this section, we present the planning of this SLR. First, we introduce research questions. Then, we present the details of the applied protocol of the search.

Research Questions. The following research questions were defined to discover references in the state-of-the-art that could include relevant quality characteristics in KIPs. The questions resulted from sets of brainstorming sessions carried on by the authors and are listed next.

RQ1. *What are the quality factors associated with Knowledge-Intensive Processes?* This question aims to discover which quality characteristics are associated with KIPs.

RQ2. *What methods, instruments or techniques are used to deal with KIPs?* This question aims to understand the instruments, methods or techniques that handle KIPs and support these processes' quality aspects.

Developing the Protocol. The protocol has been defined according to Kitchenham's suggestions [19]. To retrieve relevant research papers, we performed an automatic search on Scopus Science, IEEE Xplore and ACM Digital Library in April 2021. The search string defined in Table 1.

We tested several combinations of keywords until we had achieved a suitable search string. To assess the quality of the search string, we first defined two control papers, depicted in Table 2. The control papers CP1 and CP2 were defined based on the results of pilot searches, before defining the final search string.

Table 1. Search String.

("Knowledge-intensive process" OR "flexible Process" OR "process flexibility" OR "Intentional Process" OR "Goal-oriented process") AND ("Quality" OR "Assessment" OR "Maturity") AND ("Business process" OR "BPM" OR "Process aware information system")

Table 2. Control papers.

ID	Title	Year	Reference
CP1	Assessing suitability of adaptive case management	2017	[26]
CP2	Improve Performance Management in Flexible Business Processes	2017	[11]

As part of the protocol implementation, a set of inclusion/exclusion criteria was specified and is reported in Table 3. These criteria secure that only relevant papers are included in the study.

Table 3. Selection criteria.

ID	Inclusion Criteria
I.1	Included studies must have been published in the last 6 years (included).
I.2	The work is a primary study.
ID	Exclusion Criteria
E.1	Works outside the computing area.
E.2	The work does not relate to the context of BPM and flexible processes.
E.3	The paper is not written in English Language.

3.2 Conduction

Identification and selection of the research papers. The study selection process was performed by two researchers, as advised in the protocol, to mitigate possible biases.

For the selected articles, the two researchers independently filled out a spreadsheet with the basic information about the paper (e.g. title, authors, year of publication) and the option for including or not including the article in this study. The authors read the title and abstract of papers in this phase. The papers included were considered eligible when the researchers evaluated that the article should be included in our research. The data from the eligibility forms were stored in the spreadsheet and the validation procedure was carried out. To measure the disagreements between the researchers on the eligibility of some papers, we used Cohen's kappa to assess the reliability of the diagnosis by measuring the agreement between the two judges.

Cohen's kappa is a measure of the agreement between two raters who determine which category a finite number of subjects belonging to whereby agreement

due to chance is factored out. The two raters either agree or disagree. There are no degrees of disagreement (i.e., no weightings) [21].

To select the set of relevant studies, the following steps were performed. First, the search string was used in the selected databases returning an initial set of papers. Next, duplicates were identified and removed. After, we evaluated the papers according to the contents of their title and abstract using both the inclusion and exclusion criteria. This step was separately performed by two researchers.

In face of results, we applied Cohen's kappa (k) agreement measure to determine the level of agreement between two judges, as shown in Table 4.

Table 4. Author's agreement results.

	Judge A			
Judge B	Read	Exclude	Include	Total
Read	27	3	0	30
Exclude	0	30	3	33
Include	2	1	0	3
Total	29	34	3	66

Considering the results shown in Table 4, we observed 57 papers with a perfect agreement between the judges where 27 papers the researchers agreed that they should be read and 30 papers both agreed that they should be excluded from the study. Only six different papers are in total disagreement where three papers have found by judge A and he rated them as valid articles for the study. Three others papers were found by judge B and they have rated these additional papers as valid as well.

The Cohen´s k are calculated in Table 5. To interpret your Cohen's Kappa, the classification below was used [21]:

- 1% – 20% : slight agreement
- 21% – 40% : fair agreement
- 41% – 60% : moderate agreement
- 61% – 80% : substantial agreement
- 81% – 100% : almost perfect or perfect agreement

Table 5. Percentage of Agreement Among Researchers.

	Read	Exclude	Include	Total
Agreement (pa)	27	30	0	57
By chance	14,54	15,5	0,14	30,18
(%) Perc. of Agreement	86,36%			
Cohen´s k	74,87%			

We verified a percentage of agreement of 86.36% in Table 5. Furthermore, the Cohen´s k index was 74,87% following the adopted classification, which represents a substantial agreement in the results.

Finally, of the 66 papers retrieved by the researchers, 33 were selected for the last step for data extraction and synthesis. These 33 papers were fully read and we extracted the information related to the defined RQs, which consists of quality-related characteristics and methods/approaches for deal with KIP processes. These studies constituted the new selection for the next step of the study.

Data extraction and synthesis. The objective of the data extraction and synthesis step is to design a suitable form to record and collect the relevant information obtained from fully reading the selected research papers. The 33 relevant studies that were selected by the two researchers were fully read, and the data relevant to the research questions were extracted and recorded in a spreadsheet. Finally, we have analyzed the results, focusing on producing the desired answers for the RQs.

3.3 Reporting Results

In this section, we present the results of the SLR. At first, we reported some general information on the collected data in Section 3.2. Then considering the research questions listed in Section 3.1 we discuss (1) quality-related characteristics of Knowledge-Intensive Processes and (2) methods to deal with KIP.

- RQ1. What are the quality factors associated with Knowledge-Intensive Processes?

We observed a gap in studies about **quality** in knowledge-intensive processes, as literature lacks specific studies that aim at understanding and exploring this topic. Acknowledging this gap is important to encourage increases in specific quality studies associated with KIPs.

Di Ciccio, Marrella and Russo [10] defined eight main key representative characteristics of KIPs: Knowledge-driven, Collaboration-oriented, Unpredictable, Emergent, Goal-oriented, Event-driven, Constraint- and rule-driven and Non-repeatable. In their work, they provide a precise characterization of KIPs and, starting from three real-world application scenarios. In our study, we extended this analysis to 33 more papers with different application scenarios. To classify the 33 papers, we build the following tables with synonyms, in Table 6. These synonyms were extracted from the selected papers and classified by the author.

In the selected studies, we found the following characteristics cited by Di Ciccio, demonstrated in Figure 2. In addition to these characteristics defined in [10], we found characteristics such as traceability, control and transparency, as presented in Table 7.

- RQ2. What methods, instruments or techniques are used to deal with KIPs?

The studies found show several instruments and mechanisms to deal with KIPs. We have not found works that specifically focus on the quality of KIPs.

Table 6. Synonyms for KIP characteristics based on DiCiccio et. al. [10].

	Characteristics	Synonyms
C1	Knowledge-driven	data-oriented, human, information exchange, people-centric, user decision, drive human
C2	Collaboration-oriented	Improve Performance Management in Flexible Business Processes
C3	Unpredictable	can be fully specified, iterative and incremental, unexpected conditions, flexibility, weak structured, may change during process execution
C4	Emergent	ad-hoc changes, adaptability, uncertainty, complex
C5	Goal-oriented	milestones to be achieved, objectives determined at run-time, intermediate goals
C6	Event-driven	Changes in the process, decisions, contextual changes
C7	Collaboration-oriented	multi-user environment, participants with different roles, human-centred, transfer the data, interactive
C8	Constraint- and rule-driven	Adapt to changes/ change during process execution/ Unpredictable situations
C9	Non-repeatable	Customizable, temporal changes, multi-variant

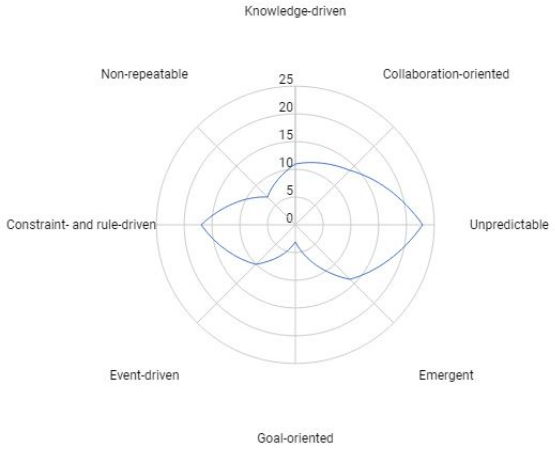

Fig. 2. Main Characteristics of KIPs per occurrences.

Table 7. Characteristics' Summary.

Characteristics	Papers
C1 - Knowledge-driven	[14], [27], [31],[35], [12], [2], [35], [26], [33], [17], [6]
C2 - Collaboration-oriented	[35], [12], [2], [3] [26], [11], [23], [23], [32], [28], [18], [17], [6], [4]
C3 - Unpredictable	[15],[1], [27], [35], [12], [2], [26], [11], [23], [33], [24], [37], [36], [30], [28],[14], [9], [17], [4], [36], [30], [18], [34]
C4 - Emergent	[14], [27], [16], [35], [3], [26], [24], [34], [36], [28], [9], [5], [17], [20]
C5 - Goal-oriented	[12],[26], [18]
C6 - Event-driven	[3], [12], [26], [36], [30], [18], [34], [23], [33], [24]
C7 - Collaboration-oriented	[14], [27], [35], [33], [37], [18], [20], [11], [23], [33], [37], [34], [8], [4]
C8 - Constraint- and rule-driven	[14], [27], [35], [3], [12], [2], [26], [11], [23], [33], [37], [34], [8], [36], [30], [18], [4]
C9 - Non-repeatable	[14], [35], [12], [26], [11], [23], [30],
C10 - Control	[13], [6]
C11 - Traceability	[16]
C12 - Transparent	[26]

However, all the proposals found seek, somehow, innovative ways to approach these types of processes.

4 Threats to validity

We present the categorization (Section 3.3) based on the characteristics presented by [10]. This is a threat because the classification was defined based on Table 6 carried out by just one researcher. However, we believe that the result presented can be interesting because it reinforces the characteristics of KIPs in different environments.

5 Conclusions and Future Work

This SLR has identified a gap in qualitative aspects to measure or qualify knowledge-intensive processes. We did not find models, guidelines or good practices in the studies for dealing with quality aspects in these types of processes. Although [10] defines the characteristics of KIPs processes well, we did not find applicable quality models in this context. We also have not found basic concepts that can serve as an initial guideline for developing quality models for KIPs. In this work, we seek to encourage and discover new ways of research to deal with aspects of qualities in KIPs

We provided an overview of the current works on quality-related characteristics in Knowledge-Intensive Processes. In this paper we performed an SLR using

Kitchenham's guidelines [19]. The results confirmed the importance of the topic, as an important research area. We examined several groups of contributions: *i* we found the characteristics cited by [10] in 33 different domains and application scenarios;*ii* we identified mechanisms to deal with KIPs in recent works.

In terms of concepts or methods of quality assurance of KIP processes, we did not find a comprehensive picture of the topic in the literature. Despite the significant efforts of researchers and practitioners in the domain, more research is still required to enhance KIP´s environments mainly when we need to think about quality aspects.

As future work, we propose to define coding protocols to better classified the papers found according to KIP characteristics presented by [10]. The authors could discuss the coded studies to identify discrepancies and shortcomings in the codes. We can use coding techniques to characterize the methods, instruments or mechanisms used to deal with KIP in these studies. We propose to use some of the quality aspects found in structured process analysis and use these as a start when analyzing KIPs. In this sense, we propose to include the evaluation in the most detailed study on the use of ISO/IEC 25000 (systems and software product quality) and ISO/IEC 3300X (Process assessment) in KIPs. Evaluating quality models that do not meet knowledge-intensive processes are also important contributions to the area.

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