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Understanding the Role of Objects in Interactive Innovation

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Abstract. The purpose of this paper is to understand the role of objects in interactive innovation, i.e. interaction for innovation among core inside innovators, peripheral inside innovators and outside innovators. Going beyond the predominant usage of ‘boundary objects’ we argue that a pluralistic approach of objects is needed to better understand and trace the different – and shifting – roles that objects play in interactive innovation. To do so, we develop a framework of the role of objects in interactive innovation. This framework is applied while designing the “IP Industry Base” (IPIB) project for interactive innovation. The IPIB is an innovative analytical database in the field of competitive intelligence (CI). From the lessons learned in this project, we discuss what needs to be considered for the conscious development of objects to foster interactive innovation in the context of highly innovative software development projects.

Keywords: interactive innovation, objects, software design, requirements engineering

1 Introduction

Organizational innovation scholars have shown a wide and deep interest in how organizations can increase its innovation capacity. Research in the field of innovation management is focusing on who is integrated in the innovation process (e.g., [31], [18]) and how this integration is mediated by objects and material artifacts (e.g., [12]).

With regard to who is integrated in the innovation process, scholars have explored how the organization itself can be the main source for innovation, i.e. the closed-innovation paradigm. In this context, the core inside innovators (i.e., the R&D departments) and the peripheral inside innovators (i.e. employees across the boundaries of the R&D department) are considered as central source of innovation (e.g., [18]). Nowadays, the focus has moved towards the analysis of how individuals across organizational boundaries, i.e. outside innovators, can become important innovators, i.e. the open-innovation paradigm (e.g., [30] etc.). In a similar vein, research interests in objects (as drivers for innovation) have a long tradition and have been discussed from a variety of perspectives [19]. In particular, research in the area of boundary objects (e.g. [4], [27], [28]) has been applied to learn more about how distinct boundary ob-

ject can be used to integrate a particular type of innovator in the innovation process. For illustration, boundary objects range from the physical prototype of a new automobile to CAD drawings, from storyboard drawings to emails. Thereby, boundary objects are shared tools and methods for solving innovation problems across different contexts. These boundary objects can have different meanings for different types of innovators, but they are familiar to all of them and thus act as a translator.

However, taken as a whole, these two strands of research beg two important issues. *First*, most research – and the resulting theoretical models – focuses on only one or two sources of innovation and their corresponding interaction. Thus, there is the need for a deeper understanding how the three types of innovators, i.e. the core inside innovators, the peripheral inside innovators and the outside innovators - might interact for innovation. We term this specific type of interaction “interactive innovation”. *Second*, the role of objects in the interaction among the three types of innovators has been largely overlooked. Scholars have already studied the influence of a variety of (boundary) objects provided by organizations for different types of innovator separately. However, they have not yet laid a foundation for exploring the capabilities of such objects with regard to enable interactive innovation, i.e. the interaction for innovation among the three types of innovators. To close this gap in literature, the aim of this paper is to merge these two perspective and, in doing so, to develop a framework of the role of objects in interactive innovation. This framework has then been applied while designing the “IP Industry Base” (IPIB, [34]) project for interactive innovation. The IPIB is an innovative analytical database in the field of competitive intelligence (CI). The goal of the project is the analysis of the players and the competitive structure in the market for managing and exploiting intellectual property rights (IPR). In the ongoing development of this web-based analytical database all types of innovators are involved and, thus, one need to carefully consider the distinct roles of objects in the interaction among them.

2 Theoretical framework

2.1 Interactive Innovation

Drawing on Weick’s concept of loose coupling [32], we argue that interactive innovation among three types of innovators can be characterized as being loosely coupled, where loosely coupling is “a situation in which elements are responsive, but retain evidence of separateness and identity” [32]. In doing so, we identify three dimensions of interactive innovation: a) situational dimension, i.e. “the situation” in which interactive innovation takes place, b) individual dimension, i.e. the reasons why individuals “retain evidence of separateness and identity” in interactive innovation, and c) the process dimension for interactive innovation, i.e. “in which elements are responsive”. Table 1 gives an overview of these three dimensions and its selected specifications under study in this paper, which are derived from Weick’s concept of loose coupling. These dimensions and its specifications are not exhaustive but they can be viewed as

central of providing a fruitful account of an explorative analysis of the role of objects in interactive innovation.

Table 1. Three dimensions of interactive innovatio

Dimension	Description	Specification
Situational dimension	The situation in which interactive innovation takes place	Ambiguity, e.g. [17], [32]
Individual dimension	The individuals' abilities and experiences that underlie interactive innovation, which are grounded in individuals' identity.	Bounded rationality, e.g., [26], semantic & pragmatic boundaries, e.g., [4]
Process dimension	The processes constituting interactive innovation, i.e. how responsive are the involved individuals towards interaction	Interaction routine dynamics, e.g., [7]

Situational dimension. Martin (1992: 134) [17] argues that “ambiguity is perceived when a lack of clarity, high complexity, or a paradox makes multiple (rather than single or dichotomous) explanations possible”. Thus, ambiguous situations are characterized (among others, see [33]) by an unclear problem statement (e.g., individuals have only vague or competing definition of the problem) and by different value orientation and emotional clashes (e.g., without having clear objective information, individuals rely more on personal/and or professional experience to understand the situation). Each innovation process that is designed towards the interaction of the three types of innovators can be seen as ambiguous situation. The problem is not clear – that is the innovative part of the task and each type of innovator is characterized by a distinctive value orientation based on different backgrounds, experience and interests with regard to the problem solution. Accordingly, it is very important that ambiguous situations lack an understanding of cause-effect relationships, e.g. distinct types of innovators do not understand what causes what in the situation. Even if they are sure of the effects they desire, they are uncertain how to obtain them [33]. This gets even more important if organizations aim at interactive innovation.

Individual dimension. For as long as interactions are taking place within the existing frame of reference of a particular type of innovator, they are increasingly becoming effective. This is based on the sheer multitude of innovation practices which are available (e.g. [24]) to foster innovation of a single type of innovator or the interaction of up to two types of innovators, e.g. outside innovators and peripheral inside innovators (e.g. marketing, as it is most often the case in the context of lead users). However, once interactions are required from outside that existing reference frame (e.g. the R&D department gets involved in lead user workshops), individuals are con-

fronted with of what Simon (1991) [26] called ‘bounded rationality,’ and underpinning them are a number of key psychological effects such as ‘groupthink’ [9]. Fischer (2011) [8] argues that individuals who are meant to share their knowledge outside their traditional frame of reference for interaction might not willing to contribute as the activities are not relevant for them. Also, the inherent need of individuals to keep things simple and stable [22] can foster the emergence of semantic and pragmatic boundaries in interactive innovation among the three types of innovators. Semantic boundaries are boundaries of interpretation. Different types of innovators possess different perspectives on the innovation task, due to their specialization, backgrounds and interests. In interactive innovation each type of innovator interprets the others’ knowledge referring to his/her specific context [1]. As a consequence, differences might emerge in the way the shared knowledge is understood, which influences the interaction. In a similar vein, “when interests are in conflict, the knowledge developed in one domain generates negative consequences in another” [4]. Referring back to James (1907) [10], the combination of dependency and novelty can create different interests among the three types of innovators. This might foster the emergence of pragmatic boundaries in interactive innovation.

Process dimension. Over the last decades, distinct research has been built up around the proposition that routines are underlying processes of organizational capabilities (e.g. [16], [5], [2]). Routines are conceptualized as “repetitive, recognizable patterns of interdependent action, carried out by multiple actors” [7]. The ‘path’ that routines undergo in practice is embedded in the interaction within a particular type of innovators (e.g. inside innovators) developing and using them in their daily interactions. In short, interaction routines are a ‘script for interaction’ that people develop together, which becomes increasingly complex as it is done. When other types of innovators are confronted with these interaction routines, there is a possibility that previous characteristics of these routines made sense in their original setting can become misinterpreted in the interactive innovation among three types of innovators. Consequently, there is a risk that these routines can become less comprehensible for the ‘joining’ types of innovators. In other words, if a routine has been developed and used by the core inside innovators in its local context, it may be problematic to use this routine in interactive innovation, i.e. if outside and peripheral inside innovators join the core insider innovators’ interactions. If these routines are introduced by one type of innovators in the interactive innovation, then those actors of a particular type of innovator that have previously worked with this routine will have a different perception or meaning of the routine than actors for which this particular routine is new. Furthermore it can be argued that these routines might have a different functionality in the interactive innovation than they had in their original settings while at the same time become ‘biased’ for the type of innovator who are used to work with this routine in its original setting. Thus, routines are tightly coupled with its enacting context, and therefore not easily transferable in the setting of interaction innovation.

Figure 1 provides a summary and lays the foundation for conceptualizing objects as enablers and triggers in interactive innovation.

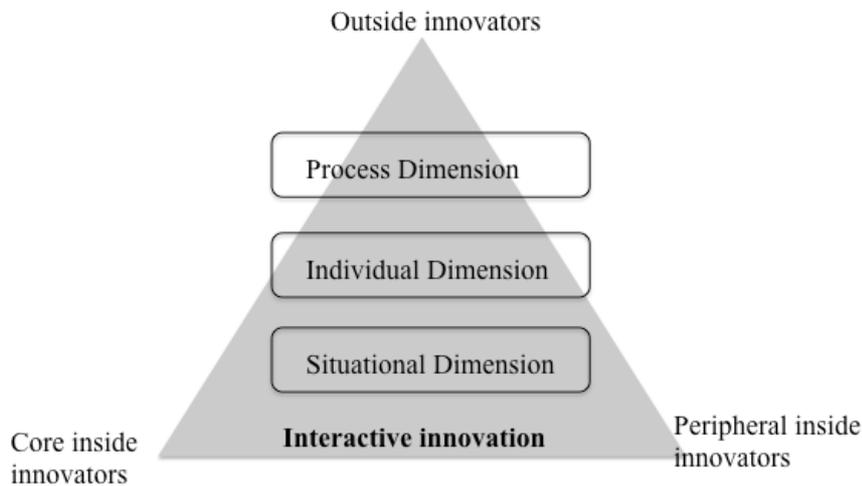


Fig. 1. Three dimensions of interactive innovation

2.2 A Pluralistic Approach for Studying Objects in Interactions

Practices (of interaction) are more than just constellations of intersubjectivity; they are also constellations of “inter-objectivity” [13]. Recent research proposes that objects play an active role in cross-disciplinary cooperation that needs to be better understood [4], [20], [21]. In particular, previous research has underlined the role of boundary objects as enabler of interaction in innovation projects [4]. Building on Nicolini et al. (2012) [19], however, we argue that the so far pre-dominantly applied theory of boundary objects may not be sufficient to understand and design objects, which enable interactive innovation. Understanding objects mainly from a boundary object theory perspective will limit our thinking of objects as “facilitator to work across different types of boundaries” [19]. Thus, to develop a framework for the role of objects in interaction innovation, we need a broader perspective of objects which enables us to integrate the situational, individual and process dimension towards interactive innovation. To do so, we build on Nicolini et al. (2012) [19] who identify in total four perspectives for studying objects in cross-disciplinary interaction. These are: material infrastructures, boundary objects, epistemic objects and activity objects.

Material infrastructure. Nicolini et al. (2012) [19] argue that all types of boundaries have the potential to become infrastructure. According to them, objects are thus “black-boxed” at one moment of interaction whereas at a different time they become central. According to Star and Ruhleder (1996) [29] “an infrastructure occurs when local practices are afforded by a larger-scale technology, which can be used in a natural, ready-to-hand fashion” (p. 112). Most infrastructures become “invisible” and only become visible when it stops to perform [19].

Boundary objects. Previous research on boundary objects shows that objects turn into boundary objects when they act as translation and transformation devices across various thought worlds (e.g., [1], [3], [4], [28]). Boundary objects are flexible artifacts that “inhabit several intersecting social worlds and satisfy the information requirements of each of them” [28]. Their flexibility is rooted in the fact that they can have different meaning in different work communities or for different types of innovators. Still their structure is common to all these groups and thus, boundary objects can serve as a means of translation in interaction innovation.

Epistemic objects. The epistemic perspective focuses on the reasons why individuals engage in searching for alignment to begin their interaction with. A core aspect of this perspective on objects is that it gives hints why solidarity among individuals happens and how it is reflected in the interaction. According to Rheinberger (2005) [25] epistemic objects hold aspects one does not yet know. Thereby, they are open ended and support interaction as source of motivation by their “opacity, their surplus, their material transcendence” [25].

Activity objects. The last perspective on explaining interactions by objects is offered by cultural historical activity theory [6], [11], [15]. From this perspective, objects motivate the interaction and direct activities. Thereby, the knowledge of the different types of innovators is hold together. Given the fluency of knowledge, activity objects are emergent, fragmented and are of expanding nature [6].

2.3 A Framework for the Role of Objects in Interactive Innovation

Juxtaposing the two theoretical lenses, i.e. the concept of loose coupling as well as the pluralistic understanding of objects, we develop our framework for the role of objects in interactive innovation (see Table 2). We argue that the role which an object plays in interactive innovation is influenced by the situational, individual or process dimension as well as the specific theoretical perspective on objects, i.e. material infrastructure, boundary objects, epistemic objects, and activity objects (see Table 2 for a description).

Table 2. Framework for the role of objects in interactive innovation

Three dimensions influencing interactive innovation	Theoretical perspectives for studying objects in interactive innovation (adapted from [19])			
	<i>Material infrastructure</i>	<i>Boundary objects</i>	<i>Epistemic objects</i>	<i>Activity objects</i>
<i>Situational dimension (ambiguity)</i>	Everyday common objects support and shape interactive innovation in their conjunction	Objects act as translation and transformation device of unclear problem statements	Objects generate mutuality and solidarity by triggering common value orientation	Objects motivate interactive innovation by framing emotions. They hold together the knowledge of different types of innovators
<i>Individual dimension (bounded rationality, semantic & pragmatic boundaries)</i>	Objects become infrastructure when bounded rationality and boundaries are a given and fall in the background	Objects support overcoming of bounded rationality and boundaries to foster interactive innovation	Objects foster individuals' attachment with it for inherent common pursuit in interactive innovation. This will bring bounded rationality and boundaries in the background.	In its emergent and expanding nature, objects are able to continuously make explicit and reflect bounded rationality and the emergence of boundaries throughout the process of interactive innovation.
<i>Process dimension (routines)</i>	The more objects become infrastructure, the more they are able to provide support for existing routines in interactive innovation	Objects translate routines in the context of interactive innovation which goes beyond the local context of a particular type of innovator	Objects foster the establishment of joint routines by creating mutual dependencies	In its fragmented nature objects address the emerging contradictions in routines throughout the process

In the following we will show how this framework has been applied while designing the project setting of the IP Industry Base (IPIB, [34]). We will highlight what role a) the IP-Industry Base itself and b) distinct mechanisms integrated in the platform play as objects to foster interactive innovation among the involved three types of innovators. Thereby we will provide initial hints what needs to be considered if one wants to consciously develop objects to foster interactive innovation in the context of highly innovative software development projects.

3 Objects in Interactive Innovation: Lessons Learned from Designing the IP Industry Base Project

3.1 Interactive Innovation in the IP Industry Base Project

The IPIB is a continuously changing, open-end result project. It aims to invent new methods and approaches in the field of data-driven competitive intelligence. Hence, the IPIB is under permanent revision in order to search, select and implement new and promising ideas, features and usage scenarios. The main target user group of the IPIB are on the one hand professionals in technology companies engaged in the IPR management, and on the other hand executives in the IP service industry which are engaged in the strategic business development of their company.

The IPIB project is managed by one of the authors and realized by an internal research and development team, i.e. the core inside innovators. The team is heterogeneous in terms of professional backgrounds - ranging from software development, over economics, law to intellectual property management – as well in terms of experiences – ranging from students to senior researchers. However, given the highly interdisciplinary nature of the project, the project manager has decided to design the project as an interactive innovation ecosystem, which should involve the three types of innovators to search, select and implement new ideas. Thus, the core inside innovators of the IPIB project actively promote the project in the research institute to include the peripheral inside innovators, i.e. all employees of the institute. Furthermore, people from the user groups as well as close members of specific research communities, i.e. outside innovators, are included as early as possible in the innovation process.

3.2 Role of Objects in Interactive Innovation within the IPIB Project

Building on our framework as presented in Table 2 we will now turn to discuss how this framework has been used to design the IPIB project for interactive innovation. In the following we show how different needs of the innovators (i.e. expressed by the situational, individual and process dimensions of interactive innovation) were translated into objects' requirements. A summary of how this is has been done can be found in table 3.

Material infrastructure in the innovation process of the IPIB project. The main material infrastructure within the whole development and innovation process of the IPIB is an issue-tracking project management system (in the IPIB the open-source

solution Redmine is used). Within such a web-based system, each issue, task, decision or other “subject of conversation” is translated into a ticket. Each ticket can be assigned to different persons and can be forwarded through different workflows. Each ticket is the central point of reference for its subject of conversation: all text-based communication is recorded there, related tickets can be linked and documents (like mock-ups) can be attached. Consequently, context and history is never missing for each type of innovator being part of the communication. By providing an API, the system is open to third party applications. This allows to deeply integrate this ticket-based routine into the whole innovation ecosystem.

Boundary objects in the innovation process of the IPIB project. The “objects of innovation” within the IPIB are concrete details in the user interface, improved user interaction, better analysis features or other concrete implementations, which make the IPIB better. One example is the internally called “company DNA” which is a colored treemap. This visualization artifact is an integral part of the innovative user experience of the IPIB interface. To foster the interactive innovation the “company DNA” acts as boundary objects. Focused on concrete and detailed issues all types of innovators can participate in the interaction by bringing in their own perspective. The boundary objects support them to find a common language and to translate their arguments into the perspective of the other innovators.

Epistemic objects in the innovation process of the IPIB project. The IPIB itself acts as an epistemic object for the research institute. To date there is no concrete evidence, which kind of detailed analysis the IPIB will support in three years. Within the interactive innovation process itself these emergent methods are shaped and will be implemented in the database. The IPIB allows the three types of innovators to exceed together the existing borders and to find innovative approaches. The core inside innovators do actively engage a vital discussion with the peripheral and the outside innovators. They realize short release cycles and communicate all changes directly to all stakeholders, by stimulating direct feedback. Furthermore, the IPIB is presented to the peripheral and outside innovators at early stages of the development, to integrate their feedback in the innovation process.

Activity objects in the innovation process of the IPIB project. From this perspective the IPIB allows the three types of innovators to motivate their interaction as well as to reveal their semantic and pragmatic borders. The IPIB itself and some parts of it are the object for all types of innovators, which enables them to actively reduce the impermeability of the borders among them. One example is the “company DNA” described above. This visualization artifact was designed by the software engineers in the core innovator team. Each time the IPIB is discussed with peripheral innovators, the idea of the company DNA is under debate. These discussions help the core innovators to better understand the perspectives and the needs of the non-engineers. Hence, the company DNA does not only act as boundary object – where the stakeholders discuss ideas for the improvement of this visualization. In its role as activity object it always motivates for deeper discussions which enables to reveal the semantic and pragmatic boundaries between all stakeholders in the innovation ecosystem.

Table 3. Designing the IPIB project for interactive innovation

Innovators' needs	Translation of innovators' needs into object requirements			
	<i>Material infrastructure (ticket-based communication)</i>	<i>Boundary objects ("objects of innovation" in IPIB)</i>	<i>Epistemic objects (the IPIB itself)</i>	<i>Activity objects (the IPIB itself)</i>
<i>Situational dimension (ambiguity)</i>	The tickets are the central point of reference and documentation for each subject of conversation; hence the ambiguity reducing context and history is never missing for each stakeholder.	The concrete "objects of innovation" (artifacts) in the IPIB act as translation and transformation device of unclear problem statements given by a particular type of innovator; a common language and shared conceptualization appears.	It is communicated to all types of innovators that the IPIB is an open-end project which intends to find new ways of analyzing the IP service market. This makes the IPIB to an epistemic object within the innovation project.	The IPIB itself shows to all three types of innovators the differences of their perspectives and perceptions. Communication about the IPIB motivates the interactive innovation.
<i>Individual dimension (bounded rationality, semantic & pragmatic boundaries)</i>	By the deep integration of the ticketing system in the innovation ecosystem the pragmatic boundaries are reduced. Whenever a user interacts with the IPIB a ticket-based conversation can be started with one click in a convenient and familiar way which is proposed to significantly decrease pragmatic boundaries for participation.	The "objects of innovation" support the distinct types of innovators to translate their ideas and requirements by using the common language and shared conceptualization. For example, the existence of the "company DNA" helps outside innovator to express their ideas for improvements.	The IPIB project setting stimulates each involved innovator to bring in new and emergent ideas or methods to be implemented. Thereby, it contributes to the reduction of semantic and pragmatic boundaries among the involved types of innovators and reduces the bounded rationality of the involved types of innovators.	Given the emergent and expanding nature of the IPIB, it continuously creates challenges for each innovator with any background, from software engineering to law. Each innovator participating in the IPIB project setting is stimulated to actively work on research issues in its own discipline.
Innovators' needs	Translation of innovators' needs into object requirements			
<i>Process dimension (routines)</i>	The ticketing system promotes a standardized and uniform pattern of interaction (routine), which easily integrates the peripheral inside and the outside innovators in the work of the core inside innovators	By actively involving all three types of innovators along the iterative improvements of the "objects of innovation" a shared practice (routine) is established.	The ticketing system allows all three types of innovators to conveniently report sudden inspirations and ideas into the innovation ecosystem; and to discuss it with the other innovators. A permanent and ubiquitous conversation about the future of the IPIB establishes as routine.	For revealing the current limitations and borders of the IPIB also on-site meetings or other face-to-face communications (with the support of the clickable IPIB prototype) are set-up as routine.

4 Discussion & Conclusion

The purpose of this paper is to understand the role of objects in interactive innovation, i.e. interaction for innovation among core inside innovators, peripheral inside innovators and outside innovators. Thereby our contribution is twofold. Our framework aims to support researchers to better understand and trace the different – and shifting – roles that objects play in interactive innovation. Building on Nicolini et al. (2012) [19] we show that a pluralistic approach to analyze the role of objects in interactive innovation is useful. In doing so, our intent has been to expand the discussion on how to enable interactive innovation. By applying our framework while designing the IPIB project setting we were able to contribute to a deeper understanding of not only “what” type of object fit best for interaction but also “when” do they fit best [19]. We show that if a distinct dimension of interactive innovation (e.g. situational dimension) is combined with a specific theoretical perspective of objects (e.g. epistemic perspective), a particular operationalization of the object, i.e. the IPIB itself or its related mechanisms is required to support the interactive innovation. It is important to emphasize the different roles that the “company DNA” or the ticket system are playing in the interactive innovation context of the IPIB project.

These findings have important implications for both information system research as well as organizational innovation research. First, experience from the practice in global requirements engineering shows that the success of software projects, which involve numbers of stakeholders with diverse backgrounds requires “even more interactive ways for communication and coordination throughout the entire project“ [35]. Our research emphasizes, that these supporting mechanisms need to go beyond the usually proposed open communication, monitoring and reporting lines. We argue that the requirements of engineering settings and practices have to be refined in terms of actively establishing different objects with their diverse functions. Thus, future research may integrate the proposed framework of “object-driven interactive innovation” in different software engineering approaches.

Second, previous interaction research has emphasized that boundary objects can also be triggers for conflict in interactions (e.g. [14], [19]), in particular if they have not been adapted to the existing context of people and work practices. From a business governance perspective, this challenge becomes even more crucial in the context of the increasingly widespread company’s approaches towards interactive innovation. Taken different types of innovators’ perspectives and needs seriously require to provide them with appropriate support mechanisms to express their ideas and contribute to the tasks they are ‘assigned’ to. The developed framework is a first step in this direction. In articulating the role of objects from different theoretical perspectives, implications for the creation and implementation of successful interactive innovation are given. Future research may want to dive deeper into what is happening if the status attributed to objects by the types of innovators differs and how this is influencing the success of interactive innovation.

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