Supporting collaboration in multilingual ontology specification: the conceptME approach

Manuel Silva[1,2], António Lucas Soares[2], Rute Costa[3],

[1] ISCAP-IPP - Rua Jaime Lopes Amorim, s/n, 4465-004 S. Mamede de Infesta
mdasilva@iscap.ipp.pt
[2]INESC Porto, Rua Dr. Roberto Frias, s/n 4200, Porto-Portugal
als@fe.up.pt
[3]CLUNL - Universidade Nova de Lisboa, Avenida de Berna 26-C 1069 - 61 Lisboa;
rutecosta@fcsh.unl.pt

Abstract. Despite the availability of tools, resources and techniques aimed at the construction of ontological artifacts, developing a shared conceptualization of a given reality still raises questions about the principles and methods that support the initial phases of conceptualization. These questions become more complex when the conceptualization occurs in a multilingual setting. To tackle these issues a collaborative platform – conceptME - was developed where terminological and knowledge representation processes support domain experts throughout a conceptualization framework, allowing the inclusion of multilingual data to promote knowledge sharing and enhance conceptualization.

Keywords: Multilingual ontology specification, Localization, Terminology, Collaborative networks, Knowledge Representation.

1 Introduction

The development of the diverse scientific and technical fields has its origin in the evolution and dynamics of knowledge and results from the constant interaction between individuals pursuing common objectives, knowledge that cannot be separated from its context, experience, culture and language. This interaction, especially in multinational and multicultural organizations, is increasingly taking place in collaborative and cooperative environments available online.

In these environments, language, as the means of human communication, and terminology, as a nuclear element for the specification and dissemination of specialized knowledge, assume an increasingly important mediation role in the communication taking place between the various interlocutors and in man-machine communication, emerging as the key link for the discovery and creation of knowledge and its effective conceptualization, representation, transmission and reuse.

To meet the increasing demands of the complex intra and inter-organizational processes, there was a growth in quality in the processes of interaction and sharing of resources inside organizations, on the one hand, through the implementation of inno-

vative forms of collaboration, such as collaborative networks, defined by [4] as *a network composed of a variety of entities - organizations and people - which are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital and goals, where participants collaborate to (better) achieve common or compatible goals, being their interactions supported by computer network* and, on the other hand, the development of more robust information and knowledge management systems, such as ontology-based knowledge management systems.

Knowledge organization and collaboration systems are thus important instruments for the success of collaborative networks of organizations. In this context, access to and representation of knowledge implies the overcoming of difficulties inherent to the use of different natural languages, through the use of processes and methodologies that support and promote knowledge sharing and organization in multilingual settings.

2 Terminology and knowledge representation

As stated in [25], an increasing number of semantic tools and resources such as concept map editors or wiki-based platforms have been built with the goal of sharing information and knowledge in collaborative networks. Despite the availability of techniques aimed at the construction of ontological artifacts, developing a shared conceptualization of a given reality still raises questions about the principles and methods that support the collaboration process. [16] underline limitations in the development of ontologies in collaborative settings: «current knowledge about the early phases of ontology construction is insufficient to support methods and techniques for a collaborative construction of a conceptualization». Techniques may involve the (re)use of ontology design patterns (ODP), which is not without its challenges: «even users with some background on ontology modelling face difficulties when reusing ODPs for their needs» [28]. These limitations grow bigger when the setting is multilingual and the ontology has to be specified in more than one natural language.

In the light of this issue, and as [25] make clear, *tasks involving conceptualization call for interplay between terminology and knowledge representation capable of rendering intuitive and operational the notions of term and concept without blurring the theoretical distinction between the different levels of analysis triggered by them*. Practical work such as representing knowledge for ontology-building purposes tends to show them as alternate (sometimes opposing) sides rather than interdependent elements of a relation between objects, concepts and terms, as it is represented in the semiotic triangle in terminological science and research.

Under the scope of the project – CogniNET[1] – a prototype of a collaborative tool – conceptME - is being developed to implement functionalities and models that will assist experts in the process of reaching a shared conceptualization of a given domain, in the form of semi-formal ontologies, based on this interplay between terminology and knowledge representation. In this article we describe the preliminary steps of conceptME approach to conceptualization in a multilingual environment, which in-

[1] http://cogninet.tk

tends to assist experts in the discussion and modelling of the concepts of their domain in a multilingual setting.

2.1 Difficulties in multilingual ontology specification

As identified in [12], current approaches to cross-lingual information access offer only partial solutions that address the problem in a restricted way. The scarcity of formal ontologies enriched with linguistic information in more than one language has its origin in other factors such as the difficulty in choosing methodologies to support the knowledge conceptualization and representation process in an environment of construction and localization of ontologies for different languages. Although localization is a well-developed practice and its methodologies and tools have been successfully employed by the language industry in the development and adaptation of multilingual content, it has not yet been sufficiently explored as an element of support for the development of ontologies represented in more than one language.

[9] identify several problematic dimensions to be taken into account in the process of ontologies localization, namely translation problems, related to the existence (1) *of exact equivalents, (2) context-dependent equivalents and (3) of conceptualization mismatches; management problems, related to maintenance and updating of translated ontology labels throughout the ontology life cycle; and multilinguality representation problems*. In fact, part of the difficulties of any localization system lies in solving problems that we can view as traditional and which result from the translation process, such as the difficulty in finding equivalents in the target language, the existence of polysemic terms and quasi-synonyms, or problems related to terminological variation.

Other problems derive mainly from linguistic problems that arise from the association of meanings of terms in different languages to concepts represented in an ontology, as *word senses and concepts cannot be said to overlap* [10] since, as recognized by [13] *word senses are tightly related to the particular vision of a language and its culture*, whereas concepts represented in an ontology refer to *objects of the real world and are defined and organized according to expert criteria agreed on by consensus*.

As [21] acknowledges, it is generally accepted that achieving a one-to-one term-concept and concept-term relationship (*Eineindeutigkeit*) within a subject field is unattainable. [21] recalls that Wüster himself *had practical doubts about the viability of achieving this goal on a comprehensive scale, and described it as "ein frommer Wunsch"* [24]. [19] on the other hand, says we *cannot communicate and share information unless we agree on the terms we use and on their meaning*. For the author, the meaning of terms rests upon a shared and consensual representation of a domain model and it is such representation that originates an ontology.

In addition to these difficulties, localizing an ontology - understood as a specific semantic artefact used to represent the knowledge of a domain, built in a given context for a particular purpose -, raises other questions, like those related to the:

1. definition and delimitation of the domain or subdomain(s) to be conceptualised;
2. selection, adaptation and integration of existing semantic resources;
3. time constraints, usually imposed on processes of conceptualization and localization;

4. approach to integration and (re)use of already available language resources and tools.

3 Approach to Multilingual Ontology Specification

The more generic goal of ontology localization is to allow *cross-lingual semantic interoperability in large-scale information environments, which usually contain a number of heterogeneous and distributed knowledge resources* [1]. The specification of an approach by which localization may contribute to enhance the cross-lingual semantic interoperability between heterogeneous resources of a specific subject field requires taking into account and acting upon the context of the ontology construction and knowledge sharing during the ontology conceptualization phase.

It also requires that we consider the objectives and purposes the community of potential users may have for this knowledge. To do so we need to focus on apprehending the subject fields' complexity, richness and semantic diversity and, at the same time, on having a method and tool to help represent its multilinguality, what should also happen during conceptualization.

The conceptualization phase of an ontology development process is of utmost importance for the success of the ontology, as it is in this phase that a socio-semantic agreement is shaped [17]. For [22] a conceptualization process is, for an individual, a *collection of ordered cognitive activities that has as inputs information and knowledge internally or externally accessible to the individual, and as the output an internal or external conceptual representation*, and a "collaborative conceptualisation process" is *a conceptualization process that involves more than one individual producing an agreed conceptual representation*, a process which involves social activities that include the negotiation of meaning and practical management activities for the collaborative process.

For [17], *ontology engineering needs a "socio-cognitive turn"* in order to generate tools that are really effective *in coping the complex, unstructured, and highly situational contexts that characterize a great deal of information and knowledge sharing*. [17] remember [3] words when he says that *we need to go beyond the approaches that provide a high level of 'automation of the meaning'; instead, we need to address situations where human beings are highly required to stay in the process, interacting during the whole life-cycle of applications, for cognitive and cooperative reasons*. The authors place conceptualization in a phase of informal specification of the ontology (previous to any formal representation) and describe its result as a shared conceptual model.

The aim is *to support the co-construction of semantic artefacts by groups of social actors placed in organizational contexts interacting towards a set of common objectives* [16]. This co-construction and the resulting conceptual representations, which are based on the analysis of different sources, including textual, terminological, taxonomic and other, and subject to constant negotiation with the direct collaboration of domain experts, could, in our opinion, assume a multilingual dimension as early as the conceptualization phase.

3.1 conceptME conceptualization framework

Based on this view and on the analysis of the process of a shared conceptualization of domain ontologies in the context of a collaborative network, we have developed a platform – conceptME - to support the process of multilingual specification of an ontology to be implemented during the conceptualization phase. For the development of our proposal we assume that the processes of conceptualization and localization of an ontology may occur consecutively, in order to allow us to consider all available information and perspectives of the different working languages and cultures as early as the conceptualization phase. The proposed iterative and, to some extent, cyclical nature of the two processes - conceptualization and localization – intends, thus, to promote more immediate access to different perspectives about the domain's knowledge.

The conceptualization framework in the platform is structured in four phases [26]: concept elicitation, concept organization, concept sharing and concept discussion. Each of these phases is supported by a set of activities related to terminology and/or knowledge representation, being that the first phase is fully supported by terminological processes, based on texts: collection, identification and classification of resources and terminological extraction. Terminological work also supports the second phase of conceptualization, when experts engage in the organization of concepts.

The conceptualization framework depicted below underpins the advances of this research on methods and tools to support the representation of conceptual structures. This framework provides a structured and multidimensional view over the conceptualization process in what regards to its main phases, activities and artefacts, tying together the terminological and knowledge representation view.

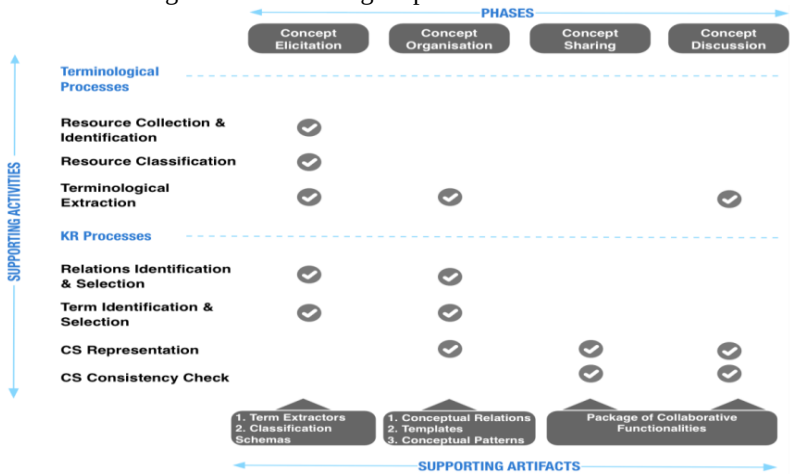

Fig. 1. Conceptualisation framework (*Sousa et al.*, 2012)

The core of conceptME platform is on supporting collaborative modelling, allowing users to create and share conceptual models, focusing on graphical knowledge representations and terminological methods, accommodated into a service's library. The platform enhances, according to [27] negotiation and discussion capabilities by

means of specific extensions, towards consensus reaching. The platform is organized as follows (see figure 1):

a) a set of functionalities to manage ongoing and previous collaborative modelling projects (generic project edition, definition and configuration of the enclosing collaborative spaces and related resources);

b) a collaborative modelling environment, which is language independent, allowing users to build their models individually or editing them collaboratively (either on their own or through available templates), while discussing around concepts;

c) a set of terminological services, based in terminological work methods and techniques, supported by the collection of domain specific textual corpus, which can be built in different languages, allowing users to associate relevant resources to their projects, performing extraction operations to retrieve candidate terms that can be used in their conceptualization process. At this level, conceptME provides: i) means for corpus organization and classification; and ii) real-time term contexts to detail existing representations;

d) a model negotiation baseline enclosing a set of features (merging individual input structures, suggestion mechanism, cross-checking corpus-based validation, autocomplete and categorization, equivalents visualization, among others) to ensure simple negotiation mechanisms, towards a common shared model. This module provides the interface and environment conditions, allowing to connect other advanced negotiation mechanisms (e.g., argumentation-based negotiation and decision-support methods), despite of their nature, domain or language.

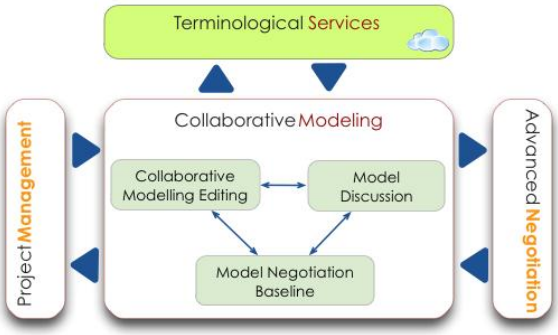

Fig. 2. - ConceptME High-level architecture (Sousa *et al.*, 2012)

3.2 Tools to support the multilingual ontology specification

Working in a collaborative space implies the availability of an environment to help promote the multilingual specification of the conceptual representation, an environment that considers both the social and organizational structure of the community and the type of existing skills. Although localization is a knowledge-based activity [23], the selection of techniques, methods and tools for the localization depend on the resources available for each particular language and for the specialized domain to be represented.

This poses a number of additional difficulties, as the available translation and localization services are almost exclusively focused on document translation and do not consider the needs of communities that operate in a multilingual network and need to deal with the presence of multiple natural languages in a same virtual collaborative space. Thus, to support the presented workflow and the subject field experts' effective participation in the localization process, we have selected a set of easily accessible Web 2.0 translation tools, lexical and terminological database, and developed a lightweight localization service support system to help the user in is search for equivalents, as depicted in the next figure.

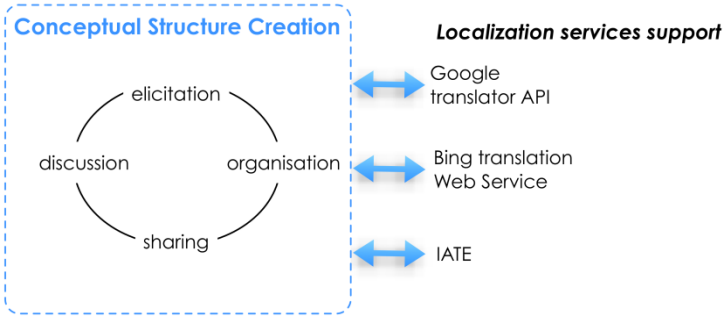

Fig. 5. Localization services support

This selection was done after an analysis of the available web translation tools which took into consideration the ease of use and access by the experts, as well as the specificities of their use in supporting localization for specialized domains. Through this service the user can either choose to localize a single term or the entire conceptual structure, and then validate or discard the results he obtained.

As we could observe, the use of these tools was, nevertheless, clearly influenced by the preexisting domain knowledge, added by the specialist to the process or that resulted from the reuse of other domain knowledge resources such as specialized multilingual dictionaries and glossaries.

4 Application scenario: development of H-Know Ontology

This approach was tested in a preliminary stage in the context of the European project H-Know - *Advanced Infrastructure for Knowledge Based Services for Restoring Buildings*. The project involved partners from five European countries and was developed in a multidisciplinary and multilingual environment involving terminologists, domain experts and knowledge engineers with the objective of building an ontology-based knowledge management platform to support the creation of cooperative and collaborative business networks to facilitate the sharing of Construction Industry knowledge in the domain of cultural heritage and old building restoration/maintenance among the network partners (SMEs and R&D Institutes). This do-

main is characterized by its cyclical and nomad activity, which involves a high number of design and production processes. The knowledge in this domain is disperse, diverse and fragmented, due to its polymorphic character and the amount of actors, rules and institutions that participate in the development of each phase of the construction process.

Management of this knowledge was based on a multilingual domain ontology for the Rehabilitation domain, the H-Know Ontology, developed with the objectives of providing an infrastructure to efficiently and effectively organize, classify and retrieve information and knowledge and to provide H-Know users with a common ground for a shared understanding of terms and concepts when engaging in the virtual collaborative network activities [6].

Implementing an approach to meet the needs of a particular process that has to be developed in a specific context has to take into consideration the users' diversity, as well as their requirements, the existing resources at the time of its implementation and the constraints that occur due to the results' integration in existing applications. In our case, and for the approach testing and implementation, it was considered that the following assumptions were gathered:

1. The collaborative network is formed, is multilingual and its objectives, mission and deadlines are established and accepted by all its members;
2. The partners will be the actors involved in the negotiation process with the aim of reaching a consensus about the representation of the domain's knowledge;
3. Each partner is seen as an expert that actively participates in the conceptualization of the domain ontology and in the localization process, according to the roles, aims and the defined calendar.

4.1 Conceptualization and multilingual specification environment

Specifying an ontology in more than one natural language is a process with its own problems, already described. When the starting point is a conceptual map there may be additional difficulties, given that the expert has to deal with both the knowledge representation specified in each conceptual map and with the localization of terms represented there.

To support the development of this task conceptME offers a conceptualization space, represented in the figure below, to support the specific communicative situation and provides a simple tool and a simple approach to facilitate access to knowledge and to represent it in a multilingual environment through the use of conceptual maps built in a shared environment, where concepts and their relations are made explicit, the equivalents displayed and where experts have the opportunity to include, together with the equivalents, other elements such as natural language definitions or share additional information considered relevant in the discussion area.

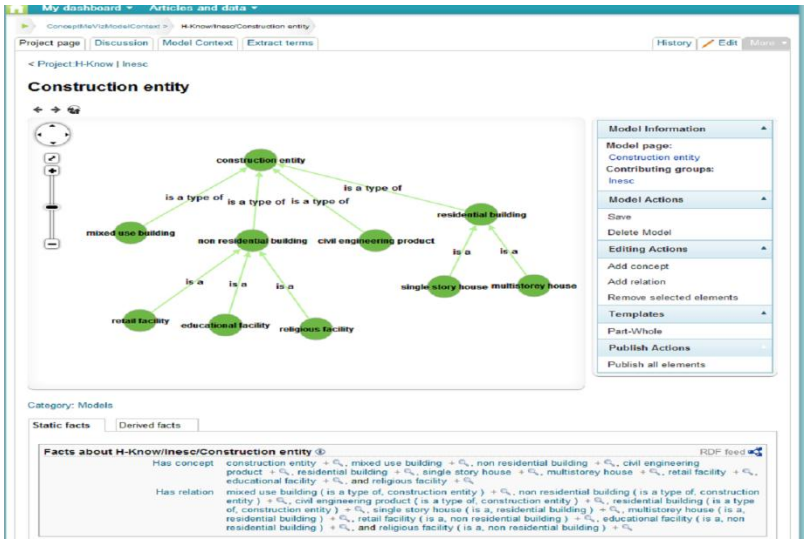

Fig. 3. Conceptual modelling space

This working environment is intended to facilitate a collaborative approach to the development of conceptual representations and to its localization and supports the inclusion of different terminological and linguistic elements, has the expert may had, along with the equivalents, terminological variants, definitions and contexts of use for his/her working language, in order to explain or support his/her choices. This environment also allows the addition and direct visualization of equivalents in the different working languages and the access to the conceptual structures in each language, as portrayed in the next figure.

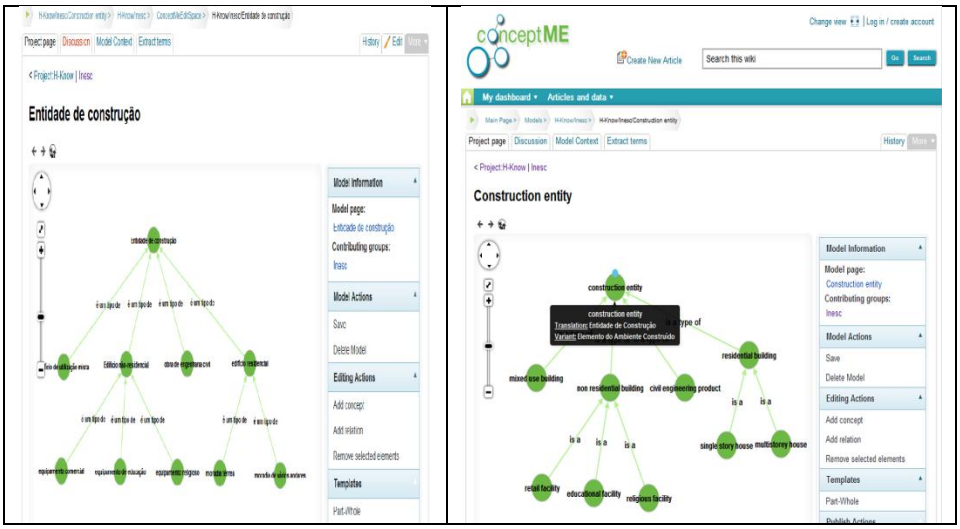

Fig. 4. Conceptual modelling space – multilingual features

The use of these elements intends to support the management of the multilingual information made available in the context of a conceptual map and to create the possibility of providing a homogeneous access to the all the partners of the network, who can thus visualize each other's work and suggestions. The use of a reduced number of elements in this space was decided after considering the time constraints that limit the process of conceptualization and localization, on the one hand, and, on the other, the need to provide a simple and functional working environment that promotes the experts' participation, for whom time is also of the essence.

5 Related work

Considering a multilingual collaborative network, in the approach we propose localization takes place after an initial conceptualization phase, developed using the English language as a starting point, and occurs in a conceptualization space, where the representation of knowledge is developed and made available to domain experts through the use of concept maps, as described in the figure presented below.
The main tasks in the conceptualization and localization for each natural language are (1) the validation of the conceptual structures; (2) translation of the terms that designate the concepts; (3) the translation of the conceptual relations and analysis of their logic validity and (4) reconceptualization, if needed. During this process, the expert must also bear in mind the need to match the represented knowledge to the purposes of the research and information management process that originated the ontology construction.

We do not use, then, a formalized ontology as a basis for localization; rather we start out from a semiformal organization of knowledge in the form of concept maps. The construction of this approach resulted also from the perception that the most commonly used approaches did not fully correspond to the prerequisites of a collaborative network where the need for localized content appears at an earlier stage, due to the short life-cycle that characterizes this type of network.

By promoting and supporting the representation of the different natural languages during conceptualization we differ from other approaches to ontology localization, as those proposed by [15], [2], [8], which focus more directly on the process of enriching formalized ontologies with linguistic elements, and we do not use either a specific ontology localization tool like LabelTranslator [7] or Ontoling [15].

Our approach to the multilingual ontology specification was chosen so as to let us consider not only the individual elements that constitute the conceptual system - concepts and relations and their equivalents in the different languages -, but also, and more importantly, the semi-formal representation as a whole, and assess, with the direct participation of the subject field experts, whether it represented knowledge as it is perceived and expressed by the community for which each expert is localizing it.

The development of this approach is based on a methodology of interlinguistic analysis that functions as a support for the conceptualization of the subject field. It is terminology-based, although it integrates elements from existing methodologies in the area of localization and translation and ontologies engineering. It follows a theoretical

framework that recognizes the conceptualization process as the basis for developing knowledge representation in more than one natural language.

6 Conclusions

The first steps given in the implementation of this approach allowed us to see that the analysis and eventual reconceptualization of the conceptual representations, reinforced by the need to simultaneously develop the localization of the represented concepts, enhanced the experts' awareness, by challenging them with the need to expose and explain their questions, doubts and uncertainties. We also observed that the clarification of doubts may lead to an attempt to conjugate different points of view between experts and between the personal highly specific knowledge and the high-level knowledge representation. This tendency for agreement happens because the expert recognizes himself as part of a collaborative network that is building a semantic representation of a specific knowledge domain which goes beyond what would be an individual representation of that same knowledge, thus valuing the ensemble of opinions and knowledge available, as well as the mediation role played by the terminologist.

This environment proved to be functional and easy to use and allowed users without great experience, who were not prepared to deal with the restrictions of formal semantics, to concentrate on the tasks of conceptualization and localization. The active participation of the experts made it possible, to a certain extent, to reduce some of the problems that hinder the swiftness and effectiveness of localizing specialized knowledge, namely conceptual problems, as experts know the domain, which contributes to reduce ambiguity and increase the semantic precision; linguistic problems, as experts are familiar with the specialized language and recognize most of the terms to localize, needing less time to find the proper equivalent; and pragmatic problems, related to the use of the term, such as its acceptance by peers, which he/she can more easily understand and anticipate.

We recognize, though, that this form of knowledge representation based on conceptual maps has a great degree of complexity which tends to increase when we use conceptual maps to develop a multilingual representation, what may hinder the understanding of the workflow and of the different tasks to be developed. Another limitation lies on the fact that this process may include a large number of the collaborative network experts which may imply, in the chain of contributions and negotiation that is generated, some loss of perception of the original meaning of a concept.

We therefore believe that this approach is adequate to the context of a multilingual collaborative network, a space where multiple partners cooperate in a common effort to represent specialized knowledge in more than one language and that it encourages interaction, knowledge sharing and consensus building.

Acknowledgements: This work is funded by the ERDF through the Programme COMPETE and by the Portuguese Government through FCT - Foundation for Science and Technology, project PTDC/EIA-EIA/103779/2008 "CogniNET".

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