An Exploratory Study on Collaboratively Conceptualizing Knowledge Intensive Processes

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Abstract. The relevance of the knowledge involved in organizational activities has already been addressed since earliest management theories. In this context, several works in the literature discuss how a so-called Knowledge Intensive Process (KIP) may be better understood and managed. The first step towards these goals is the identification of its elements. This is not a trivial task, since KIP involve many subjective and complex concepts that are typically tacit to stakeholders, and thus subject to different interpretations. However, a common interpretation of a KIP among all its participants is essential to prevent communication and comprehension problems. This paper presents an ontology that defines concepts and relationships of a KIP. We discuss the results of an exploratory study where a KIP was described by its participants in a collaborative manner, using a storytelling technique. The goal was to explore the use of the ontology as a basis for identifying the elements within the process description.

Keywords: Knowledge Intensive Process, Knowledge Intensive Process Ontology, Process Representation.

1 Introduction

A Business process is a set of resources, together with interrelated and interactive activities, that transform inputs into services or products (outputs). Typically, business processes are planned and carried out to add value to the organization. A business process may be represented by a business process model (and its corresponding diagram in a graphical notation), which usually comprises the control flow of well-structured activities that an organization performs to achieve its objectives.

However, this traditional way of representing a process is not suitable for the so-called Knowledge Intensive Processes (KIP). This type of process comprises sequences of activities based on intensive acquisition, sharing, storage, and (re)use of knowledge, so that the amount of value added to the organization depends on the actor knowledge. They are naturally more complex, since they deal with diffuse and tacit definitions, unpredictable decisions, creativity-oriented tasks and paths, dynamic execution that evolves based on the experience acquired by the actors. All these

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characteristics difficult the identification of well-structured activities and their control flow in a KIP, as well as KIP representation as a whole. The work of Nurcan and Edme [20] supports the representation of business process with low or high structure, considering in first line its objectives and strategies linked to an intentional driven modeling. Following this understanding, the representation of the process becomes operational, thinking about activities that comprise the process.

Some traditional process modeling approaches like Event Driven Process Chain (EPC) [11], Business Process Modeling Notation (BPMN) [15], Process Specification Language (PSL) [21], and Business Process Modeling Ontology (BPMO) [2]; have been adapted to allow the representation of the intrinsic elements of knowledge within business processes, but these methods do not include all the features necessary to describe a KIP. Besides, the literature shows a set of approaches dedicated to highly-intensive knowledge processes representation including Business Process Knowledge Method (BPKM) [16], Knowledge Transfer Agent (KTA) [23], DECOR [1], CommonKADS [22], Knowledge Modeling Description Language (KMDL) [9], and the work of Donadel [3]. However all of them, as well as traditional process modeling approaches, do not reach all the KIP relevant elements, as shown in [5].

Based on the difficult to represent and organize the knowledge involved in intensive knowledge processes, the Knowledge Intensive Process Ontology (KIPO) was proposed in order to address existing limitations through a new approach that considers the concepts of KIP that relate to traditional business processes [5].

In this paper, we discuss the results of an exploratory study where a knowledge intensive process was described by its participants, in a collaborative manner, using a storytelling technique. The goal was to explore the use of the ontology as basis for identifying the elements within the KIP narrative and organize the knowledge involved in its description. The paper is organized as following form: Section 2 presents related work about modeling KIP; Section 3 describes the KIP ontology; Section 4 discusses the exploratory study and Section 5 concludes the paper and highlights future perspectives of this research.

2 Knowledge Intensive Processes

The Process-Oriented Knowledge Management approach intends to organize and support the organizational processes, as well as to describe the conversion of knowledge within the process. Its objective is to identify, model, analyze and optimize knowledge intensive processes [10].

2.1 KIP Fundamentals

According to [18], KIP are sequences of activities based on the acquisition and intensive use of knowledge, regardless the business type or size. KIP can only be partially mapped through a traditional process model, due to unpredictable decisions and tasks guided by creativity. For [9], new objects of knowledge or information are created by the conversion of existing ones in the process.

Gronau et al [9] propose a list of requirements for modeling KIP based on: (i) Modeling goals: Which goals shall be reached with the modeling? Are they only documentation purposes or do they require an analysis of weak spots and definition of a new process? (ii) Integration of process and knowledge: There should be a unique approach that combines or integrates the process definition with the flow and transfer of knowledge. (iii) Tacit knowledge: Which definition and appreciation of knowledge is used by the models approach? Is there a differentiation between explicit and tacit knowledge? (iv) Knowledge conversion: Are different mechanisms of knowledge conversion considered and expressed separately in the process model? (v) Knowledge flow: Is there a differentiation between information flow and knowledge transfer? (vi) Offer and demand: Is it possible to indicate in the model differences between the offer of knowledge and its demand? (vii) Person-related knowledge: Is the modeling of knowledge restricted to organizational units or is it possible to show knowledge bound to persons? (viii) Comparison of intended and actual level of knowledge: Is it possible to compare the knowledge levels required for jobs with the knowledge people actually have? (ix) View representation: Is it possible to navigate through the models using different views? (x) Knowledge map: Is it possible to generate knowledge maps from the results of process modeling?

Moreover, to enhance the representation of knowledge to business processes, [3] highlighted the key features required to support a KIP as follow: (i) The guidance value stream, making it easier to obtain results with the representation. (ii) Representation of the business model, integrated with the knowledge representation to add value to knowledge within the business structure of the organization. (iii) Prioritization of tasks for the organization of knowledge of what actions should be performed first. (iv) Artifacts of knowledge when there is a need to differentiate knowledge representation from business representation. (v) Dynamic artifacts to enable the representation of the dynamic elements that behave differently depending on the context. (vi) Representation of knowledge skills involved in each process. (vii) Concepts domain to enable the contextualization of the representation environment.

According to the above mentioned, organizing the knowledge in processes like this is not an easy task. Besides, KIP commonly presents a diversity of information sources, and its execution involves many participants and the assistance of many experts, who carry out actions with high levels of creativity and innovation [10]. Several process modeling techniques are found in literature as likely to represent KIP.

2.2 KIP Representation Approaches

The CommonKADS [22] focuses on knowledge representation. Various stages of modeling attempt to establish a structured approach so that knowledge can be managed with the support of technical and engineering tools. Three basic points characterize these demands: the details of the skills involved in process execution, the representation of the processes through artifacts and semantic analysis, and the opportunities for improvement regarding the process and use of knowledge.

The BPKM - Business Process Knowledge Method [16] - presents a meta-model for integrating business process modeling aspects with Knowledge Management.

This meta-model transcribes the four perspectives of a workflow: task (which tasks are executed in the workflow process), organizational (who performs the specified task), logical (in which order these tasks are executed), data (which data is consumed, produced or exchanged between tasks). The meta-model was extended to include knowledge management tasks that support business processes (knowledge perspective) represented by the elements: Knowledge Management Task, Knowledge Object and Knowledge Archive.

The Knowledge Modeling Description Language (KMDL) [9] represents tacit knowledge of the process, besides the explicit knowledge. Thus, the different possibilities of knowledge conversion can be modeled and the flow of knowledge between actors is depicted. Two other approaches of knowledge representation are the Knowledge Transfer Agent (KTA) Modeling Method [23] and the DECOR Project [1]. The first describes how to create knowledge transferring models. The method consists of modeling in three distinct level of detail and possibilities of analysis. DECOR Project delivery context-sensitive organizational knowledge and has its focus in representation of knowledge processes across diagrams embedded in organizational memory. In the method proposed by [3] the value chain of the organization is mapped and the aspects of knowledge that can influence the organizational processes are represented.

The main deficiency observed in those proposals is that none of them includes or addresses all the requirements discussed in literature. Besides, they do not clearly represent important characteristics of KIP, such as: agents that influences the actions; dynamic aspects; collaboration; communication and interaction among actors while they produce knowledge; decision making rationale based on experience and creativity; and rules that might interfere on agents decisions. Moreover, some proposals do not differentiate between tacit and explicit knowledge [16][3][23][22]; and others do not address the representation of artifacts and dynamic aspects of processes and modeling agents [9].

Based on this analysis, the following sections present the Knowledge Intensive Process Ontology [5], which identifies KIP characteristics, and was built to represent the concepts and relationships of a KIP more adequately, providing a common and precise understanding about what exactly is a knowledge intensive process and what takes place in a KIP environment.

3 The KIP Ontology

Ontology is an explicit and formal representation of a shared conceptualization [7]. It is used to create an unequivocal abstraction of reality; one that is comprehensible by humans, for communication purposes. Based on the limitations of the methods described in the last section, we propose an ontology to precisely represent the concepts of this domain, thus providing a common understanding of a KIP environment. The high level Knowledge Intensive Ontology (KIPO) [5] is presented in Figure 1, which highlights the five components proposed for KIP conceptualization: Collaborative ontology, Business process ontology, Business rules ontology, Decision Ontology, and Knowledge Intensive Process Core Ontology (KIPCO).

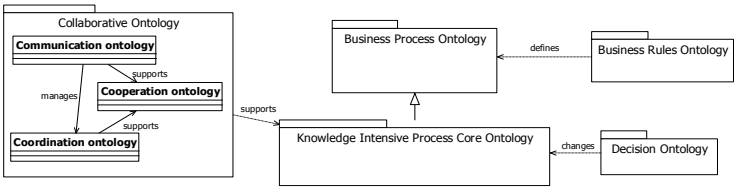

Fig. 1. KIP Ontology Components

The Business Process Ontology (BPO) component is based on the BPMN meta-model [15]. Although it is difficult to display a KIP with all the details of their flows and information previously defined, this is not reason to dismiss the properties applied in the modeling and description of knowledge in structured business processes. In a high level of abstraction, a KIP may be represented as a set of (macro) activities, typically with a simple control flow among them.

The Collaborative ontology was developed by Oliveira [14]. The author defines cooperation as essential to the evolutionary process; communication as a process where people can exchange information, express wishes, emotions and ideas; and coordination as representation of domain elements that are used to promote organization and harmony between concepts of communication and cooperation ontology. These elements are required due to the high degree of tacit knowledge exchanged among stakeholders, since a KIP may evolve along each instance, according to the participant´s interaction. The literature also cites [19] that proposes a process meta-model, which can deal with both well-defined and wickled work procedures and their interactions. However, its focus is on cooperative work processes representation and the interest of KIPO is to understand the cooperation, but the communication and coordination inherent in a KIP too.

The Decision Ontology (DO), presented in [17], makes it possible to adequately explicit all the rationale followed by a professional when making a decision, including the representation of which factors led a stakeholder to make a particular decision. The Business rules ontology is based on [12], and enables a precise and correct representation of the domain rules in which the KIP will be instantiated.

The Business Rules Ontology follows the proposal from Lopes et al [12] that describes the set of Business Rules that restrict a KIP domain. Business rules are relevant for a KIP since it typically defines restrictions that must be followed in the domain of a KIP, and that are the reason for several decisions made by a KIP executor.

The core component of KIPO is the Knowledge Intensive Process Core Ontology (KIPCO), which contains specific KIP elements specializing BPO concepts. KIPCO concepts are further described in this section.

Figure 2 illustrates the proposed KIPO (Knowledge Intensive Process Ontology) in Unified Modeling Language (UML) notation, where gray items are reused from the UFO (Unified Foundational Ontology) formalization [8]. Although some of the KIP properties are addressed by the above-mentioned sub-Ontologies that compose KIPO, the appropriate representation of a KIP requires additional elements/concepts, and relationships. By directing attention to the construction of KIPCO that is core of KIPO, its construction methodology was directed by the five questions from Table 1 that are considered the questions of competence according to the methodologies like [13]. More details about KIPCO construction are described in [5].

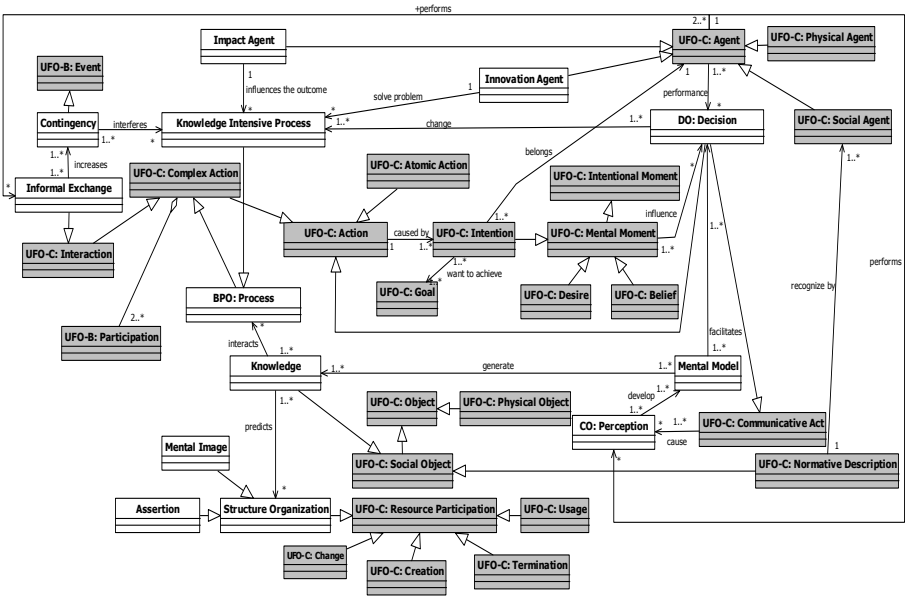

Fig. 2. Knowledge Intensive Process Ontology – KIPO

As shown in Table 1, the answers aim to elicit characteristics of KIP for the composition of KIPCO and consequently for the composition of KIPO, as a whole. For example, as KIP are processes that have the influence of, the first question focuses on the definition of agents that must interact in such processes. Impact agents and Innovation agents are considered as KIP actors. The second question is concerned with the type of interaction that occurs in KIP. Since these processes are highly dynamic and part of knowledge is tacit, many interactions occur informally among the agents to solve problems, make decisions, cooperate within the process execution, and build new knowledge.

The goal of KIPO is to organize the knowledge involved in KIP, and for that, abstractions of the real world must be made. Possible abstractions correspond to the business processes itself. Finally, Table 1 describes which data are exchanged in KIP and which is manipulated and constructed within such processes. The answer is mental models, contingency and decisions.

Regarding the definition of products generated and manipulated by a KIP, their relevance lies in discovering where knowledge is registered to possibly be reused. These products incorporate the knowledge; the perception; the structure in which knowledge is organized; the mental image developed on the agents minds, and the assertions that might present the knowledge formalism.

KIPO may be considered as the consolidation of the concepts from all its components and their relationships. While current KIP modeling methodologies do not fully consider these concepts, the KIP ontology includes them. It is up to the process modelers to appropriately choose a methodology that addresses the different concepts presented in the KIP ontology, allowing the knowledge generated by the process instances to be modeled, stored and reused.

Table 1. Questions used to build KIPCO

Group	Concept	Definition
What types of agents must interact during a KIP?	Impact Agent	This agent performs many tasks at once. The necessary knowledge to execute KIP actions, normally is found in agent tacit, or is based on previously experiences.
	Innovation Agent	One who is responsible for solving issues in the process with innovation and creativity.
How the interactions occur in a KIP?	Informal Exchange	Exchange that occur informally, face to face, or based in documentation.
Which elements are abstractions of the real world?	Business Process	Set of structured activities that seek the transformation of their inputs into services or product.
	Knowledge Intensive Process	Can be semi-structured, structured and unstructured depending on your abstraction, possessing a high degree of dynamism in the objectives' change, high complexity, and dependent on the explicit and tacit knowledge of people involved in the process and the activities that compose it.
Through of what the information are transmitted?	Mental Model	Allows interpretation and improvement of information that create knowledge.
	Contingency	Significant dependence in influences the environment. Tells what motivated interference in the execution process.
	Decision	Identifies information related to the decision as a whole. Informs the solutions taken by the agents so that the process is executed.
What are the elements produced by, or manipulated during, a KIP?	Knowledge	Experiences, values, contextual information and insights that create a framework for improvement and incorporating new experiences and information. The knowledge is derived and applied in people's minds.
	Organizational Structure	The structure in which knowledge is organized.
	Mental Image	Knowledge Organization still remain in the mental sphere. Is developed on the agents with basis in the knowledge built.
	Assertion	They are representations of sense completely abstracted, capable of verbal expression. Present the formalism of knowledge built in process explained.
	Perception	Represents the action of perceiving the message exchanged by agents.

4 Exploratory Case Study

A case study is an empirical research strategy applied to investigate contemporaneous events in their real-life context; those in which the frontier between the analyzed event and its context is not clearly defined. By following this strategy, the researcher has little or no control over the events; therefore he/she cannot manipulate a relevant behavior [24]. In a case study approach, exploratory studies are suggested to conduct initial investigations over a phenomenon in order to build or refine a hypothesis or a theory; explanatory studies, on the other hand, are then applied to confirm or deny the hypothesis or theory [4].

In this work, we conducted an exploratory case study in order to investigate the KIPO [5] with regard to two perspectives: (i) its adequacy for modeling a real KIP; and (ii) its comprehensibility by the stakeholders involved in the KIP execution. More specifically, we evaluated the usage of the KIPO as a basis for discovering elements that characterize a KIP from its description.

The exploratory study was conducted by three analysts in the context of a post-graduate course, and they have deep knowledge about the KIP reported. Applying the Storytelling [6] technique, eight first-year master students were asked to collaboratively tell a story describing the process of elaborating a master thesis, using the TellStory application [6]. During 15 days, each student accessed the tool to create story events that he/she found important for this process and to express their opinions about other events created by another colleague. To come up with a unique and collaborative story, they interacted with each other in an asynchronous way through the tool, highlighting their points of view, reporting their previous experiences and arguing about what was likely to be done in different ways, based on specific knowledge that each one had about a given activity. The analysts did not interfere during the story telling.

At the end of this stage, the history produced by the students was handed to the three analysts, who were asked to separately identify concepts and relationships instances from the KIPO within the story text. Each analyst mapped knowledge elements and built his/her instance of the ontology. Since the focus of the exploratory study was on identifying knowledge elements and instantiating them using the ontology, and not on the modeling language being adopted, this decision was left to the analysts; therefore, each analyst modeled his/her ontology instance using the notation of his/her choice, as long as it comprised notational constructs for concepts and relationships among them.

The analysts were also instructed to report cases in which some identified knowledge element had not a corresponding class in the ontology. Figures 3 and 4 illustrate two out of the three elaborated KIPO instances.

The story told by the students was grouped into eight activities: *Select theme, Set main purpose and specific goals of research, Identify a research problem, Search literature related to the research problem, Review theme and issues, Propose a solution for the problem, Define research method, and Write dissertation*. This organization was carried out to promote the discussion of the actions conducted by students in this KIP. As an example, about the activity "Select theme", the following information has been reported (according to passages extracted from the story):

Participant 1: "Writing the dissertation is the most important and relevant stage of the process; it could lead to an important goal..." "For some people the choice of the theme occurs before starting the course. For others, the issue arises on the basis of ideas developed by teachers and classmates... ";

Participant 2: "I think the theme will also depend on the supervisor.";

Participant 3: "I think this issue is the easiest. The major obstacle is finding a niche to think about a problem and its solution."

Analyst 3 identified ten concepts within this part of the history, which, according to KIPO, are found in the Business Process Ontology (BPO), Knowledge Intensive Process Core Ontology (KIPCO), and Decision Ontology (DO). The concepts of BPO correspond to the activities of KIP. The concepts pointed by KIPCO are related to knowledge, informal exchange, mental model, impact agent and innovation agent. Finally, concepts of decisions to be made and alternatives chosen were also identified. These concepts are listed bellow and appear in the instance of KIPO in Figure 3.

- BPO::Activity::Write paper
- BPO::Activity::Select interest theme
- KIPCO::Knowledge::Select research goal
- KIPCO::Informal_exchange::exchange the ideas developed by students and teachers
- KIPCO::Mental_model::Identification of problem to be worked
- KIPCO::Mental_model::Actions to be taken to solve the research problem
- KIPCO::Agent_Impact::Student
- KIPCO::Agent_Innovation::Student
- KIPCO::Agent_Innovation::Supervisor
- Decision_Ontology::Decision::Decide when to select the theme
- Decision_Ontology::Chosen_alternative::Select theme before get in course
- Decision_Ontology:: Chosen_alternative::Select theme from ideas exchange
- Decision_Ontology:: Decision::Decide research theme

Analyst 2 identified nine concepts. The concepts supported by KIPCO are related to Structure Organization, Knowledge, Innovation Agent, and Impact Agent. The DO provided concepts concerned with decisions to be made in the process, regarding the definition and solving of the research problem, besides the research topic. The concepts identified by the Analyst 2 are listed below and are present in the instance of KIPO in Figure 4:

- KIPCO::StructureOrganization::Write Dissertation
- KIPCO::Knowledge::Problem Solving
- Decision_Ontology::Decision::Research Problem
- Decision_Ontology::Decision::Define Goals
- Decision_Ontology::Decision:: ResearchProblem
- Decision_Ontology::Decision::InterestTopic
- KIPCO::Agent_Innovation::Supervisor
- KIPCO::Agent_Impact::Supervisor
- KIPCO::Agent_Impact::Student

The analysts focused on identifying instances of the KIPCO sub-ontology, since it contains the core KIPO concepts for a KIP. Nevertheless, we argue that the results of this exploratory study show the applicability of this ontology in identifying relevant knowledge elements from a KIP description. The instance created by Analyst 2 (Figure 4) contains 2 relationships that were not prescribed in KIPO: the instance represents that a *perception* can develop *knowledge* (while in KIPO a *perception* develops *mental model*), and that *informal exchange* develops a *perception* (while in KIPO an *informal exchange* increases *contingency*).

Table 2 shows how each knowledge element found in the story text was represented by each analyst in his/her ontology instance. For example (line 3), a Student was represented as an Innovation Agent by analyst 1, as an Impact Agent by analyst 2, while analyst 3 considered a Student as both Impact Agent and Innovation Agent. This table has been consolidated jointly by the three analysts. They tried to approximate semantically the terms used by each one as much as possible.

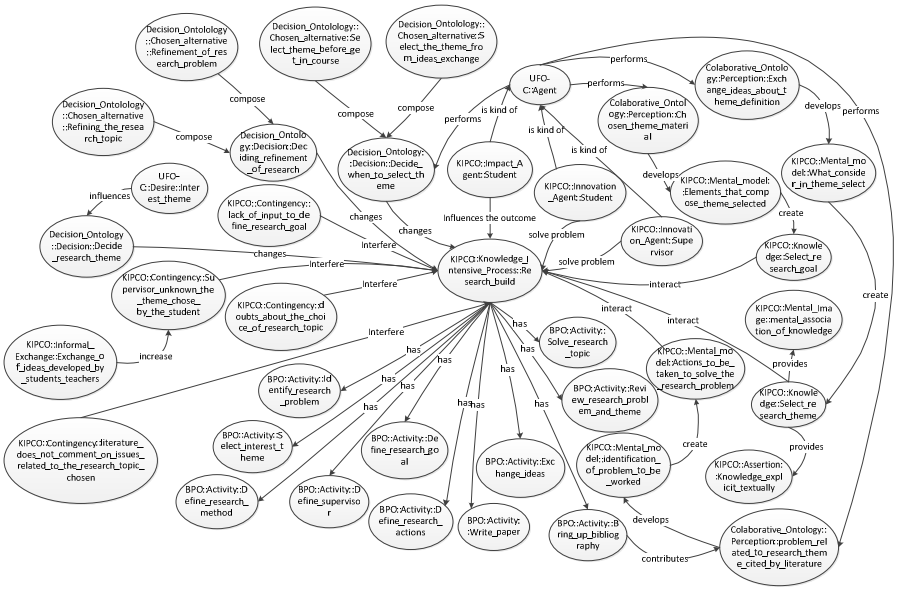

Fig. 3. KIPO instance created by Analyst 3

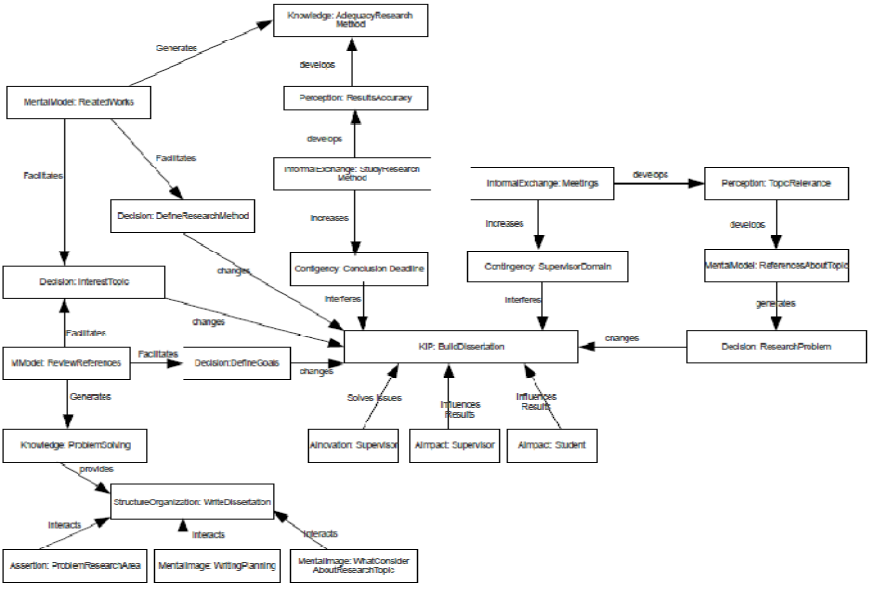

Fig. 4. KIPO instance created by Analyst 2

Table 2. Knowledge elements mapped according to KIPO

Knowledge element	Analyst 1	Analyst 2	Analyst 3
Build dissertation	Knowledge Intensive Process	Knowledge Intensive Process	Knowledge Intensive Process
Supervisor	Impact Agent	Impact Agent Innovation Agent	Innovation Agent
Student	Innovation Agent	Impact Agent	Impact Agent Innovation Agent
Related work cited in literature related to the topic	Informal Exchange	Mental Model	Contigency Perception (Collaboration Ontology)
Research problem identification	Contingency	Decision (Decision Ontology)	Mental Model Activity (Process Meta-model)
Activities to be performed in order to solve the problem	Contingency	Knowledge	Mental Model e Activity (Process Meta-model)
Define the research goals	Decision (Decision Ontology)	Decision (Decision Ontology)	Activity (Process Meta-model) Knowledge
Idea Exchange by students and teachers (meetings)	Informal Exchange	Informal Exchange	Informal Exchange Activity (Process Meta-model)
Supervisor does not know the topic chosen by the student (supervisor domain)	Informal Exchange	Contingency	Contingency
Decide interest topic	Contingency	Decision (Decision Ontology)	Decision (Decision Ontology) Knowledge Activity (Process Meta-model)
Search references/Review references	Mental Model	Mental Model	Activity (Process Meta-model)
Write dissertation	Mental Model	Structure Organization	Activity (Process Meta-model)
Define research method	Decision (Decision Ontology)	Decision (Decision Ontology)	Activity (Process Meta-model)
What to consider while choosing the research topic	**x**	Mental Model	Mental Model
References about the topic chosen	**x**	Mental Model	Perception (Collaboration Ontology)
Chose the topic from ideas exchanged	**x**	Perception (Collaboration Ontology)	Alternative chosen (Decision Ontology)
Interest topic	**x**	Mental Image	Desire (UFO-C)
Chose the topic before starting the course (personal affinity)	Informal Exchange	**x**	Alternative chosen (Decision Ontology)
Review topic and research problem	Decision (Decision Ontology)	**x**	Decision (Decision Ontology) e Activity (Process Meta-model)
Writing planning	Decision (Decision Ontology)	Mental Image	**x**
Problem from the research area	Informal Exchange	Assertion	**x**
Exchanged ideas about the topic definition	**x**	**x**	Perception (Collaboration Ontology)

Table 2. (*Continued*)

Elements that compose the topic chosen	**x**	**x**	Mental Model
Decide the moment to chose the topic	**x**	**x**	Decision (Decision Ontology)
Doubt about the research topic to choose	**x**	**x**	Contingency
Lack of resources to help defining the research goal	**x**	**x**	Contingency
Refinement of the research problem	**x**	**x**	Alternative chosen (Decision Ontology)
Refinement of the research topic	**x**	**x**	Alternative chosen (Decision Ontology)
Define research activities	**x**	**x**	Activity (Process Meta-model)
Define supervisor	**x**	**x**	Activity (Process Meta-model)
Study research methods	**x**	Informal Exchange	**x**
Adequacy of research method	**x**	Knowledge	**x**
Conclusion deadline	**x**	Contingency	**x**
Necessity to review literature	Perception (Collaboration Ontology)	**x**	**x**
Hypothesis	Informal Exchange	**x**	**x**
Results Accuracy	x	Perception	**x**

Result Analysis and Discussion

The third Analyst elaborated an ontology instance (Figure 3) that covered a larger number of concepts and relationships from the KIP domain, when compared to the second Analyst (Figure 4). This occurred since Analyst 3 knew more about the ontology, thus better understanding its concepts applicability in several scenarios.

No new classes were identified, that is, the concepts contemplated in KIPO were sufficient to identify all KIP elements present in its description. Only two new relationships were presented by Analyst 2. It points to the adequacy of the ontology to represent the process described. Figure 5 depicts the analysis of the mapped elements among all three analysts: 35 elements were mapped; 37% were found in all three instances, and 23% were mapped by at least two analysts, who classified them differently. Some elements were identified only by one analyst, which represented 40% of the total number of elements. The third analyst mapped 80% of the elements, and 20% were also identified by other analysts.

A comparison of the ontology instances points to some difficulties found by three analysts. All the analysts agreed that the story told by the students was not rich in details; therefore it was not easy to identify many of the elements. The divergence in the elements mapping was also due to the fact that each analyst had a distinct interpretation of the described process. This was somehow expected, due to the inherent and well-known ambiguity of natural languages.

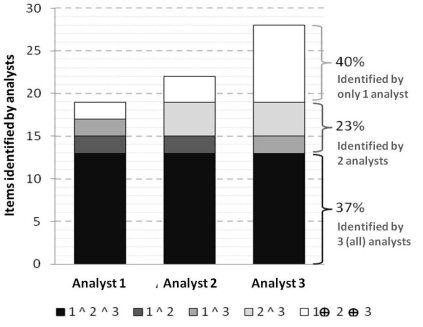

Fig. 5. Common elements identified by analysts

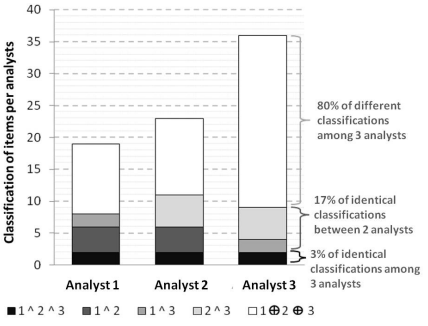

Fig. 6. Ranking analysis of the elements

Figure 6 presents a ranking analysis of the elements mapped by the analysts. This analysis shows that different classifications were the most part (80%). This is an indication that the ontology does not yet provide a good common vocabulary for analysts. The analysts reported that they have had trouble in understanding the meaning of each ontology element; thus, we can conclude that the description of the concepts is not yet been clearly shown by the author.

These concepts only became clear after a meeting conducted by the ontology author with the analysts to review Table 3. This enabled a deeper understanding of the concepts. Thus, another possible conclusion is that the differences in classification of the elements are associated with the fact that concepts descriptions are not clearly provided. Based on it, the need for more relationships pointed by Analyst 2 may have been caused by his difficulty in understanding KIPO.

5 Conclusions

This work presented a case study that explored the conceptualization and representation of a knowledge intensive process (KIP) based on the Knowledge Intensive Process Ontology (KIPO) previously proposed. We evaluated the potential of the KIPO in providing the knowledge organization and an adequate understanding of a KIP. The exploratory study was conducted by three analysts, who generated Ontology instances representing the KIP of elaborating a MSc dissertation. The Ontology instances were generated in a collaborative manner, using the TellStory [6]. The results showed that the set of concepts and relationships (together with their properties) of KIPO were enough to act as a structural model for the KIP being addressed.

The study also evidenced that some Ontology concepts required a more detailed description, to enable a more explicit differentiation among them and facilitate their identification in real scenarios, We also observed that the Ontology instance elaborated by the analyst who had proposed KIPO was richer (that is, containing more concepts) than the other 2 elaborated by the other two analysts. This result evidences that the KIP conceptualization represented by KIPO should be better explained to be fully internalized and comprehensible to be applied. Finally, our reflections on the

results from this study led us towards the evolution of KIPO, especially with regard to their concepts descriptions, so that its elements are presented with less ambiguity, thus achieving a higher precision in the Ontology model and its instantiation.

The limitations of our study include the lack of details in the story that described the KIP being addressed, thus making it more difficult for the three analysts to map knowledge items to the Ontology concepts. The representation of distinct ontology elements with similar semantics, as well as the different number of elements in the three instances, hardened the consolidation of all instances into the same mod-el. All the obtained results point to the need of a more precise conceptualization for KIP, using a foundational ontology as a basis, such as DOLCE or UFO.

References

1. Abecker, A.: DECOR Consortium: DECOR – Delivery of context-sensitive organizational knowledge. In: E-Work and E-Commerce. IOS Press (2001)
2. Cabral, L., Norton, B., Domingue, J.: The Business Process Modelling Ontology. In: 4th International Workshop on Semantic Business Process Management (SBPM 2009), Workshop at ESWC 2009, Crete (June 2009)
3. Donadel, A.C.: A method for representing knowledge-intensive processes. 2007. MSc Dissertation. Programa de Pós-Graduação em Engenharia e Gestão do Conhecimento, Universidade Federal de Santa Catarina, Brazil (2007) (in Portuguese)
4. Easterbrook, S.M., Singer, J., Storey, M., e Damian, D.: Selecting Empirical Methods for Software Engineering Research. In: Shull, F., Singer, J. (eds.) Guide to Advanced Empirical Software Engineering. Springer (2007)
5. França, J.S.F., Santoro, F.M., Baião, F.A.: Towards Characterizing Knowledge Intensive Processes. In: International Conference on Computer-Supported Cooperative Work in Design (CSCWD 2012), China (accepted for publication, 2012)
6. Gonçalves, J.C., Santoro, F.M., Baião, F.A.: Business Process Mining from Group Stories. In: 13th International Conference on Computer Supported Cooperative Work in Design, Santiago, Chile, pp. 161–166 (2009)
7. Guarino, N.: Formal Ontology, Conceptual Analysis and Knowledge Representation. International Journal of Human and Computer Studies 43(5/6), 625–640 (1995)
8. Guizzardi, G.: Ontological Foundations for Structural Conceptual Models. Universal Press, The Netherlands (2005) ISBN 90-75176-81-3
9. Gronau, N., Weber, E.: Management of Knowledge Intensive Business Processes. In: Desel, J., Pernici, B., Weske, M. (eds.) BPM 2004. LNCS, vol. 3080, pp. 163–178. Springer, Heidelberg (2004)
10. Gronau, N., Muller, C., Korf, R.: KMDL – Capturing, analyzing and improving Knowledge-intensive business process. Journal of Universal Computer Science 11(4), 452–472 (2005)
11. Korherr, B., List, B.: A UML 2 Profile for Event Driven Process Chains. In: Tjoa, A.M., Xu, L., Chaudhry, S. (eds.) Proceedings of the 1st IFIP International Conference on Research and Practical Issues of Enterprise Information Systems. IFIP, vol. 205, pp. 161–172. Springer, Boston (2006)
12. Lopes, M., Baião, F., Siqueira, S.: Expressing Business Rules in a Foundational-based Domain Ontology: Towards Higher-quality Conceptual Models. In: International Conference on Information Integration and Web-based Applications & Services, Paris (2010)

13. Noy, N.F., Mcguinness, D.L.: Ontology Development 101: A Guide to Creating Your First Ontology. Knowledge Systems Laboratoty (2001)
14. Oliveira, F.F.: Ontology Collaboration and its Applications. MSc Dissertation. Programa de Pós-Graduação em Informática, Universidade Federal do Espírito Santo, Vitória, Brazil (2009) (in Portuguese)
15. OMG: Business Process Modeling and Notation (BPMN). Version 2.0 (2011), http://www.bpmn.org/ (accessed in: June 26, 2011)
16. Papavassiliou, G., Ntioudis, S., Abecker, A., Mentzas, G.: Managing knowledge in weakly-structured administrative processes. In: 3rd European Conference on Organizational Knowledge, Learning and Capabilities, 3, Atenas, Grécia, Abr. 5-6 (2002)
17. Pereira, A., Santoro, F.: Cognitive Decision Making Process as Context Information. In: The 15th IFIP WG8.3 International Conference on Decision Support Systems (DSS 2010), Lisboa, Portugal (2010)
18. Richter-Von Hagen, C., Ratz, D., Povalej, R.: Towards self-organizing Knowledge-intensive Processes. Journal of Universal Knowledge Management (2005)
19. Nurcan, S., Rolland, C.: Meta-modelling for cooperative processes. In: The 7th European-Japanese Conference on Information Modelling and Knowledge Bases, Toulouse, May 27-30, pp. 361–377 (1997)
20. Nurcan, S., Edme, M.-H.: Intention Driven Modelling for Flexible Workflow Applications. Special issue of the Software Process: Improvement and Practice Journal on Business Process Management, Development and Support 10(4) (2005)
21. Schlenoff, C., Gruninger, M., Tissot, F., Valois, J., Lubell, J., Lee, J.: The Process Specification Language (PSL) Overview and Version 1.0 Specification (2000), http://www.mel.nist.gov/psl/ (accessed in June 27, 2011)
22. Schreiber, G., Akkermans, H., Anjewierden, A., Hoog, R., Shadbolt, N., De Velde, W.V., Wielinga, B.: Knowledge Engineering and Management: The CommonKADS Methedology. MIT Press, Cambridge (2002)
23. Strohmaier, M., Yu, E., Horkoff, J., Aranda, J., Easterbook, S.: Analyzing Knowledge Transfer Effectiveness – An Agent-Oriented Modeling Approach. In: Proceedings of the 40th Hawaii International Conference on System Sciences, USA (2007)
24. Yin, R.K.: Case study research: design and methods, 3rd edn. Sage Publications Inc. (2003)