Supporting Collaborative Innovation Networks for New Concept Development Through Web Mashups

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Abstract. The new concept development is a critical stage of the innovation process that can be seen as a new knowledge creation process. This paper presents a new approach and a software tool for a collaborative new concept development. Our approach considers Collaborative Innovation Networks as ecosystems for new knowledge creation and integration, and Web Mashups as supporting platforms for the development of virtual co-learning and knowledge co-creation environments. The achieved results confirm the utility and efficacy of the software tool and allow foreseeing its suitability for use in educational contexts.

Keywords: Collaborative innovation networks · Learning · Web mashups

1 Introduction

Innovation plays a central role within businesses because it is seen as a way of sustainable competitive advantage creation. Initially rooted in R&D and based only on organizations' internal knowledge, the innovation models have evolved to the current open and networked models. Today, the locus of innovation is no longer the individual or the organization, but, increasingly, the network where the firm is embedded [1]. External socio-economic agents such as clients and users of products and services are significant sources of knowledge, especially in the Front End of Innovation (FEI). User communities are an important locus of innovation and can increase the productivity in the development, test, and diffusion of innovations. Information Technologies (IT) and the Web 2.0 have come promote and facilitate the creation of innovation communities. *User Innovation Networks*, *Peer Production*, *Community-Driven Innovation* or *Crowdsourcing*, are terms often used to describe the innovation by virtual user communities. Table 1 presents a summary of IT tools that operationalize the mechanisms [2] typically used to acquire user's knowledge for innovation. On the one hand, current approaches are not entirely effective because

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they limit user participation to idea generation and design of simple products. On the other hand, the supporting IT tools may not also be totally efficient in knowledge structuration and systematization, two key requirements for easy knowledge transfer [3, 4]. Moreover, these tools are not entirely effective in the exploration of the tacit knowledge latent in people's mind. The linear text format typically used to express ideas makes difficult the establishment of connections between ideas.

Table 1. User innovations promotion mechanisms in the front end of innovation

Mechanisms	Operationalization	Studies
Idea contests (Ideagoras, Ideariums, Ideatubes)	Knowledge brokers applications	[5]
	Social media platforms; SNS platforms	[6, 7]
Product related discussion forums	Discussion forums	[2]
Communities of creation	Social media platforms; SNS platforms	[2, 4]

In the contemporary context, the integration of external and internal knowledge to organizations through collaborative approaches is a critical factor for successful innovation. Thus, a collaborative model that integrates clients, innovative users and partners in the development of new concepts can increase the chances of creating products or services commercially attractive. Notwithstanding, the integration, absorption and application of this external knowledge require mastering a set of dynamic capabilities where the absorptive capacity (learn, integrate and apply the acquired knowledge) plays a central role. Firms with a higher absorptive capacity show a strong capacity of learning with their partners.

This paper is structured as follows. Section 2 presents some background concepts. Section 3 presents our approach and a software tool for a collaborative new concept development. Section 4 presents tests and results. Finally, Sect. 5 presents the conclusions.

2 Collaborative Innovation Networks, Knowledge Dynamics, and Web Mashups: Background Concepts

2.1 Collaborative Innovation Networks

A Collaborative Innovation Network (COIN) [8] is a social construct that is used to describe innovative teams or groups. COINs are powered by *swarm creativity* - their structural mechanism - and are defined as auto-organized cyber teams of auto-motivated people that share a common vision and use the Web to collaborate, sharing ideas, information and work, aiming to create something new. The underlying concept builds on the premise that, the creative production that results from the open share of ideas and work within a group, is exponential greater than the sum of individual creative production of each element of the group [8, 9]. In fact, the underlying premise is tightly related to the foundations of the Collective Intelligence (CI) concept. COINs are the core of a knowledge ecosystem that encompasses some other virtual collaborative communities (learning and information), through which the generated knowledge flows until reaches the virtual world. They can emerge spontaneously outside or within firms. Internal COINs can cross firm's boundaries and include external members and even other firm's members. Thus, a COIN can be considered, in a natural way, a productive innovation ecosystem powered by CI that leverages and integrates external and internal knowledge to firms. Under this view, COINs can work as enablers or facilitators of the absorptive capability in organizations.

2.2 Knowledge Dynamics and Learning

In knowledge management (KM) related literature [10, 11], knowledge is commonly classified along two dimensions [12]: *tacit knowledge* (TK) and *explicit knowledge* (EK). TK is personal, context-specific, composed by intuitions, mental models unarticulated or technical competencies. EK is articulated, codified and can be transmitted in natural or symbolic language and computationally processed [11].

Knowledge creation is a complex social process that involves the acquisition, replacement and reconfiguration of existing knowledge structures in entities (individuals, groups or organizations). The SECI model [11] explicitly addresses the social nature of knowledge creation dynamics and comprises two dimensions: (1) *epistemological*, which describes TK to EK conversion and vice versa; (2) *ontological*, which describes knowledge transformation and flow between individuals groups and organizations. Thus, knowledge creation is a spiral process that builds on four stages of knowledge conversion (TK → EK; EK → TK): Socialization; Externalization; Combination and Internalization. Socialization is a social process and consists of sharing TK through communication. Externalization is an individual process and refers to the expression and translation of TK into tangible media such as text, concepts or models (EK). Combination is a social process and consists in the conversion of EK into more complex sets of EK by means of sorting, combining, adding and categorizing. At last, Internalization is an individual process that involves the conversion of newly created knowledge (EK) into TK through reasoning and reflection, *i.e.*, learning. This process is iterative and takes place in a shared place known as *ba* that defines the context in which knowledge is created.

Individual learning occurs in the Internalization stage. Group learning occurs in the Socialization stage. Once internalized, the explicit knowledge becomes part of the individual's knowledge base and becomes an asset for the organization.

2.3 Web Mashups as Learning and Knowledge Management Supporting Tools

The openness and participatory nature of Web 2.0 changed the way that people use the Web allowing peer production, sharing and collaboration harnessing CI. Users, prior content consumers become content producers. Rapidly, the web became a huge repository of information and knowledge (opinions, know-how, etc.) in the form of knowledge artifacts. An intrinsic feature of Web 2.0 applications is the openness of their APIs, which

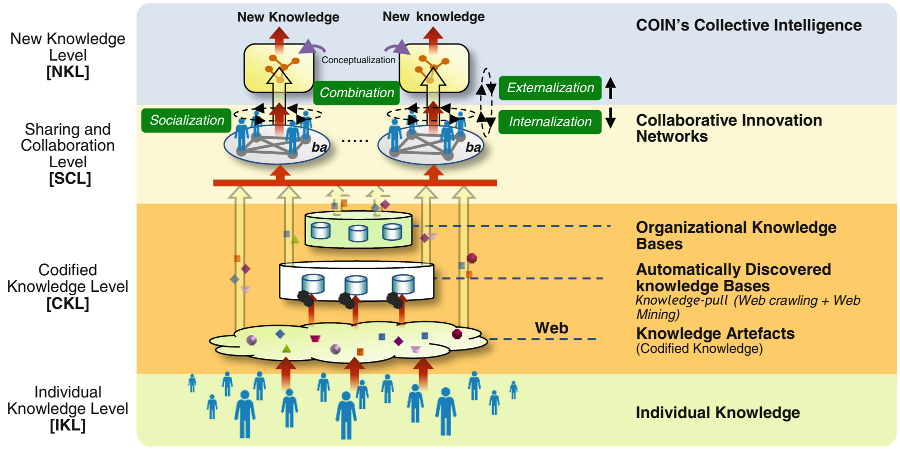

Fig. 1. A conceptual framework for harnessing the collective intelligence in COINS

allows the development new applications based on those exposed interfaces. These are known as Web Mashups – composite Web applications that allow extend original functionalities or the combination of data from different sources into a new presentation, giving rise to new sets of data, information and knowledge representations. Web Mashups have been exploited in support of Web-based learning and KM. As supporting platforms for learning contexts, Web Mashups are capable to integrate and enable the learning functions that the learning process depends on [13]. In the scope of education, several studies [14] showed the benefits of Web Mashups for the construction of Personal Learning Environments. In the scope of KM, the literature shows practices of analysis [15] and attempts of use of Web mashups in the development of KM tools [16]. These platforms provide a solid support for personal KM and informal learning [15, 16].

3 Supporting Collaborative Innovation Networks for New Concept Development Trough Web Mashups

Supported by the concepts presented in the previous section, we derived a conceptual framework (Fig. 1) for the development of new concepts in FEI, harnessing CI of COINs. The framework assumes the new concept development process as a new knowledge creation process [17] and the Web as a vast repository of individual knowledge representations in the form of knowledge artifacts.

Around a seminal idea about a new concept of a product or service, a group need or a market need, a COIN can emerge. Its members can join in a virtual shared space (*ba*) and start to collaborate by sharing ideas, know-how, experiences and opinions (Socialization) around a shared vision that is mapped into a plan (NKL) and codified as a shared conceptual structure (Externalization). The externalized knowledge can be combined or supported by/with knowledge embedded in knowledge artefacts distributed and available on the Web (videos, images, Web pages, RSS feeds, etc.) or located in organizational knowledge bases (design schematics, models, product's data, etc.). Web knowledge artefacts can be manually or automatically selected and aggregated and then manually combined and recombined (mashup) giving origin to new and more complex knowledge artifacts (Combination). The analysis and reflection on the conceptual structure collaboratively created, promote knowledge endogenization (Internalization), *i.e.*, learning. The process is iterative and stops when a common understanding about the new concept is reached, which can be translated as new knowledge that results from the CI of COIN members. This new knowledge can, in fact, promote the organizational learning once it may help improving organization's technology, processes and structure and consequently, acquire market competitive advantage.

3.1 A Web-Based Software Tool for New Concept Development

The conceptual framework provided a base for the development of a collaborative Web-based software tool aiming to support COIN's activities in the new concept development in the FEI. The tool builds on a set of ontology-based knowledge management services [18] that provide an effective management of COINs' activities and resources. The system relies on a multi-layer modular architecture (Fig. 2) in which three major modules stand out: (1) *Collaboration Module*; (2) *User Mashup Builder Module*; (3) *Mashup Middleware*. The Collaboration Module operationalizes a virtual collaboration space (*ba*) providing users with communication tools, real-time collaboration and a shared whiteboard used for the co-construction of the shared conceptualization which is shaped by an extended concept map, where the shared concepts can be supported by Web Mashups. The User Mashup Builder Module provides functionalities for setting up searches and combination of results into a single and new representation – a mashup. Finally, the Mashup Middleware provides an interface layer for fetching and pre-processing data.

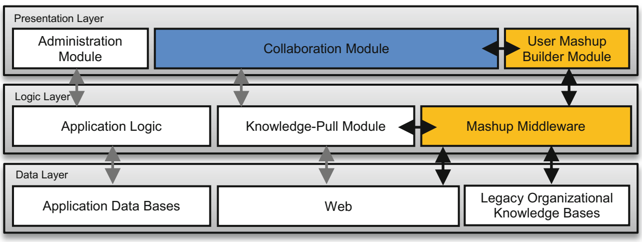

Fig. 2. Simplified high-level architecture of the software tool

3.2 The Mashups Development Process

The mashup development process is performed in two levels (Fig. 3). The first level (low level) is supported and operationalized by the Mashup Middleware which

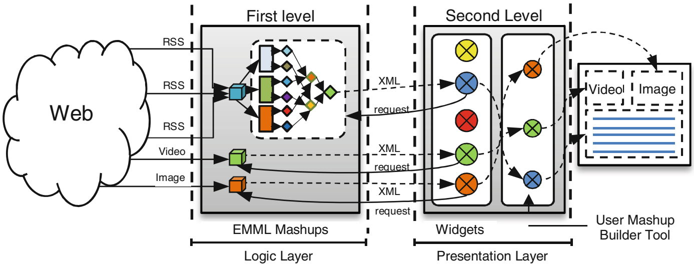

Fig. 3. Mashup development process

establishes an interface between data sources and data presentation by providing data access and data pre-processing. Data pre-processing can be simple consisting of data cleaning and filtering followed by data structuring in a normalized format; or it can be far complex involving data acquisition from different sources, data cleaning, data filtering, data integration/combination through *union*, *join* or *sort* operations and subsequent data structuring in a normalized format. This subsystem is supported by an open mashup platform known as *Enterprise Mashup Platform* that allows describing low-level mashups in EMML (Enterprise Mashup Markup Language), an XML dialect. The module provides multiple data access methods (REST, WS, JDBC, and POJO), supports multiple data formats (XML, JSON e Java Objects) and several data processing methods (EMML flow control structures, XPath, and JavaScript). EMML mashups are hard-coded and developed by software developers.

The second level (high level) is operationalized by the User Mashup Builder Module. This module builds on three components (Fig. 4): (1) *Resources Library* [a], which provides access and represents the EMML mashups available on the Mashup Middleware; (2) *Mashup Dashboard* [b], which hosts the mashup widgets selected in the Resource Library; (3) Composer [c], which allow the composition and combination of widgets selected resources into a single representation.

The Widgets define the user interface of EMML mashups providing search queries parameterization (filtering and sorting criteria), results presentation and selection.

The construction of user mashups for supporting a given concept of the shared conceptualization can be briefly defined as the selection of data sources [a], data source's modeling through the corresponding Widgets, searching, result selection [b], composition and combination into a single representation [c] and subsequent association to the correspondent concept.

4 Testing and Results

Two tests were conducted aiming to verify the utility, quality and efficacy of the software tool. The first test was performed in the form a real-time collaborative session, involving persons geographically dispersed (Portugal and Brazil). The main objective was to verify the system stability in the collaborative construction of a shared conceptualization. The second test was performed within a real business environment and had as a goal the

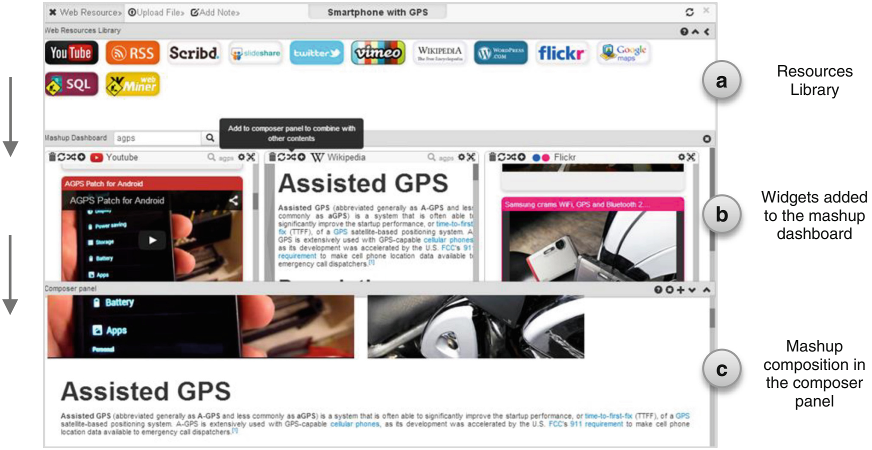

Fig. 4. The user interface of the *User Mashup Builder Module*.

collaborative development of a solution to an existent identified problem. Data was collected by semi-structured interviews with the members of the involved teams. Data analysis was done by qualitative methods using the dimensions and measures for information systems evaluation proposed in [19].

The tool revealed to be efficient in supporting the problems in both contexts. Especially on the second test, the software tool was able to bridge an existing gap related with the process of idea enrichment/maturing. Beyond this, the involved participants identified several positive aspects that can be classified into two levels: *individual* and *organizational*. In the individual level, the promotion of the individual learning and networking were pointed out as two value-added features. The richness, comprehensibility, format and accuracy of information were the factors identified as enablers for an easy learning and knowledge transfer. In the organizational level, the results achieved (in the second test) produced a positive impact on the environment which can be translated as an improvement in business process and subsequent cost reduction.

5 Conclusions

This paper presented a new approach that relies on Web Mashups as supporting tools for the process of new concept development in the FEI. The results obtained in both performed tests showed a positive impact on learning and new knowledge creation processes. COINs are very productive knowledge creation ecosystems and may integrate internal and external persons to organizations. By fostering and nurturing these networks through a collaborative platform of this nature, one can promote new knowledge creation by integrating external and internal knowledge to organizations, facilitating thus the absorptive capacity and consequently, the innovation.

The contributions of this work are tightly related to learning and knowledge creation through reflection. The developed software tool revealed the ability to provide the creation of virtual learning environments. Future work will include the study of its suitability and extension to educational contexts.

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