Integrating individual knowledge into innovation processes of R&D alliance

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MEDIATING BOUNDARY OBJECTS TO INTEGRATING INDIVIDUAL KNOWLEDGE INTO INNOVATION PROCESSES OF R&D ALLIANCES THROUGH DESIGN

Abstract

1. Introduction

Innovation processes of New and Product Development (NPD) involve individuals from different parties within and across organisations (Grigoriou and Rothaermel, 2017, Mahr et al., 2014). Throughout these processes, individuals exchange knowledge of each other to solve problems and innovate (Arnett and Wittmann, 2014). Exchanged individual knowledge can be explicit and tacit (Arnett and Wittmann, 2014, Cavusgil et al., 2003, Chua, 2002, Lam, 1997, Nonaka and Takeuchi, 1995, Seidler-de Alwis and Hartmann, 2008). While explicit knowledge is easy to be codified and verbalised, tacit knowledge is hidden within the actions, commitments, values, emotions, educational background, natural talent and experiences of individuals (Kikoski and Kikoski, 2004, Koskinen and Vanharanta, 2002, Nonaka and Takeuchi, 1995, Seidler-de Alwis and Hartmann, 2008). This paper looks at how tacit knowledge delivered within innovation processes can be translated to benefit future innovation partnerships and projects within and across particular organisations.

The purpose of individual knowledge can play a key role to succeed innovation processes and maintain the competitive advantage of organisations by solving the problems with their subjective methods. It is widely acknowledged that tacit knowledge is as relevant as explicit knowledge in maintaining competitive advantages of organisations in innovation processes (Arnett and Wittmann, ...
learning among R&D partners, both within the cross-functional teams in a single organisation and the alliances for new product development (NPD) are especially significant particularly interesting when industry clusters, innovation networks, R&D consortia (Gulati, 1998, Kogut, 1988, Trott, 2012), R&D among different forms of strategic alliances (e.g. supplier relations, licensing, outsourcing, joint venture, strategic partnerships as a form of collaborative innovation practices across the boundaries of single organisations are faced with all of these knowledge boundaries (Sampson, 2007). These objects enable organisations to transform knowledge among individuals within and across organisations (crossing pragmatic boundaries) and learn about differences and similarities of each other (crossing syntactic boundaries) and learn about differences and similarities of each other (crossing syntactic boundaries) and learn about differences and similarities of each other (crossing syntactic boundaries) and learn about differences and similarities of each other (crossing syntactic boundaries). Despite its significance, it is challenging to integrate tacit knowledge into innovation processes (Cavusgil et al., 2003, Nonaka, 1994) due to pre-existing knowledge boundaries present in any collaboration, which leads to different levels of boundaries among individuals part of the innovation processes (Bartel and Garud, 2009). Literature suggests these boundaries can be divided into three levels: (1) syntactic boundaries, which are built around the lack of sharing (Carlile, 2004), (2) semantic boundaries, which arise due to lack of understanding and meaning among innovation team members (Arnett and Wittmann, 2014) and (3) pragmatic boundaries, that develop due to the individual’s lack of interest to share, which can be related to. Whilst individual knowledge contains high level of tacitness, there are pragmatic boundaries that knowledge needs to be transformed, whilst individual knowledge contains some level of tacitness there are semantic boundaries that knowledge needs to be translated (Carlile, 2004). For example, cross-functional internal teams have semantic boundaries (Arnett and Wittmann, 2014) and they need to translate the tacit knowledge to explicit knowledge. Moreover, individuals from different organisations are faced with pragmatic boundaries because of geographical, cultural and organisational differences among the team members (Larsson, 2003, Mahr et al., 2014, van de Vrande et al., 2009). In knowledge is highly tacit organisations need to transform the knowledge (Carlile, 2004). In addition to these two knowledge boundaries, there are also syntactic boundaries that knowledge is explicit but needs to be transferred across different parties (Carlile, 2004). All knowledge boundaries introduced on the previous paragraph can be observed among strategic alliances as a form of collaborative innovation practices across the boundaries of single organisations are faced with all of these knowledge boundaries (Sampson, 2007), who involve in innovation processes of NPD that individuals have to operate and collaborate internally and externally to exchange knowledge and resources (Dyer and Nobeoka, 2000, Grant and Baden-Fuller, 2004, Grigoriou and Rothaermel, 2017, Gulati et al., 2000, Mowery et al., 1996, Muthusamy and White, 2005, Simonin, 1999, Trott, 2012). Moreover, they establish To be innovative, they need to establish strong bonds in the form of partnerships that facilitate explicit and tacit knowledge learning throughout innovation processes (Cavusgil et al., 2003, Grant and Baden-Fuller, 2004, Kaplan et al., 2010, Muthusamy and White, 2005, Rothaermel and Deeds, 2004, Serrat, 2017, Tidd et al., 2005, Zhang et al., 2013). Among different forms of strategic alliances (e.g. supplier relations, licensing, outsourcing, joint venture, industry clusters, innovation networks, R&D consortia) (Gulati, 1998, Kogut, 1988, Trott, 2012), R&D alliances for new product development (NPD) are especially significant particularly interesting when researching innovation, knowledge and learning. There is a high level of knowledge exchange and learning among R&D partners, both within the cross-functional teams in a single organisation and the cross-organisational teams participating in the alliance and internal cross-functional teams that can be observed throughout the innovation processes (Abuja and Kattila, 2001, Han et al., 1998, Keil et al., 2008, Koschatzky, 2001, Liao et al., 2007, Lin et al., 2012, Sampson, 2005). Despite their significance, the process is very complex with individual knowledge boundaries (syntactic, semantic and pragmatic), which needs to be crossed so that organisations learn from individual knowledge of internal and external parties. The knowledge boundaries in such alliances are even more complex, as the network of collaborating individuals, who need to translate their tacit knowledge into the innovation process, increases (Sampson, 2007). The purpose of the paragraph: 3) knowledge boundaries (semantic syntactic pragmatic) Commented [IT7]: sentence structure. Please rephrase. Commented [IT8]: where Commented [IT9]: are faced with... Commented [IT10]: New sentence Commented [IT11]: comma Commented [IT12]: how or into what...? Commented [IT13]: sentence structure not clear Commented [IT14]: forming partnerships? Or formal? 5) Boundary objects to overcome knowledge boundaries
individuals within their innovation processes. However, literature currently does not address these issues and there is a little empirical research done on this matter (Grigoriou and Rothaermel, 2017). Therefore, there is a need for new studies focusing on ways to mediate how innovation activities can be mediated to benefit from individual knowledge (Alegre et al., 2013). To fill the knowledge gap of mediating the activities, this research proposes design to coordinate processes and outline what is unknown (Bertelsen, 2000). Thus, this research contributes to the existing literature by using design to mediate boundary objects to benefit from individual knowledge in innovation processes of R&D alliances.

The main aim of this paper is to develop a conceptual framework to map out mediation of boundary objects to mediate knowledge transfer throughout innovation processes of R&D alliances to benefit from individual knowledge. Following research questions will be addressed by using this framework. This paper addresses this need by building a theoretical proposition to explore how design and boundary objects in particular mitigate knowledge transfer within innovative processes of strategic alliances. To develop the proposition, literature focusing on knowledge transfer, knowledge boundaries and innovation processes of strategic alliances is reviewed. The theoretical framework is presented as a result of the review and a short validity and reliability test for it is outlined. The paper concludes with key limitations to the approach and future steps.

2.1. Individual knowledge in innovation processes

Knowledge is an important resource for organisations to maintain their competitive advantages, propose new solutions, learn from the processes and situations and make decisions (Alegre et al., 2013, DeLong and Fahney, 2000, Liao et al., 2007, Nonaka, 1994).

Throughout innovation processes of NPD, individual knowledge (tacit and explicit) has a dynamic nature that permits the cross knowledge boundaries and innovation processes of strategic alliances is reviewed. The theoretical framework is presented as a result of the review and a short validity and reliability test for it is outlined. The paper concludes with key limitations to the approach and future steps.

6.2. Literature Review

As literature review aims to build new conceptual framework to mediate boundary objects through design, literature is reviewed to define key topics and theories to constitute the framework. First section of literature review will focus on the relevance of individual knowledge for innovation processes.

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Commented [IT22]: What type of design are we talking about here?

Commented [IT23]: As with your previous question, it is the boundary objects which mediate the knowledge transfer between the R&D members? Is this the case, then the question should be something like: How boundary objects mediate knowledge transfer between R&D alliances? -- here I presume you want to look at the knowledge transfer between organisations -- is this correct?

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Commented [IT25]: I do not see a link with design innovation in Q 2 and 3

Commented [IT26]: the purpose of this paragraph a clear structure of literature review to build the framework

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Commented [IT29]: I believe all these terms need to be defined.

Commented [IT30]: What does it mean? Why is it important? What is/are the implication(s)?

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2.2. Crossing individual knowledge boundaries

Tacit and explicit nature of individual knowledge leads to different knowledge boundaries (Cavusgil et al., 2003, Lam, 1997). The study of Carlile (2004) suggests an integrative framework to cross knowledge boundaries whilst individuals from different parties collaborate for during NPD in innovation processes. The integrative framework proposed by Carlile has three ways of crossing knowledge boundaries between different individuals. These are (i) transferring, (ii) translating, and (iii) transforming” knowledge respectively to cross “syntactic, semantic and pragmatic” boundaries (Shannon and Weaver, 1949).

Knowledge transfer is used when knowledge is known (almost explicit); knowledge translation is used when some meanings are missing and there is a level of tacitness (Carlile, 2004). When individual knowledge is unknown (almost tacit), knowledge transformation approach is suggested (Carlile, 2002, Carlile, 2004, Carlile and Rebentisch, 2003). Knowledge transformation proposes more than translating or communicating the knowledge, rather it suggests a system that individuals need to change their current knowledge, create new knowledge, and validate it within and across functions (Carlile, 1997, Carlile, 2004). To learn from knowledge crossing, Carlile and Rebentisch (2003) developed a knowledge transformation cycle comprising of these three elements: (i) transforming, (ii) retrieving and (iii) storing (Carlile and Rebentisch, 2003).

2.3. Learning from individual knowledge

Learning in innovation processes of R&D alliances can occur in two ways. First one is internal learning that organisations learn from new individual knowledge created by their own employees when they propose new solutions throughout innovation processes; second one is external learning new individual knowledge created by their partners that they need to integrate it into their systems (Alegre et al., 2013). New created knowledge might need knowledge transfer, translation and transformation based on their level of tacitness. Internal learning generally has semantic boundaries (functional differences) so knowledge needs to be translated among cross-functional teams (e.g. translating the mathematical equations to text), whilst external learning has pragmatic boundaries knowledge requires to be transformed (e.g. prototyping)(Carlile, 2004). Syntactic boundaries can also be seen in these processes where explicit knowledge needs to be transferred (e.g. sending a report through e-mail) (Carlile, 2004).

For internal learning, Carlile (2004) suggests that organisations need to create common meanings, assess and share them within other individuals. For external learning, the study of Kale et al. (2001) proposes 4Cs of learning and leveraging know-how of alliances. The four steps are: (i) capturing the experience by getting insights and feedback from partners, (ii) codifying these experiences in the form of guidelines to help managers undertake the critical decisions in the process, such as partner assessment and selection, alliance negotiation, development of alliance contract, (iii) creating decision making tools and communicating through forums and networks or video conferencing, chat rooms and (iv) coaching managers to learn new knowledge (Kale et al., 2001). The strength of this framework is that when
employees leave the company, tacit knowledge of these employees can be ‘kept’ in the organisation. Still, the implementation of this learning theory into practice may be challenging, as managers need to convince employees to do extra-curricular activities to learn from the innovation processes. Therefore, this research aims to embed learning processes into the innovation process. This will be achieved by using boundary objects throughout innovation processes. This will be elaborated on the next section with introduction of boundary objects.

2.4. Boundary objects to cross knowledge boundaries

Boundary objects were defined as “objects that are plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites” (p. 393), when it was first coined by Star and Griesemer (1989) in social sciences. In the last decades, these objects have been adopted by organisational and innovation studies to cross the boundaries (Bucciarelli, 2002, Carlile, 2002, Carlile, 2004, Jalonen, 2011, especially to collaborate with different parties (Carlile, 2002, Carlile, 2004, Jalonen, 2011, Nicolini et al., 2012b, Star and Griesemer, 1989)(Figure 4). Thus, boundary objects enable transforming knowledge among individuals from different parties and regions (pragmatic boundaries), establishing a common language among individuals from different parties (semantic boundaries) and learning about differences and similarities of each other (syntactic boundaries) (Carlile, 2002, Carlile and Rebentisch, 2003, Huybrechts et al., 2009, Star and Griesemer, 1989). Star and Griesemer (1989) propose four types of boundary objects: (i) repositories (modular, indexable objects) as piles of materials located in an environment that allows people to indirectly interact (e.g. museums and libraries), (ii) ideal type as objects (e.g. diagrams and maps), (iii) coincident boundaries by using same objects with different context, (iv) standardised forms to transfer objects and communicate across parties. In the context of this research, standardised forms and objects can be used to cross syntactic and pragmatic boundaries respectively. To have a better understanding of crossing boundaries and learning, boundary objects will be framed for the case of innovation processes of R&D alliances.

2.6. Design as a mediated activity

As this research focuses on understanding benefiting from tacit nature of individual knowledge, literature has already suggested different theoretical frameworks to benefit from tacit knowledge of R&D alliances (Carlile, 2004, Kale et al., 2001), but these theories lack a clear understanding on how these processes are coordinated. Lokitz et al. (2016) defined design as “creating the conditions by which businesses thrive, grow, and evolve in the face of uncertainty and change” (p. 9). As tacit knowledge is unknown, designing the overall framework will allow academia and industry to mediate the processes of benefiting from tacit knowledge to have a comprehensive understanding on coordinating boundary objects to cross knowledge boundaries. From these aspects, design is beyond communication, and it is about designing the overall framework in a strategic level (Elving, 2005) that framework would allow managers to coordinate these processes (Elving, 2005). Research Method

To achieve the research purpose, the visual design framework will be generated (Bertelsen, 2000, Walsh, 1996). To coordinate activities through boundary objects to benefit from new tacit knowledge of individuals, activity theory of Vygotsky (1978) and (Engeström, 1987) will be used as an evaluation tool. By using this theory, all activity can be seen as a design activity and boundary objects are design artefacts to coordinate the process (Bertelsen, 2000). This theory can be used in organisations to understand who is doing what, why and how by using six dimensions as subject, object, division of labour, instruments, rules, community (Hasan and Kazlauskas, 2014). To understand how boundary objects are coordinated these questions will be searched for each stage of benefiting from tacit knowledge.

2.7. Innovation 2.5. Innovation processes of R&D alliances

6.1.1. Defining innovation
In the context of this research, innovation involves a successful creation of knowledge (Alegre et al., 2013). This can be done in a variety of ways, through a variety of knowledge translation systems, including translation of knowledge to build products, processes and transform organisations. Dodgson et al. (2002) for example define innovation as “the productive use of knowledge manifested in the successful development and introduction of new products, processes and/or services” (p. 53). As the main purpose is to benefit from tacit knowledge, it links with innovation in three different ways. Firstly, as the main focus is to use tacit knowledge of individuals by crossing boundaries throughout innovation processes, it may have a positive impact on process innovation, which is defined by Dodgson et al. (2002) as “the productive use of knowledge manifested in the successful development and introduction of new products, processes and/or services” (p. 53). Moreover, enhancing process innovation in turn enhances organisational innovation, which is defined as implementing new innovation related with to products/products, processes, technology and so on (Salavou et al., 2004). From a product innovation perspective, Trott (2012) further enhances this perspective and defines innovation as “the management of all the activities involved in the process of idea generation, technology development, manufacturing and marketing of a new (or improved) product or manufacturing process of equipment” (p. 15). As this research specifically focuses on innovation processes of R&D alliances, the successful outcome of these processes would be product innovation. Enhancing innovation processes and organisational innovation would indirectly affect the outcome of the innovation process, which is a product innovation. All three types of innovation [key] throughout innovation processes, these processes will be introduced in the case of R&D alliances.

### Innovation processes of R&D Alliances

The relevance of knowledge translation in innovation processes becomes particularly relevant for strategic R&D alliances where the management of knowledge needs to happen within and beyond a single organisation.

Organisations build R&D alliances through collaboration and co-operation for the purposes of achieving a greater innovation results than it could have done individually. Whilst Polenske (2004) defines collaboration as “to include direct participation by two or more actors in designing, producing and/or marketing a product (process)” (p. 1031); Roschelle and Teasley (1995) define co-operation as “the division of labour among participants as an activity where each person is responsible for a portion of the problem solving” (p. 70). As defined above, R&D alliances involve co-operation (innovation networks) and collaboration activities (R&D consortia) that can be seen in the innovation processes.

There are different innovation processes that are used to frame activities of R&D alliances (Cooper, 2008, Van der Meer, 2007). Current literature often discusses these under the umbrella of open innovation, where partners are actively contributing to the overall innovation processes for different purposes (Cooper, 2008, Enkel et al., 2005, Piller and West, 2014). These models enable the open innovation approach enables knowledge flows among partners throughout innovation processes for monetary and non-monetary activities (Chesbrough and Bogers, 2014). Key activities of partners differ across different stages of the innovation process. Piller and West (2014) propose a process model clustered into four stages: i) defining, ii) finding participants, iii) collaborating, and iv) leveraging. The key activities regarding each stage are listed in Table 1.

### Table 1. A process model for open innovation

<table>
<thead>
<tr>
<th>Process Stage</th>
<th>Key Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining</td>
<td>Problem formulation</td>
</tr>
<tr>
<td></td>
<td>Institutions and rules: including contract terms, IP</td>
</tr>
<tr>
<td></td>
<td>Resource allocation and strategic commitment</td>
</tr>
<tr>
<td>Finding Participant</td>
<td>Identifying participants with right characteristics</td>
</tr>
<tr>
<td></td>
<td>Selecting the right participants</td>
</tr>
<tr>
<td>Collaborating</td>
<td>Governance of the collaboration process: organising, monitoring</td>
</tr>
<tr>
<td></td>
<td>Interaction platforms and other tools</td>
</tr>
<tr>
<td></td>
<td>Openness of firm attitudes, structure and processes</td>
</tr>
</tbody>
</table>
Leveraging Integrating external knowledge Commercialising the knowledge through product and services

These open innovation models are generally integrated with all the activities need to be purposefully managed and structured decision making processes are needed to agree the deliverables and key criteria for progressing through the innovation process. The activities are often combined into stages and decisions made at gates (Cooper, 2008). Stage-Gate model of Cooper (2008). These models are very common in R&D industry and open innovation version of Stage-Gate model i and although defined as linear, they are usually flexible, scalable and iterative (Cooper, 2008).

Within these models knowledge of partners can be integrated into innovation processes; internal knowledge can be leveraged and shared with partners (Chesbrough and Bogers, 2014, Enkel et al., 2009, Gassmann and Enkel, 2004). Main R&D partners of NPD are customers, manufacturers, universities, research institutes, government bodies, funding bodies, suppliers and competitors (Canik et al., 2017, Fritsch and Lukas, 2001, Sáez et al., 2002, Un and Asakawa, 2015). Among these partners, customers are highly valued for innovation, knowledge and learning (Canik et al., 2017, Greer and Lei, 2012, Sáez et al., 2002). Mahr et al. (2014) highlight the significance of integrating knowledge of customers throughout innovation processes (e.g. co-creation, co-production). Although customer involvement is important, organisations that involve customers in the process require different mechanisms of knowledge transfer because of organisational boundaries (Mahr et al., 2014). Regarding internal management of these projects, organisations work with cross-functional teams including employees from engineering, sales, marketing, manufacturing and operations department (Hoegl et al., 2004, Olson et al., 2001). Internal cross-functional teams contribute to the integration of the external knowledge and propose their knowledge into processes (Olson et al., 2001).

All in all, R&D alliances require internal and external co-operative and collaborative activities. Based on the stage of innovation processes, internal and external collaboration activities have different purposes (e.g. co-operating with customers to get ideas, collaborating with customers to develop projects). In each stage of the innovation process, new knowledge of partners and cross-functional teams can be generated and validated in the gate meetings. Thus, the role of new tacit knowledge is significant in any stage of innovation processes (Seidler-de Alwis and Hartmann, 2008). Once knowledge is created, it is up to organisations to integrate that knowledge to the process; if they give a yes decision in a board meeting, this knowledge needs to be retrieved and stored in the organisation to be used for future projects (Carlile and Rebentisch, 2003). Within the innovation process introduced in Table 1, literature suggest a variety of alliance activities:

- Define: Getting suggestions and complaints from R&D alliances to formulate the problem through idea generation workshops and forums (Enkel et al., 2005, Rohrbeck et al., 2009)
- Find participants: Interacting with potential partners through events, internet platforms (Rohrbeck et al., 2009)
- Collaboration: Undertaking R&D activities (e.g. prototyping, in-licensing) by building partnerships through R&D consortia, endowed chairs, internet platforms, joint development (Enkel et al., 2005, Rohrbeck et al., 2009)
- Leverage: Spin-outs, internet platforms, joint ventures with partners (Rohrbeck et al., 2009) and out-licensing strategies IP and technologies (Enkel et al., 2005)

The literature suggests a diverse numbers of boundary objects that can be used in innovation processes. These are documents, individual icons (open to iterations and further developments), spreadsheets, workshops (Huybrechts et al., 2009), email systems, phone, documents (project proposal), built environments, visual slides (Nicolini et al., 2012a), prototypes (Bechky, 2003, Carlile, 2002), IT-based artefacts (e.g. internet applications) (Levina and Vaast, 2005) and drawings (of various kinds), a CAD system, a physical scale model, a dayfile, a mailing system, a filing system, annotation, marking tools, desks, walls to pin drawings on duplication and shrinking technology (photocopier) communication technologies (Perry and Sanderson, 1998) and so
on. Among all these boundary objects, studies emphasise they need to make sense for each party involved (Carlile, 2002, Levina and Vaast, 2005).

For each stage of the innovation process, a variety of boundary objects can be used based on the preferences of the participants. Some examples of boundary objects that can be used in the innovation processes are summarised by (Rohrbeck et al., 2009): (i) workshops, online platforms for define stage, (ii) events and online platforms for find stage, (iii) prototypes for collaborate stage, and (iv) internet platforms, reports for leverage stage. All these boundary objects can be used to cross different boundaries. For example, internet platforms can be used to share knowledge (e.g. syntactic boundaries).

7.3. The conceptual framework design

So far, the literature review has highlighted theories a variety of influencing factors and potential support tools to cross knowledge boundaries within innovation processes, in order to benefit and learn from tacit knowledge and consequently enhance innovation processes and future engagement of strategic alliances by using boundary objects throughout innovation processes. Designing the overall framework will allow organisations to understand how boundary objects to cross boundaries and integrate individual tacit knowledge into innovation processes. This framework has a potential to enhance process and organisational innovation, which will also indirectly help organisations succeed product innovation. A summary of the discussed constructs is presented in an integrated theoretical framework (Figure 1), which has according to authors’ understanding not been done before. The framework builds on the literature through identifying where knowledge translation is needed within the innovation process of strategic alliances and provides the initial identification of where boundary objects may play a role. The framework is illustrated in Figure 1.

As it is seen on Figure 1, it is divided into four stages of innovation. The framework follows Piller and West’s (2014) stage process. As it is introduced before, in each stage, partners and individuals from cross-functional teams exchange their individual knowledge, which often includes with high levels of tacit knowledge (Grigoriou and Rothaermel, 2017, Mahr et al., 2014). In between stages, executive teams in organisations accept and decline ideas and propositions made by the teams. For Within this framework, the key decision is related to assessing how and if tacit knowledge of partners or...
and internal employees should be proceeded or not used, coded and stored and what aspects of it will progress into the next stage.

On In the define stage, boundary objects are used to integrate suggestions and complaints from partners and internal employees (Enkel et al., 2005). On In the find participant stage, the main idea is finding potential participants through networking events and internet platforms. A variety of can be used as boundary objects can support this process (Rohrbeck et al., 2009). These two stages are different from last two stages because partners are not part of the decision making processes yet. On In the collaboration stage, partners become part of the process, so there are stronger levels of interaction.

Often this is done through prototypes as boundary objects (Enkel et al., 2005, Rohrbeck et al., 2009). On In the leverage stage, external partners from their the wider networks of the alliance networks could be involved in processes (Rohrbeck et al., 2009). This framework does not only use boundary objects but also mediate them to cross knowledge boundaries and learn from tacit knowledge of individuals.

These coordination process has been outlined in Figure 1. Related to the framework has been developed by merging frameworks of Carlile (2004), Carlile and Rebentisch (2003) and Kale et al. (2001). Based on these frameworks, this research introduces following steps that internal and external learning are embedded on the processes to cross knowledge boundaries. These steps will be differentiated to cross syntactic, semantic and pragmatic and learn from individual knowledge. For syntactic boundaries, Carlile (2004) suggests the need for sharing knowledge within and across functions and assess. For semantic boundaries, Carlile (2004) suggests translating knowledge to create common meanings and assess that knowledge. For pragmatic boundaries, Carlile (2004) suggests to store and retrieve it. Although these theories suggest main steps, they do not outline how these processes are coordinated (e.g. who assesses the knowledge or which tools are used and why). Moreover, from learning perspective, it does not outline who learns what. As a result, this research designed to following steps by merging different frameworks that can be applicable to different boundaries.

For external and internal learning, syntactic, semantic and pragmatic boundaries are crossed by using different boundary objects throughout the innovation processes. Based on different literature review, following steps are designed:

1. Retrieve previous experiences: Capture previous experiences
2. Create a common interest to share through boundary objects. Co-operate with cross-functional teams to create boundary objects. (the phase that internal cross-functional teams collaborate with partners to create common interest to share with external parties.)
3. Capture the new knowledge: By sharing boundary objects with partners, cross-functional teams can capture new tacit knowledge
4. Validate within and across functions: New tacit knowledge is assessed and approved or declined by decision makers at gates
5. Codify and store the new knowledge: If it is approved, cross-functional teams codify new tacit knowledge by using boundary objects to be used for future projects
6. Communicate and coach: Communicate and coach other individuals regarding new knowledge by using boundary objects

According to Carlile (2004), Step 2, 3, 4 are to cross pragmatic boundaries, whereas step 1, 5, 6, is used for enabling internal and external learning (Carlile and Rebentisch, 2003, Kale et al., 2001). Moreover, co-operative activities among cross-functional teams involve crossing semantic boundaries (Carlile, 2004); each step also involves boundary objects to cross syntactic boundaries that there is a need for sharing knowledge. All in all, by using this framework, different boundary objects to cross different boundaries for each step of innovation can be identified. In addition to existing literature, how each step is coordinated with boundary objects can be evaluated by using activity theory. In each step, the questions of who, what, why, how, where, whom will be asked (Hasan and Kazlauskas, 2014).

8.4. Conclusion and Further steps

This conceptual framework contributes to the literature by filling the knowledge gaps to outline how boundary objects are coordinated through design outlining how knowledge translation within strategy.
alliances occurs in innovation processes and where boundary objects may support the translation of tacit knowledge into re-usable knowledge inventory. Academic and industry can use this framework in strategic level to benefit from individual tacit knowledge of their partners and employees. This would help them maintain knowledge inside organisations and learn from knowledge, even employees leave the company. As a result, this framework will enhance process and organisational innovation, which would have an indirect positive impact on product innovation. Despite the significance of this research, it has some limitations. At this stage boundary objects that have been cited in literature to enable this knowledge translation are used to support the framework, it is however anticipated that a case study within an industrial partner will be performed in the next months, to explore what is taking place within industry and how that compares to the proposed framework. A full map of boundary objects used in the strategic alliances of the industrial partner will be developed and linked to the different actors within the innovation process. Through a structured research protocol developed from the literature the knowledge boundaries of the participating case will be explored and artefacts used to overcome them discussed. This will inform the validation and reliability testing of the framework. This framework will guide observation of organisations and academic observe how things are coordinated within innovation process. Therefore, ethnographic research approach will be done by conducting a longitudinal case study to observe cross-functional teams and executive teams of innovation processes of R&D alliances will be developed. The case study company is a R&D institute in manufacturing sector specialised in automotive industry. They provide innovative services in manufacturing sector. Strategic alliances of the industrial partner will be developed and linked to the different actors within the industry and how that compares to the proposed framework. A full map of boundary objects used in the innovation process. Through a structured research protocol developed from the literature the knowledge boundaries of the participating case will be explored and artefacts used to overcome them discussed. This will inform the validation and reliability testing of the framework. This framework will guide observation of organisations and academic observe how things are coordinated within innovation process. Therefore, ethnographic research approach will be done by conducting a longitudinal case study to observe cross-functional teams and executive teams of innovation processes of R&D alliances will be developed. The case study company is a R&D institute in manufacturing sector specialised in automotive industry. They provide innovative services in manufacturing sector. Strategic alliances of the industrial partner will be developed and linked to the different actors within the industry and how that compares to the proposed framework. A full map of boundary objects used in the innovation process. Therefore, following questions will be asked and repeated for each step and stage (define problem, find participants, collaborate, leverage) based on Activity Theory evaluation framework. What are the boundary objects? (object) Who generates these objects? (subjects) What is the division of labour among teams? (division of labour) Which instruments and tools are used? (instruments and tools) Whom learn from these processes? (community) What is the outcome? (next step)

The observation will be done by shadowing employees. The results will be visualised based on Figure 1 to answer three research questions. Overall, the main purpose of this paper was to introduce the conceptual framework and get feedback before conducting case study. The framework contributes to the literature by outlining how boundary objects are mediated through design and allowing managers to give strategic decisions to coordinate the processes, which would link with process, organisational and product innovation.

9.5. References


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