Boundary Objects as Part of Knowledge Integration for Networked Innovation

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Sari Mäenpää, Anu Helena Suominen, and Rainer Breite

> *"All knowledge is connected to all other knowledge. The fun is in making the connections."*
>
> Arthur Aufderheide (1922–2013)
> Paleopathologist

Networked innovation in co-creation networks is not possible without collaborative practices. Especially in complex projects, contextual knowledge is often spread among different stakeholders. To harness this dispersed knowledge for networked innovation, working knowledge management and collaborative practices are needed. This article addresses this need for better understanding and approaches to facilitate knowledge integration for networked innovation. We consider knowledge integration as the ability to put knowledge into action, and networked innovation as the co-created goal-driven output of selected partners. Our study focuses on describing and reporting a cross-learning type of expert knowledge-integration process with boundary objects, concrete or abstract "bridges" for overcoming possible knowledge boundaries, in a co-creation network. This article adds knowledge on networked innovation through knowledge integration with boundary objects. The reported process will help managers to systematically approach problems requiring expert knowledge that does not exist within their own organization and to better integrate knowledge required for innovation within their project networks.

Introduction

When problems arise in a project, particularly in an industrial R&D project, they can quickly become quite complex due to the number of participating actors, changing situations and demands, insufficient know-how, and a requirement for prompt knowledge sharing in the face of global competition. Solving complex problems often demands new solutions through innovation. The expert knowledge of individuals is an essential component of organizational innovation (Amabile, 1998); yet, expert knowledge can be dispersed within an organization, and sometimes lies beyond the organization's boundaries. In complex cases, the needed knowledge can be a combination of tacit, personalized expert knowledge that is spread across multiple stakeholders. Tacit knowledge, which is personal, context-specific, and hard to formalize, cannot be transferred but must be shared in social interaction (Nonaka, 1995). Therefore, to yield networked innovations that are goal oriented, brought about in a process open to selected participants in co-creation from tacit knowledge, knowledge management processes must be in place to support knowledge sharing (Valkokari et al., 2012). Such knowledge management processes encompass, for example, knowledge integration (Lee & Yang, 2000). In practice, knowledge integration (Grant, 1996) is an ability to put knowledge into action; therefore, active doing is an imperative part of the process (Tiwari, 2015). In the literature, knowledge integration is approached by either relying on structural mechanisms or enabling cross-learning that emphasizes frequent communication and extensive mechanisms based on knowledge sharing (Enberg, 2012). Our view is based on the latter, because knowledge integration through cross-learning aims at integrating knowledge that resides in individuals (Enberg, 2012) by bringing people together to share knowledge in co-creation. In other words, the cross-learning type of knowledge integration as a knowledge management process constitutes a platform for learning and knowledge sharing.

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We found innovation process studies showing that a diverse set of stakeholders are scarcely collaborating simultaneously (Kazadi et al., 2015). Yet, according to West and Bogers (2014), co-creation has been studied in an open innovation context to some extent. However, Valkokari and colleagues (2012) state that knowledge co-creation between firms and the knowledge owner's motivation to share knowledge are more narrowly studied subjects. In their model of networked innovation, which includes transaction networks and co-creation networks, they point out that knowledge management and collaboration practices should be different in those two network types. Particularly in co-creation networks, the collaboration is more exploratory and is aimed at creating new knowledge. However, they stress that the concept of networked innovation is not yet complete, having identified a research gap in terms of how networked innovation relates to the knowledge management and collaborative practices.

There is literature regarding knowledge integration (e.g., Baxter et al., 2013; Enberg, 2006, 2012; Mitchell, 2006; Tsai et al., 2015) and its three stages: knowledge identification, knowledge acquisition, and knowledge utilization. Tiwari's (2015) study revealed that knowledge coordination is also an important intermediate process of knowledge integration, especially in a multi-stakeholder environment, which presupposes collaboration. Furthermore, in an inter-organizational setting, besides common knowledge and understanding (Grant, 1986), knowledge integration requires overcoming organizational boundaries (Carlile, 2004). This boundary spanning can be done with the help of concrete (Star & Griesemer, 1989; Star, 2010) boundary objects, such as maps, repositories, and standardized forms, and metaphorical (Koskinen, 2005) boundary objects, such as figures of speech. Tiwari's (2015) model of knowledge integration, including the three stages of knowledge integration together with coordination and collaboration as intermediate processes, was empirically studied in one transaction type of network. Therefore, the model's applicability to co-creation networks should also be studied, including the role of boundary objects as potential boundary-spanning elements.

Our study examines the knowledge management process of networked innovation in a co-creation network in an R&D-project context. The focus is on the cross-learning type of knowledge integration process and the role of boundary objects in spanning the boundaries between organizations. This article describes the knowledge integration process, its outcomes, and feedback from the case process. Tiwari's (2015) knowledge integration process model is used as a theoretical basis for the case of networked innovation efforts. The process aims to enhance communication, knowledge sharing of versatile expertise, and collaboration demanding endeavours by identifying and utilizing various boundary spanning objects and activities. Therefore, the article also presents the various boundary objects applied in the knowledge integration process, and discusses their usability from the viewpoints of different stakeholders, such as internal and external experts, suppliers, and customers.

Our study features two research questions:

1. *Given that collaboration and knowledge management practices in co-creation networks yielding networked innovation should be different from transaction networks, is the Tiwari's knowledge integration model applicable also for co-creation networks?*

2. *What kind of boundary objects can enhance communication and knowledge sharing in a knowledge integration process in co-creation networks yielding networked innovation?*

Our case of the knowledge integration process was carried out in the context of a temporary R&D and innovation project in an industrial organization's network. A co-creative process was put into practice with multiple inter-organizational stakeholders and facilitated by external facilitators (university researchers).

The article is structured as follows. In this introduction, we have justified the need to further test Tiwari's knowledge integration process as a knowledge management process for networked innovation in co-creation networks. Next, we discuss the literature regarding knowledge, knowledge integration based on communication, and knowledge sharing together with networked innovation and boundary objects. The method and case description follow the use of single empirical case study (Dyer et al., 1991; Siggelkow, 2007; Weick, 2007) applied in a networked innovation context. Next, we describe the results by portraying the knowledge integration process with boundary objects together with the stakeholder feedback and the networked innovation outcomes. Finally, we contemplate the usability of the further developed knowledge integration process and conclude with some practical and managerial implications.

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Knowledge, Innovation, and Knowledge Integration

Knowledge

Polanyi (1966) identified two distinct types of knowledge – explicit and tacit – which interact in individuals (Nonaka, 1995). Explicit knowledge can be codified, and is thus transmittable in formal, systematic language, whereas tacit knowledge is personal and context-specific, and is thus hard to formalize and communicate (Nonaka, 1995). Therefore, there are also different knowledge management strategies for organizations: i) codification for explicit knowledge, which links people to documents and ii) personalization for tacit knowledge, which links people to people (Hansen et al., 1999).

Another relevant characteristic of knowledge is its mobility. Knowledge mobility is the "ease with which knowledge is shared, acquired, and deployed within the network" (Dhanaraj & Parkhe, 2006). In other words, knowledge moves whether being transferred (Szulanski, 1996) or shared (Nonaka, 1995).

Networked innovation

Innovation is a process that encompasses the transformation of valuable ideas "into new forms of added value for the organization, customers, employees and stakeholders" (Merx-Chermin & Nijhof, 2005), or invention into action within the organization (Martins & Terblanche, 2003). Our view on innovation is based on its process-type characteristic of transformation. Organizational innovation is intertwined with the creativity of individuals in organizations (Amabile, 1997). Besides motivation and creative thinking skills, one of the three components of human creativity is expertise, which includes technical, procedural, and intellectual knowledge. Here, we concentrate on the form of expertise that manifests as expert knowledge.

Organizational innovation requires combining different types expertise (Amabile, 1998), but innovation sometimes requires organizations to cross organizational borders to gain access to ideas (Amabile et al., 1996) and knowledge (Enberg, 2012). Depending on the willingness and opportunities for spanning organizational boundaries, innovations can be either closed, open (Chesbrough, 2004), or networked (Valkokari et al., 2012). In networked innovation, interdependent but independent network actors co-produce the innovation outcome (Valkokari et al., 2012). "Networked innovation occurs through relationships that are negotiated in an ongoing communicative process, and which relies on neither market nor hierarchical mechanisms of control" (Swan & Scarbrough, 2005). According to Valkokari and colleagues (2012), networked innovation has three collaboration characteristics: i) it includes multiple actors and is seldom open to everyone, ii) it happens always for a specific purpose, and iii) the models deal with both the knowledge transfer and co-creation functions between actors. Depending on their knowledge management needs, there are two types of networks focusing on transaction of explicit knowledge (i.e., transaction networks) or co-creation of new knowledge (i.e., co-creation networks). Our view concentrates on networked innovation in co-creation networks, which means that the network process is open to selected participants, has a specific aim (for new knowledge), and is focused on co-creation between actors. Even though a lot of research on co-creation exists, few studies cover the diverse set of stakeholders collaborating simultaneously in the innovation process (Kazadi et al., 2015).

Knowledge management processes for innovation: knowledge integration

Innovation networks are described as loosely coupled systems of autonomous firms (Dhanaraj & Parkhe, 2006) with properties of sparseness, asymmetry, and locally clustered with low diameter (Cowan & Jonard, 2009). However, "project business is the part of business that relates directly or indirectly to projects, with a purpose to achieve objectives of a firm or several firms." (Artto & Wikström, 2005) Those firms form a project network, which is a network "including several firms and other organizations from different businesses and from different institutional environments that are participating in a project" (Artto & Kujala, 2008). Project networks have a temporary nature: "they exist in that specific form only during the time-line of a single project" (Artto et al., 2008). Thereby, similarly to networked innovation, project networks have various organizations cooperating, none of which have a completely dominating role and an aspiration toward precise and specified objectives; however, project networks are distinctively temporal in nature (Tiwari, 2015). Therefore, rather than using the term "innovation network", we use the term "project network" because we want to emphasize the task-specific combination of organizations, the goal orientation, and the temporal nature.

When project networks produce innovations, they need various knowledge management processes, such as knowledge integration, as introduced by Grant (1996). Enberg (2012) defines knowledge integration as a "goal-oriented process with the purpose of taking advantage

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of knowledge complementarities which exist between individuals with differentiated knowledge bases" (Enberg, 2012). Knowledge integration is needed when knowledge is specialized and dispersed among individuals. Knowledge integration can be enabled by the use of different integration mechanisms. In the knowledge integration literature, there are two main approaches. One relies on structural mechanisms and downplays the need for communication and knowledge sharing. The other, the cross-learning approach, emphasizes the need for knowledge integration mechanisms that are based on frequent communication and extensive knowledge sharing (Enberg, 2012). Our view is based on the latter approach: cross-learning.

According to Tiwari (2015), past studies have revealed that knowledge integration in project networks basically includes a three-stage process of knowledge identification, knowledge acquisition, and knowledge utilization, which all should be seamlessly and efficiently integrated in order for a project network to successfully achieve its goals in a dynamic environment. Tiwari (2015) has based her framework on those three stages (Figure 1). The emphasis on knowledge integration in a project network is in the ongoing collective process facilitated by social engagements. That is, knowledge integration is the ability to "transform knowledge into action" (Tiwari, 2015). Thus, Tiwari also emphasizes the significance of coordination and collaboration, because in some cases, for example where the required expert knowledge (for complex problem solving) resides within multiple professionals, plain knowledge acquisition is neither sensible nor adequate.

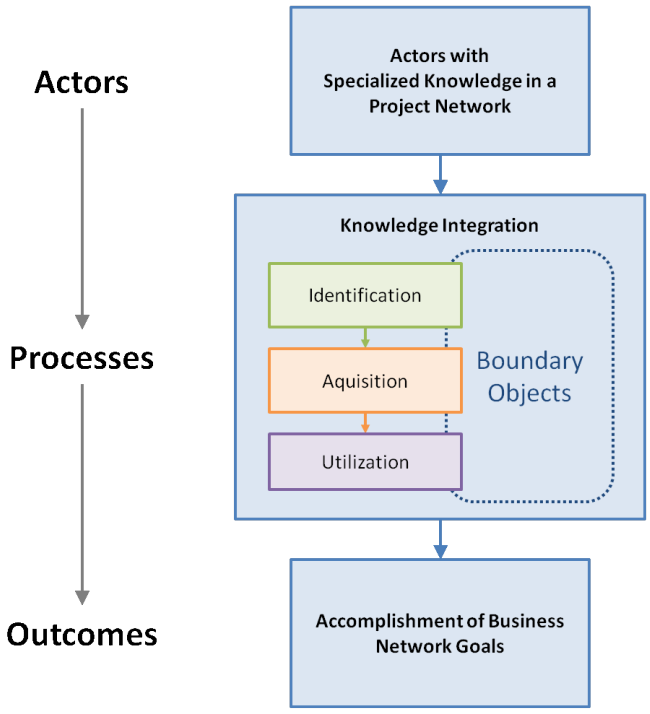

Figure 1. Knowledge integration in a project network (adapted from Tiwari, 2015)

Inter-organizational knowledge integration requires common knowledge and understanding (Grant, 1986), therefore it also requires overcoming the possible knowledge boundaries between organizations (Carlile, 2004). To overcome these knowledge boundaries, boundary objects are needed and should be taken into account when designing processes for knowledge integration. Boundary objects are "a sort of arrangement that allow different groups to work together without consensus" and are the "stuff of action" (Star, 2010). In other words, boundary objects aid the collaboration of various experts by letting them communicate and work on a target that is not yet mutually perceived. Besides being concrete, boundary objects may also be metaphorical and intangible, such as figures of speech or renaming a concrete phenomenon in an illustrating manner, yet even so can play a significant role, especially in the sharing of tacit knowledge and understanding between people (Koskinen, 2005).

Tiwari has framed her model and empirically tested it in a large project network with a "transaction network" type of explicit knowledge transfer. Although our focus is on co-creation networks, the general nature of Tiwari's model allows us to use it as our theoretical framework and then expand it with the use of boundary-spanning elements (boundary objects).

Method and Case Description

We chose a case study approach (Dyer et al., 1991; Siggelkow, 2007; Weick, 2007) to further develop and test the knowledge integration process for networked innovation in project networks. First, we examined the literature on networked innovation theory, knowledge management processes (including knowledge integration based on communication and knowledge sharing) and boundary objects. Then, we selected a networked innovation project as the case study. The particular project (described below) was chosen because of its idiosyncrasy: it involved multiple stakeholders collaborating simultaneously, which is rare in research on innovation processes (cf. Kazadi et al., 2015). Therefore, having participants from multiple corporations concurrently yielding a real-life networked innovation with significant impacts on the whole network gives unique

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information about knowledge integration for networked innovation. Thus, the case is interesting from both academic and practical viewpoints.

Tiwari's model was tested by observing one focal company from a point early on in its quest for a solution to a major production-automation problem and the related subsequent series of workshops in its project network. Workshops as a setting for yielding networked innovations presume that learning will occur via active participation and involvement, because workshops have many benefits for interactive learning and teaching in small groups. Workshops typically also facilitate problem solving, decision making, communication skills, and "thinking on your feet" (Steinert, 2010). For studying knowledge integration, workshops provide the needed observable collaborative environment in which the same information in the same form (by utilizing the same boundary objects) is conveyed to all participants simultaneously, further allowing concurrent communication. Thus, workshops create opportunities for the creation of collective understanding.

The research material was gathered from multiple sources. The entire chain of events and workshops were observed by three researchers and recorded as memos. By using the memos, the process of the workshop series and its resemblance to Tiwari's model was detected.

Also, the networked innovation outcomes, as well as the boundary objects, were discovered by the researchers during the workshops. The information on the relevance of both the knowledge integration process and the discovered boundary objects were collected from the project network stakeholders through a "Webropol" online survey. The online survey included a questionnaire with 57 questions, 52 evaluations on the scale of 5 (completely agree) to 1 (completely disagree), and 5 open-ended questions regarding:

- the problem area, the workshops such as the amount of events and their scheduling, and the boundary objects
- cooperation with others and with other organizations in workshops and during the process
- gaining of new knowledge from the workshops, utilizing the gained new knowledge, and the effects and follow-up of the new knowledge

The link to the online survey was sent to all 26 different participants of various workshops. We received only 7 responses, however, they were from different stakeholders: two were from focal company representatives, two were from suppliers, and three were from research partners. The survey material was analyzed using spreadsheet computation. Both the data collection and analysis were carried out in both research material and researcher triangulation because three researchers participated in all of the workshops and material collection as well as in the analysis.

Case description

The concrete case of networked innovation was carried out in a multi-stakeholder project. The multi-stakeholder environment included a multi-national industrial production company as the focal company, its three suppliers, one customer, and university researchers from various fields. The focal company is a large global machinery producer, and the project involved the participation of one of its subsidiaries, a world-class machinery production unit, which produces products that are more unique than mass production pieces. The turnover of the subsidiary is 500 million euro, it employs 600 people, and it delivers maritime products worldwide: indeed, 99% of its products are exported. The customer involved in this case is a vast foreign shipyard with various operations. The technology supplier is family-owned industrial forerunner, with system deliveries to 50 countries, exporting90 % of its products with yearly turnover of 35 million euro, with 136 personnel. The two other suppliers were subcontractors that deliver large metal machinery pieces. One subcontractor was family-owned, employing over 100 people, with yearly turnover of 20 million euro. The other employs approximately 70 people, with turnover of 15 million euro. The university researchers were from two technical universities and included experts on manufacturing technologies, production processes, and industrial engineering. The facilitators were three researchers with industrial and knowledge management backgrounds.

The industry in which the focal company operates is quite conservative, thus the changes are slow, yet their change effects, including economic effects, are significant. The focal company was in need of expert knowledge regarding the implementation of automation in the production process, which they did not possess internally. Therefore, stakeholders were brought together to collaboratively innovate in a complex product and production process development project. The networked organization (i.e., the case company) contemplated a major manufacturing investment that would alter their production process, and early on they no-

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ticed that they did not have all the internal capabilities needed to come up with decisions required by the investment. In a process aiming to accomplish a functional solution for a production system, which later expanded to include new product solutions, the goal of the case was to integrate the various types of expert knowledge that would benefit not only the focal company but the entire network. The process involved various operations of the focal company (i.e., internal stakeholders, such as R&D, procurement, and production).The customers, the suppliers, the technology supplier, and the research institutes operated as external stakeholders (Figure 2).

The knowledge integration case aiming at networked innovation was carried out in a project of temporary R&D and innovation that concerned product and production process development within the network. In the project, a new production method was introduced to the focal company and its stakeholders. This new production method required both deployments of a new technology and changes to the product design, too. Consequently, the new product design had implications to the production processes of the suppliers. As neither the focal company nor its suppliers were familiar with the newly selected production technology, both product and production changes required acquiring new technical expertise, possibly from university researchers and technology suppliers. Thus, the chain of requirements led to a collaborative, co-creative development process with multiple stakeholders participating workshops and thus necessitating knowledge integration that rested on communication and knowledge sharing.

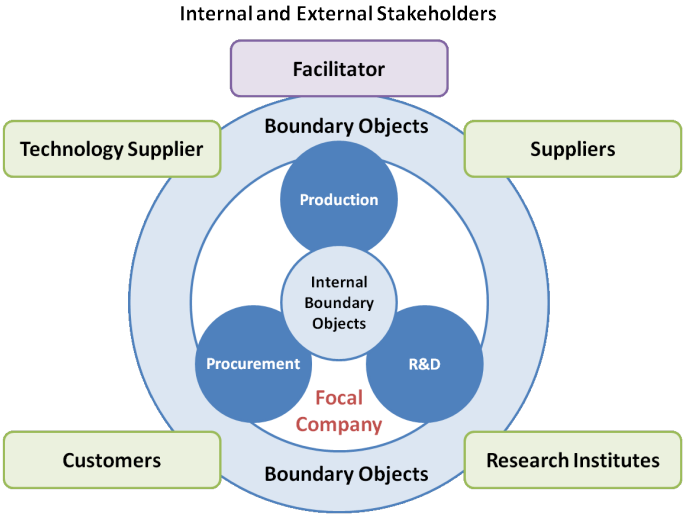

Figure 2. Case context: networked innovation carried out in a multi-stakeholder project with boundary objects

Results

Our results were generated from: i) the knowledge integration process in co-creation network with the used boundary objects and ii) the results of an online survey with respondents from the various stakeholder organizations of this co-creative process. The questionnaire within the survey dealt with the practical relevance of expert knowledge integration process as well as the six boundary objects and activities applied in the process. The results also cover the business network accomplishment of the knowledge integration process: the networked innovations.

The expert knowledge integration process with boundary objects

The knowledge integration process had three main phases, corresponding to Tiwari's (2015) model: knowledge identification, knowledge acquisition, and knowledge utilization. However, these three main phases could be broken down to a further eight stages when knowledge integration is carried out in co-creation network for networked innovation (Figure 3).

In the first part of the "knowledge identification" phase, the main problem was clarified in the focal company internally. Next, "coordinated knowledge identification" was carried out in collaboration with the focal company and the facilitator (the university researchers), aiming at locating the needed and available external know-how. Then, in the "coordinated knowledge acquisition" phase, the expert knowledge was coordinated by the facilitator by mapping and contacting the appropriate experts. The next five stages, ideation, innovation, analysis, conclusions, and proposals, and the actions of "knowledge utilization", included wider multi-stakeholder participation. In this final phase, there were three workshops:

1. *Ideation:* In the first workshop, a common mindset was created by open discussion with five focal company representatives and seven technical university experts with two presentations of the problem area. The plan for the further workshops and the topic to be covered was created.

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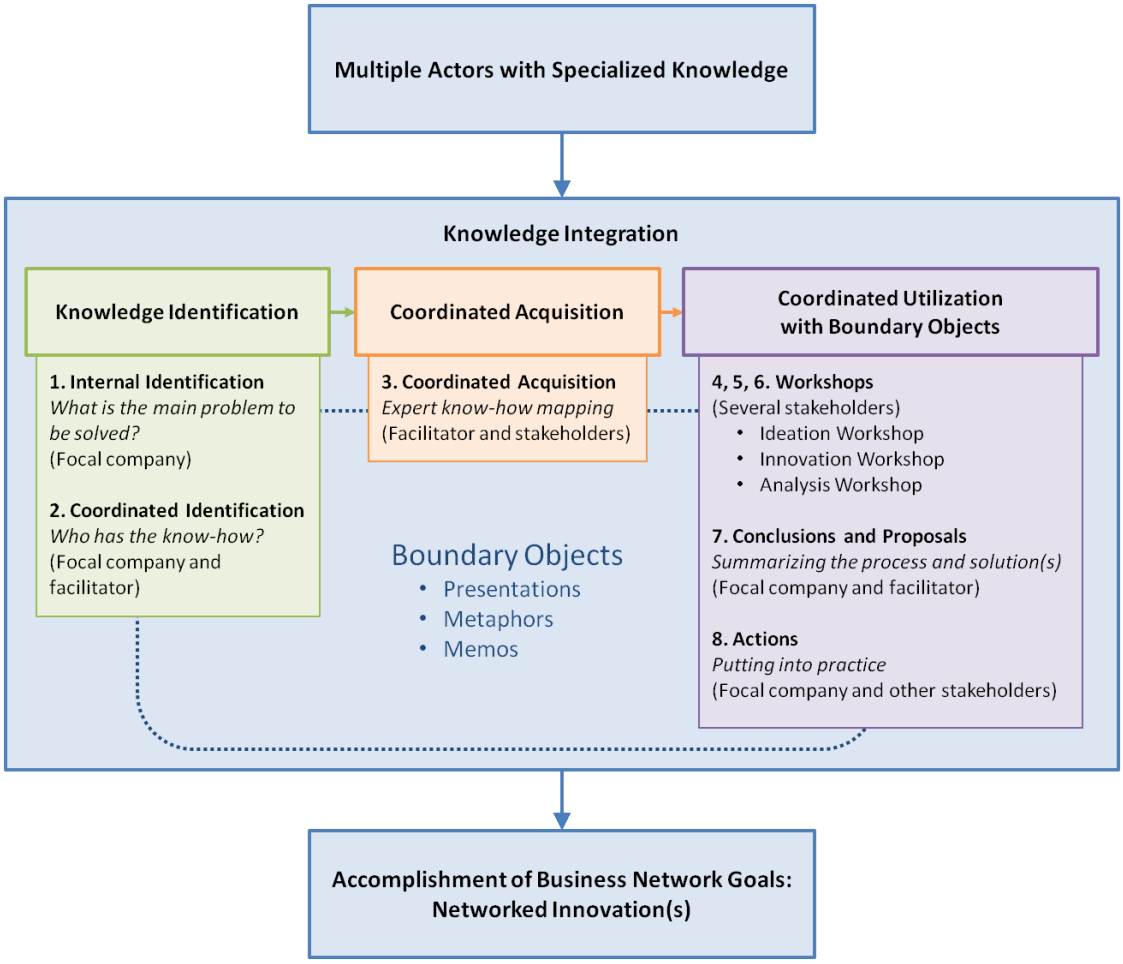

Figure 3. The knowledge integration process for networked innovation in a co-creation network

2. *Innovation:* In the second workshop, the focal requirements and objectives in relation to the problem at hand were discovered with the help of boundary objects of six expert presentations, two metaphors, and a memo prepared and distributed right after the workshop. Altogether 21 people participated in this workshop.

3. *Analysis:* The ideas were analyzed and sorted in the final workshop, by discussion again with the help of boundary objects of three supplier presentations, two metaphors, a factory tour, and a memo prepared and distributed right after the workshop. Altogether 17 people participated in this workshop.

After the workshops, the solutions, as well as the knowledge integration process, were summarized in close cooperation between the focal company and the facilitator. In the final stage, "actions", the created knowledge was put into practice: the solutions of the knowledge integration process were utilized, depending on each separate stakeholder.

Within the three multi-stakeholder workshops (ideation, innovation, and analysis) of "knowledge utilization", six boundary objects (four concrete and two metaphorical), were discovered and used. The concrete boundary objects included workshop memos, pictures and blueprints, presentations, and a factory tour (in the third workshop). The metaphorical boundary objects were "Metaphor 1", representing the new structure to be developed and "Metaphor 2", representing the former structure. In the co-creation network, where the aim was to produce networked innovation, the boundary objects were particularly useful in the knowledge utilization phase, where the knowledge is actually put to use. This finding supports Tiwari's (2015) perception of the emphasis on knowledge integration in a project

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network being the ongoing collective process through social engagements and knowledge integration being the ability to "transform knowledge into action".

Feedback: The practical relevance of the knowledge integration process and applied boundary objects

Feedback from the case process was gathered through an online survey. The questionnaire included questions about the number and duration of joint events, the ability of joint events and workshops to support and increase knowledge sharing, as well as impressions about cooperation with others during the process. According to the feedback, the number and duration of joint events were sufficient. The joint development events were found useful for creating new knowledge, sharing knowledge, and increasing openness between stakeholders. This kind of multi-stakeholder knowledge coordination and collaboration was also found to be a useful way of solving similar problems in the future. However, information given prior to the events as well as the collaboration between companies and universities, and between universities was evaluated lower than other aspects of the entire process: this information was found to be inadequate and did not help the participants to prepare for the meetings.

Feedback about the boundary objects used in the case process was also gathered through the online survey. All of the applied boundary objects were considered useful in terms of the overall evaluations. The boundary objects that were most helpful in clarifying the problem in the workshops were pictures and blueprints. Presentations were also deemed similarly helpful, but to a lesser extent. Additionally, the metaphorical boundary objects of "Metaphor 1" for the new structure and "Metaphor 2" for the former structure also helped clarify the problem. Memos from the three workshops and the factory tour were considered less effective boundary objects. However, due to the small sample size – only seven participants responded to the online survey – the differences were not statistically significant. But, the results suggest that providing or producing vivid illustrations of the problem to be solved would be helpful, especially if the problem is a technical one. Also, creating a metaphor or two of the problem or generated solution may advance the discussion and comprehension. From a process development viewpoint, the feedback on the process used in the case was very encouraging: participants at the focal company informed us that this networked innovation process may next be applied to other development projects within the company.

In summary, by applying various boundary spanning objects and activities, this knowledge integration process shows promise for enhancing communication and knowledge sharing of versatile expertise in endeavours demanding collaboration. The process is also potentially applicable to other types of networked innovation situations.

Networked innovation outcomes: The manifestation of the knowledge integration process in practice

In practice, the outcomes of the knowledge integration process take the form of networked innovation of new technical solutions and operating models. However, the process outcomes also emerge as new business opportunities. Table 1 presents the case customer company's objectives, the external stakeholders' contributions, and the corresponding outcomes of knowledge integration process.

As shown in Table 1, the main networked innovation outcomes (i.e., the main outcomes for the project network of the knowledge integration process) are:

- a new product structure to be produced using automation, resulting in cost savings with, for example, diminished production times and improved quality and relocation of component production to subcontractors
- new research tasks and business cases between suppliers as well as universities and suppliers
- awareness of a new method for integrating knowledge during multi-actor collaboration, which can be used in other cases as well

Noteworthy in the outcomes is that not only the focal company gained from the process but other organizations in its network too. Both suppliers and universities found new projects to collaborate on in the future.

To sum up the results, Tiwari's model, with its three major phases of knowledge identification, knowledge acquisition and knowledge utilization, was applied to the knowledge integration process for networked innovation in a co-creation network. However, the three knowledge integration phases were divided into eight smaller stages. For networked innovation in a co-creation network, when the emphasis is on communication and cross-learning requiring boundary spanning, the model does benefit from the use of boundary objects, especially in the knowledge utilization phase. The boundary objects applicable to enhancing communica-

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Table 1. Objectives, contribution, and outcomes of the knowledge integration process

Case Company's Objectives	**Outcome(s)**
More intensive supplier participation in customer's R&D activities	Supplier involvement in knowledge integration workshops – continuing in the future
Integration of R&D activities into manufacturing activities	More open internal discussion, opening up towards suppliers
Improved networking ability	New business cases between suppliers as well as between universities and suppliers
External Stakeholders' Contribution	**Outcome(s)**
Ideation based on specialist views	Common interest detected; focal company's main problem formulated
Value analysis and alternative technical decisions based on scenarios	New product structure stated
Forming a standard connection plan; ideation of cost-effective manufacturing decisions for suppliers	New product structure enabling cost savings (e.g., diminished production times and improved quality, requiring increased focus on assembly, shifting component production to subcontractors)
Research Unit's Contribution	**Outcome(s)**
Model/framework/way of acting for future co-operation	A new method: knowledge integration with multi-actor collaboration; can be used for cooperation in other cases as well

tion and knowledge sharing in co-creation networks yielding networked innovation were both concrete and metaphorical. Furthermore, providing or producing vivid illustrations of the technical problems at hand were found useful. Also, creating metaphors relating to the problem or generated solution advances the discussion and comprehension in the co-creation process. Additionally, the co-creative knowledge integration process yields multiple types of networked innovations, not only concrete solutions for products and production processes but also new links between stakeholders, thus creating opportunities for further collaboration in business and research.

Discussion and Conclusion

Theoretical contribution and limitations

This article contributes to the concept of networked innovation by highlighting the knowledge management processes involved. The contribution regards the expert knowledge integration in co-creation networks by enhancing Tiwari's knowledge integration model with boundary objects. The significance of the boundary objects is to enhance knowledge and organization boundary spanning within the knowledge integration among multiple stakeholders.

Although a co-creation network was a new environment for testing Tiwari's knowledge integration model, naturally this study does have its limitations. The empirical testing was carried out with a single case in a co-creation network; other networks and network types should be involved in future studies and in the further development of the process. Also, the online survey was completed by only seven people, which limits our scope for statistical analyses. Additionally, in this case, six boundary objects were discovered and used; however, other cases might bring forward other usable boundary objects to study.

We presume that the findings will benefit academics studying knowledge management practices, including knowledge integration, especially in the context of collaborative and networked innovation by highlighting the role of the boundary objects as the knowledge and organization boundary-spanning elements. Prior re-

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search has shown that the cross-learning type of knowledge integration provides a platform for learning and knowledge sharing. Our results emphasize that communication, which is essential in cross-learning type of knowledge integration, can be enhanced with boundary objects.

Practical and managerial implications
Practitioners operating in industrial settings, particularly in those relating to industrial product and production process development, who are aiming to enhance innovation operations by involving various stakeholders, may benefit from this study. In some cases, losing control of core capabilities or information might be the downside of open innovation, but in our case, the networked innovation process with knowledge integration in a project network worked and generated the desired results for the focal company and its stakeholders. This finding might encourage other innovation-requiring companies to open up their closed innovation system to other stakeholders, such as suppliers, customers, universities, and research institutes, while still keeping control over their company's confidential and core capabilities.

Additional information on the character of networked innovation showed that the co-creative knowledge integration process yielded another type of output beyond product and production process changes or enhancement: new links between stakeholders. Thus, it creates opportunities for further collaboration both in business and research. This knowledge might encourage other stakeholders to participate in networked innovation cases, where the direct gain for the company or research institute could be hard to anticipate in advance.

A real-life co-creation network case with substantial impacts on the whole network gives unique insights about knowledge integration for networked innovation. In practice, setting up networked innovation is easier when the companies and project networks have a mechanism that enables learning and collaboration: an environment or platform, such as a process or method, which guides them through a chain of events and brings the stakeholders together to share their knowledge, which in many cases is tacit. Therefore, this study gives general guidelines on how to kick off the networked innovation. Yet, the process is flexible and can be adjusted to the problem and network at hand.

Further research
Networked innovation as a concept and its knowledge management processes need further research; our approach to knowledge integration is just one of many potential approaches. Also, Tiwari's model of knowledge integration process needs further testing at least in co-creation networks and potentially also with transaction networks. In our case, the discovered boundary objects were both concrete and metaphorical. Some of the boundary objects were found to be more applicable than others, and this finding contributes new knowledge of the use of boundary objects in knowledge integration. Yet, there is a wide range of usable boundary objects to be further studied in co-creation networks aiming to yield networked innovation. We find our results encouraging, and we hope that they will encourage others to undertake further research along these lines.

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Boundary Objects as Part of Knowledge Integration for Networked Innovation

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