Combining Open Innovation and Knowledge Management for a Community of Practice – An Analytics Driven Approach

**Abstract**

Communities connecting people who want to create and share knowledge and participate in the development of new products and services related to emerging technologies gain increasingly attention. Such communities of practices benefit from components that allow innovation activities for the community members. Also, the shared creation of a knowledge base can contribute to community success. So far, these two components have been addressed separately. In our research, we integrate them by means of an analytics component. It can foster the processes within a community and provide novel insights about the domain in focus, such as by observing the community members behavior, as these members represent relevant stakeholders for the domain. We conceptualize a framework for integrating the components open innovation, knowledge management, community management, and analytics. In a multi-year research project we have implemented and evaluated the framework. The paper at hand presents preliminary findings.

**Keywords**

Open innovation, knowledge management, big data, analytics, communities of practice, virtual communities, conceptual framework, design science research

**Introduction**

In today's fast-paced world the establishment of new technologies in society is a major challenge for both, the private and the public sector. Especially with respect to global trends, such as digitization, the emergence of renewable energy or alternative driving technologies many citizens are skeptical due to manifold reasons. They feel not involved in the rapid technology development and the resulting social changes, because – among others - their expectations are not met. Furthermore, citizens lack specific domain knowledge about new technologies, which would allow them to draw a realistic picture of their impact on personal and social life. One approach to get rid of these resentments in society is to bring people and new technologies in touch to alleviate their anxieties and concerns. Thus, knowledge of the application areas and of the possibilities of a new technology can change their perception regarding costs, risks, and benefits sustainably (Huijts et al. 2012). In addition, citizens’ needs and requirements should be considered in the development process of products and services, which are based on the new technology. In order to involve people directly in the shaping of new technologies and evolving service ecosystems around them, open innovation (OI) (Chesbrough 2003) provides a suitable opportunity to break barriers and to degrade skepticism with respect to the new technology.
Since the advent of Web 2.0 online platforms have increasingly been established for a variety of purposes. The platforms or applications can be used by people who are interested in specific domains for discussion, sharing knowledge, and learning (Dubé et al. 2005). They provide the technological basis for the genesis of virtual communities. Such communities allow to connect people who want to create and share knowledge and participate in the development of new products and services related to an emerging technology. We argue that this kind of virtual communities could be captured by virtual communities of practice (VCOP) (Lave and Wenger 1991). The specific characteristics of communities of practice (COP) are in particular suitable to convey knowledge of experts and practitioners in the field of new technologies to newcomers within the community. Furthermore, the collaborative and interactive character of a COP, especially the combination of competencies and knowledge of different participants results in a high innovation potential within the community. We argue that this climate of innovation can excellently be used as a breeding ground for the development of new products and services around the technology, in particular by means of an OI approach. In addition, the creation of knowledge can be managed efficiently within such communities.

In this paper, we develop a conceptual framework providing recommendations for the design of an online platform which combines OI and knowledge management (KM) in a VCOP and which ensures a mutual enrichment of these two components. The opportunity to create and share knowledge and expertise with other members fosters OI within the community. In addition, the outcome of OI can contribute to the knowledge base. In order to achieve this mutual improvement we use modern analytical methods - not only for monitoring the OI and KM processes. Moreover, we can generate deeper insights by analyzing the behavior and the activities of the community members across both components. Based on these considerations, our research questions are as follows: How a platform for VCOPs combining OI and KM components, can be designed? How can analytics foster the innovation and knowledge ecosystem in a VCOP? The remainder of the paper is organized as follows: We give an overview about the foundations and the state of the art in the relevant research areas (KM and innovation, COP, and analytics). Afterwards, we explain our methodological approach and the research design. Next, we develop the conceptual framework, before we introduce a multi-year research project, which we use to evaluate our framework. Hereinafter, we provide a discussion about our findings before we end with a conclusion.

Foundations

Following, we provide an overview of the foundations and the state of the art of the research streams relevant for answering our research questions, i.e. the “components” KM, (open) innovation, (virtual) communities of practice, and analytics and component combinations that we focus on.

Knowledge Management and Innovation

Knowledge as a resource for R&D has gained growing importance in literature and has been addressed in many different research streams, in particular in innovation literature and organizational learning theory (cf. Dahlander and Gann 2010). For instance, Cohen and Levinthal (1990) introduce absorptive capacity and argue, that the ability of an organization to integrate and use external knowledge has impact on their innovative capability. The paradigm shift from a product-centered towards a service-oriented view causes, that knowledge takes a central role for innovation and competition. Especially tactic knowledge represents a rich source for collaborative innovation (Leonard and Sensiper 1998). In this context, innovation can be understood as creating new knowledge by the recombination of existing knowledge in a novel way (Madhavan and Grover 1998). Since innovation processes have become open (Chesbrough 2003) and users can participate in the development of new products and services (von Hippel 1986), organizations receive amounts of stakeholder knowledge. In order to make this knowledge usable there is a need for the systematic management of knowledge creation and distribution. Lichtenthaler and Lichtenthaler (2009) also highlight the importance of the organizational capability to manage exploration, retention, and exploitation of internal and external knowledge for innovation processes. In summary, KM plays a key role for successful innovation processes (Plessis 2007). The other way around, innovation processes can also foster knowledge creation and management. Chesbrough and Appleyard (2007) argue that the results of innovation processes consist of new knowledge again contributing to the knowledge base. This knowledge can be reused in other contexts and by other individuals. Thus, the knowledge endowment of the organization, but also of the interacting individuals increases by participation in the innovation process. In a nutshell, literature suggests a mutual relationship between
KM and innovation, as on the one hand, knowledge is the basis of every innovative effort and on the other hand innovation contributes to expand the knowledge base and provides new solutions for organizations as well as for individuals.

Communities of Practice

The concept of COPs has its origins in anthropological studies of Lave and Wenger (1991) about the learning behavior in groups. A COP can be defined as a “group of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (Wenger and Trayner-Wenger 2015, p.1). In addition, a COP exhibits the following characteristics (Wenger et al. 2002): First, a COP is defined by a shared domain of interest, which gives them a joint identity. The members are connected by their commitment to the domain. Second, members are engaged in joint activities and discussions to share knowledge, discuss ideas, and help each other. They build relationships, show mutual engagement and face a joint challenge. Third, COPs are more than mere communities of interest, rather their members are practitioners in terms of developing a shared repertoire of resources that consists of experiences, stories, tools, and methods for problem solving (Wenger et al. 2002). These practices represent the joint learning processes, the cooperation, and identity within the community. Since the origins of COPs are in organizational learning research, many studies deal with KM within organizations and interpret the term COP in different ways for their work (for a comprehensive review cf. Bolisani and Scarso 2014). Otherwise, COPs are also frequently described as a source of creativity and innovation within literature (cf. Amin and Roberts 2008; Hislop 2003). In contrast to “traditional” offline COPs, member interaction and communication take place in VOPs primarily through computer-mediated communication (Agterberg 2014), in this case via the internet.

Analytics domains

Chen et al. (2012) have introduced a meanwhile accepted and established analytics research framework in which they distinguish into five technical sub-domains. The first sub-domain is referred to as big data analytics. A well-known definition for big data, proposed by Gartner research institute (Laney 2001), includes the “three Vs” (Volume, Velocity, and Variety). The sub-domain encompasses a variety of research areas dealing with different kinds of (structured) data and with a broad range of advanced analytical techniques (Chen et al. 2012) requiring high computing power. Text analytics as another sub-domain is targeting the analysis of unstructured text data. The third sub-domain, web analytics has gained growing relevance with the emergence of web applications as services and of cloud computing and cloud services (Chen et al. 2012). Network analytics also has gained attention with the increasing importance of social media, communities, and social networks. It supports the identification of relationships and network characteristics between different entities. Finally, mobile analytics as a sub-domain can be described as the measurement and analysis of data generated by mobile platforms and environments (Chen et al. 2012). While this categorization has rather been driven by the underlying data types, a differentiation according to the domain for which analytics is conducted, is also common. In the context of our research the following domains (and analytics) are relevant:

Community Management and Analytics: Monitoring and controlling online communities by means of analytics is widely discussed in literature (cf. Matthews et al. 2013). Quantitative and qualitative measures have been established to capture the success of online communities. The number of community members, their participation (in terms of visits, logins, retention times, etc.) and the volume of their messages and posts serve as indicators for community success. Also, the degree of communal spirit and relationship between the members and their satisfaction with the community are important (Iriberri and Leroy 2009). Therefore, community analytics is related to activities, to the participation and the evaluation of social relationships and interactions within virtual communities. Descriptive indicators for the community platform, such as access frequency, retention time, and referrers can be detected by means of web analytics tools (Phippen 2004). Furthermore community analytics builds upon methods of social network analysis in order to identify lead users and to analyze the development and composition of virtual communities (Borgatti et al. 2009).

Innovation Management and Analytics: Using analytics in order to support (open) innovation management encompasses several aspects. On the one hand, previous research has focused on monitoring and analyzing innovation processes. For example, an overview of the innovation management
measurement areas can be found in Adams et al. (2006). On the other hand, with the advent of big data and the aforementioned analytics categories, such as text mining, web mining, and social network analytics, analytics is also used within innovation processes to gain insights that support for example the ideation stage. A related research stream which is not in our focus, investigates the so-called data driven business model innovation, i.e. the systematic development of new business models and use cases based on (big) data and corresponding analytics techniques. For an overview we refer to Hartmann et al. (2014).

Knowledge Management and Analytics: The high relevance of knowledge in society has fostered the use of methods for measuring its value for and its impact on organizations (Bose 2004). In particular the application of data/text mining methods for identifying knowledge in large amounts of unstructured data is a valuable source for KM (King 2009). With respect to KM in communities literature also suggests the application of social network analytics in terms of understanding the flow of knowledge between different participants and foster knowledge creation within the community (Cross et al. 2006). Other relevant approaches related to this area are represented by the research on learning analytics and educational data mining (Siemens and Baker 2012). These approaches use data intensive analytical methods for evaluating personal learning environments and aim at improving learning processes in order to investigate the behavior of learners. In this context also data mining methods are applied for identifying patterns in large amounts of learning data (Romero et al. 2009). In addition, social network analytics examines relationships between learners or learning content (Cambridge and Perez-Lopez 2012).

Research Methodology

The increasing need for the integration of OI and KM by analytics has been elaborated in the introduction. Aiming at developing a conceptual framework for this integration we followed the design science research (DSR) process as introduced by Peffers et al. (2007). DSR is in particular suitable for our problem as it specifically addresses the construction of socio-technical models for the IS domain (Gregor and Hevner 2013). It enables us to formalize the conceptualization of the framework. The DSR process consists of the stages (i) problem identification and motivation, (ii) objectives of the solution, (iii) design and development, (iv) demonstration, (v) evaluation, and (vi) communication. Stages (i) and (ii) have already been addressed in the Introduction. We design a conceptual framework for the analytics-driven integration of OI and KM in a VCOP as an artifact in the following section. For this purpose, we develop a conceptual data model to describe and to integrate the domains of OI and KM. Furthermore, we examine how analytics could foster this interaction by presenting sample use cases (iii and iv). To demonstrate and evaluate the resulting artifact (iv and v), we have implemented a pilot in a multi-year research project.

Conceptual Framework for the Integration of Open Innovation and Knowledge Management

According to our research questions we investigate the analytics-driven integration of OI and KM in the context of a VCOP. Figure 1 gives an overview of the resulting main components in the conceptual framework. The community management (CM) component encompasses all activities and functionalities that are needed to maintain the VCOP platform and to acquire or retain community members.

![Figure 1. Conceptual Framework for the VCOP](image)

The interaction between the OI, KM, and CM components could be specified in detail by their main processes and a systematic derivation of how other components are accessed or integrated within the process stages. For example, during the ideation stage (within the OI process) knowledge modules of the
KM component might be accessed in order to better understand the context of an innovation challenge and to get familiar with legal or technical constraints that should be considered when developing new ideas. However, the direct interaction between the components is not in the focus of the paper at hand, therefore it is not further elaborated here. We focus on how the analytics component can support the OI, KM, and CM components. The analytics component acts as a “data hub” that collects data from these components. Its main purpose is to monitor the platform activities and events, to analyze these activities, and to support the platform components by providing analysis results. The analysis results might also be of overall (“external”) benefit, for example if they allow insights in interests, preferences, opinions, behavior, etc. of the VCOP members with regard to the domain that is in the focus of the community.

In the following, we specify the role of the analytics component by means of a conceptual data model that integrates all data that is provided by the OI, KM, and CM components. Before presenting the data model in detail, we give a short overview which data the analytics component receives.

- **Open Innovation → Analytics:** According to the four major stages in open innovation processes (ideation, development, assessment, implementation) the following data should be captured in the OI component and forwarded to the analytics component:
  - OI users and their activities (captured by events)
  - OI content in terms of user contribution (ideas)
  - OI ratings (user rate and comment the ideas of other OI participants)

- **Knowledge Management → Analytics:** Also in the context of KM an established process model can be used to identify the data categories which should be forwarded to the analytics component:
  - KM contributors/users and their activities (captured by events)
  - KM content in terms of knowledge modules
  - If available: ratings (users rate and comment the knowledge modules)
  - Usage patterns (order, duration of usage, etc.)

- **Community Management → Analytics:** Depending on the concrete realization and the functionality that is offered by the VCOP, further data should be provided to the analytics component:
  - Community members and their activities
  - User-generated content (e.g., in blogs, forums)

**Conceptual Data Model**

The data flows are integrated in a conceptual data model in UML2 notation which is depicted in Figure 2.

![Figure 2. Conceptual Data Model of the Analytics Component](image-url)
The abstract class Activity captures all activities on the platform. Its abstract subclass ArtifactActivity encompasses all activities that relate to the abstract class Artifact which is the superclass of those artifacts that can be created/read/updated/deleted/liked on the platform. Objects of the class Comment can refer to all Artifacts including to (other) comments. Assuming that OI is realized by idea contests with various challenges within the community we represent the OI component by the classes IdeaChallenge and Idea.

According to the nature of a conceptual (data) model it can be extended or modified in specific situations, for example by including further OI, KM, and CM activities, distinguishing additional roles of community members, or by replacing the like activity by a more detailed rating schema (e.g., a star rating schema). Also, the classes include only the basic attributes; in concrete VCOPs, the classes will probably exhibit various attributes. In order to enable such extensions we introduced the abstract classes Artifact, ArtifactActivity, Activity, and Role. Furthermore, the subclasses of the abstract class Artifact are modeled as black boxes in order to capture the various options for modeling these subclasses in detail resulting in different attributes or methods.

Capturing and storing data over the time allows a broad range of analysis and of use cases. Following, we list sample potential use cases that are based on this data and that the components (depicted by OI, KM, CM) can benefit from. We also add some examples how external stakeholders (ES) can use the analysis results, too. The options become even more if external data (such as social media data) will also be used in the analytics component. For clarity we have not included such external data sources in the data model.

- OI: Identification of lead users (most active users, users with good ratings, etc.)
- OI: Preparation of OI challenges by text mining and social media analytics (assessing opinions, user needs, etc. on the platform or in social media for certain products, services, or design challenges)
- KM: Identification of knowledge gaps (by monitoring social media and/or the community content)
- KM: Connecting innovation challenges with knowledge modules and vice versa (based on historical data and/or correlations in usage of both elements)
- CM: Control and management of the platform (efficiency of member recruitment activities, measurement of activity levels, etc.)
- CM: Optimization of the design of the platform (e.g., by analyzing clickstream patterns between the OI and KM component)
- ES: Insights about the behavior of community members in the VCOP domain (not their community activities are in focus, but their domain-related behavior)
- ES: Insights about the opinion of community members with regard to questions, products, services, etc. in the VCOP domain; these opinions might change over time

The conceptual framework can be stepwise refined by a systematic derivation of metrics and use cases, both based on the data that the analytical component receives from the OI, KM, and CM components. In the following section, we evaluate and demonstrate the applicability of the conceptual framework in a multi-year research project with industry partners and for a concrete domain (electromobility).

**Implementation & Evaluation of a Pilot Project**

**The Research Project CODIFeY**

The German Federal Government has launched a campaign to put 1 million electric vehicles on German roads by the year of 2020. Although being fascinated by the technology and recognizing ecological advantages, people often experience great challenges with respect to their own mobility habits. They do not only doubt about the capacity of electric cars for daily use, they also face insufficient solutions and services as well as lacking experiences. Thus, the interdisciplinary multi-year research project “CODIFeY - Community based service innovation for e-mobility” among three research institutions and three industrial partners (plus several e-mobility associations) aims at significantly increasing the number of users and the long-term acceptance of electromobility (e-mobility) in society by inducing behavioral changes of individuals. Integrating potential users in the development of new services and solutions in the context of e-mobility is considered to be the key to foster user acceptance and attracting them as
convincing proponents of this promising technology. To achieve this goal, the innovative online community platform eMobilisten (www.emobilisten.de) has been established in 2014 and since then new members have been continuously acquired. The platform integrates the following three main components (cf. Figure 3):

**Figure 3. The CODIFeY Approach**

The component *knowledge creation* reduces the lack of knowledge in the society in order to reduce barriers and obstacles related to e-mobility. Within the *service innovation* component new sustainable e-mobility solutions with a focus on needs and desires of the users are co-created. Finally, *community analytics* monitors and evaluates the behavior of e-mobility actors, as well as it fosters the interaction between knowledge creation and service innovation.

Community members act as co-creators for service innovation and contribute to the knowledge base. They collaborate among each other and with various stakeholder groups in order to develop smart solutions for e-mobility. Continuous analytics allows to observe and analyze the activities and behavioral patterns of the community members. In doing so, knowledge deficiencies are identified and innovation challenges regarding e-mobility can be addressed. Whereas the CODIFeY project enables the academic project partners to address current research challenges in the field of interactive value creation, the industry partners receive new business opportunities in an economically and ecologically highly relevant domain. Besides learning about actual market needs, the CODIFeY project allows these organizations to integrate user competencies and feedback in all stages of the innovation process, independent of spatial and temporal barriers. Figure 4 presents the system architecture of the eMobilisten platform.
The platform consists of two commercial software solutions, IdeaNet for OI and KnowledgeWorker for KM. IdeaNet represents the leading component for user registration and authentication. Both components are connected via single sign-on using an OpenID Connect server for authentication (http://openid.net/connect/). The OI component maintains idea challenges dealing with specific questions concerning service innovation for e-mobility as well as ideas and comments posted by the community members. Furthermore, members can ask questions and share their knowledge and experience via a Q&A forum. Therefore, no dedicated community management component has been integrated in the platform, as the OI component also provides community management functionalities. KnowledgeWorker maintains knowledge modules which can be assembled to comprehensive knowledge courses for e-mobility. The analytics component gathers platform data via three separate interfaces. First, the proprietary API to IdeaNet provides data in form of csv-files. Second, the analytics component monitors platform activities by means of web analytics (the open-source software PIWIK). In both cases, the data is stored in a relational database management system (RDBMS). Third, the analytics components receives data from KnowledgeWorker via ExperienceAPI (xAPI), a specification for data exchange in e-learning environments. This learning data is stored in a learning record store (LRS).

**Evaluation and Preliminary Findings**

The CODiFeY project has demonstrated the applicability and benefits of our research approach. Since 2014 several OI challenges have been set up on the eMobilisten platform and knowledge modules for various e-mobility topics have been created. The platform provides a seamless and transparent integration of the OI and the KM components which is frequently used by the community members. First results have shown that the systematic creation and deployment of knowledge can support the innovation process within the VCOP. Some service innovation challenges were of a very complex nature and required extensive background information exceeding pure domain knowledge about e-mobility. In one concrete case, the challenge addressed the development of a sustainability label for e-mobility. By providing knowledge modules about existing sustainability labels in other domains the community members could better understand the requirements for such labels. The other way around, the creation of user-generated knowledge modules was supported by applying open innovation methods. Through a specific innovation challenge for knowledge creation on the platform, users could be motivated to create knowledge modules concerning e-mobility and to share them within the community. Afterwards these modules could be rated and commented on by the community in order to improve them and to honor the most innovative and insightful posts.
The analytics component and the underlying conceptual data model have been realized in a very similar manner as our conceptual framework suggests. Since 2014 data has been continuously extracted from the OI and KM components and the analytics results have been provided to the project partners who maintain the OI and KM components. The analyses cover many of the use cases as suggested in our conceptual framework. In addition, the data and the analytics results are used by the academic partners for further research about behavior patterns, acceptance, etc. of e-mobility actors.

One major finding so far has been that the success of the platform and therefore of our research approach depends on the number and activity level of the community members. Therefore, many efforts have been invested in the CODIFeY project to acquire new members and to encourage them to actively participate in the community. The more members and the more activities can be analyzed, the more insightful and reliable are the results.

Conclusions

Our approach to integrate OI and KM in a VCOP by means of analytics seems to achieve the benefits and synergy effects as assumed before. It can provide added value for both, for economy and for society. From a societal perspective, our approach can help to establish new technologies and to gain insights about the needs, fears, and problems of the citizens regarding emerging technologies. This is achieved on the one hand by the development of a knowledge base and the resulting reduction of uncertainty and misinformation, on the other hand by designing an ecosystem of products and services around the new technology by OI activities. The mutual benefits of both components can be increased by an additional analytics component. Organizations might adapt our approach by establishing internal VCOP alike settings allowing them to receive added value from the mutual enrichment of innovation and KM. Analytics will help them to better understand the processes of knowledge creation and innovation and to extract valuable information about the behavior and needs of the VCOP members. Finally, also the individual VCOP members benefit from the approach as they acquire knowledge, communicate with other members, and make their life with the new technology more convenient. Future research should examine the relationship between the individual components in more detail in order to exploit the mutual enrichment within the VCOP.

REFERENCES


