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Erratum

How much do specialists have to learn from each other when they jointly develop radical product innovations?

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ABSTRACT

Specialists of different domains have to collaborate whenever technically demanding product innovations are developed. Their respective knowledge contributions need to be integrated into a functioning whole. Two approaches provide insight into how this is achieved: the dominating cross-learning approach assumes that the specialists of different knowledge domains have to intensively learn from each other in order to be able to jointly develop the new product. This cross-learning implies that groups of specialists transfer their specific knowledge, which encompasses different concepts (theories), methods and world views, among each other. However, some researchers argue that intensive cross-learning between specialists is a considerable expense in time and effort and, therefore, inefficient. They insist that integration of specialists' knowledge is achieved through structural mechanisms that significantly reduce the need for cross-learning. This article is based on one of the latter approaches. We argue that the mechanisms of transactive memory, modularization and prototyping in combination can considerably reduce knowledge transfers. This assumption has found empirical support for incremental innovations. On the basis of a comparison between incremental and radical innovation projects in an electrotechnical company, we analyze whether the assumption that, on the basis of structural mechanisms, specialists can integrate their knowledge without having to intensively learn from each other, also holds for radical innovations.

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1. Introduction: How do specialists coordinate their knowledge contributions to product innovations?

Knowledge from many different fields is needed to design and produce new products of a more complex nature like a new car model, a new production system or a new racing bicycle. Specialists with extensive education and training in different fields – mechanical engineering, electrical engineering, physics, software design, etc. – have to contribute knowledge to projects of this sort. Their contributions have to be coordinated in a way that the solutions specialists in one field come up with are compatible with the solutions contributed by specialists from other fields. Studies (e.g., Brusconi et al., 2001; Patel and Pavitt, 1997; Patel and Pavitt, 2000) show that large innovative companies are able to integrate knowledge from a wide range of technological fields, including fields in which they do not innovate themselves, but cooperate with suppliers. The implication is that these firms have learned to integrate different technologies within a certain range of domains. In the following we analyse how companies manage this kind of knowledge integration.

Knowledge transfer between specialists is not an easy task as severe communication problems have to be overcome: "Different percepts and different attitudes shaped by practice make interchange [. . .] remarkably difficult, and thus they invisibly pressure disciplines to work among themselves rather than to engage in cross-disciplinary research" (Brown and Duguid, 1998, p. 101). Suggestions on how to deal with this communication and coordination

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problem extend from the intensification of inter-discipline learning over the deployment of translators, mediators and boundary objects as facilitators up to the use of structural mechanisms that reduce the need for communication and cross-learning. These approaches will be described in the following section.

2. Approaches to knowledge integration

2.1. Cross-learning

Many authors dealing with the problem of knowledge integration assume that intensive cross-learning between specialists does the job. Among the first proponents of this approach were Argyris and Schön (1978, p. 17, 94). They hold that knowledge has to be transferred between individuals in order to create shared "organizational maps" that provide a basis for successful innovation through recombinations of knowledge elements. In a similar vein, Nonaka (1994), Nonaka and Takeuchi (1995), Nonaka and Toyama (2000) maintain that new knowledge is predominantly created in "cross-functional teams" (Nonaka, 1994, p. 24) in which each member acquires other members' implicit knowledge through "observation, imitation, and practice" (p. 19). The "challenging task [of converting tacit knowledge into an explicit concept] involves repeated time-consuming dialogue among members [of cross-functional teams for innovation projects]" (p. 24). Substantial communication in these teams leads to new organizational knowledge in the form of new concepts or products.

Other authors argue that knowledge transfer between specialists requires structural support mechanisms. For example, in a survey of automotive companies, Clark and Fujimoto (1991, p. 103) identified "liaison engineers" "whose principal job was to link one department (e.g., chassis engineering) with one or more related departments (e.g., body, engine, and/or production)". They also report that formal meetings were the major coordination platform and that, obviously, modularization played a supporting role as "[m]ultifunctional task forces and small teams organized around components or particular problems were commonplace" (p. 103). Brown and Duguid (1998, p. 103) conceptualize an "enabling architecture" for overcoming the barriers between cross-disciplinary communities of practice, that extends to three structural mechanisms: "organizational translators" who are "sufficiently knowledgeable about the work of both communities to be able to translate" (p. 103), "knowledge brokers" who not only translate between communities but also "truly participate in both worlds" (p. 103), and "boundary objects" such as contracts, documents and concepts that create a "compelling need to share an interpretation" (p. 104) between communities (other enabling architectures in the sense of Brown and Duguid (1998) have been suggested by Boland and Tenkasi (1995), Leonard (1998) and Carlile and Rebentisch (2003).

2.2. Reduction of cross-learning

Some authors argue that transfer of knowledge between specialists, even if supported by an enabling architecture, can easily overstrain an individual's limited cognitive capacities. For example, Demsetz (1991, p. 71) points out:

> Although knowledge can be learned more effectively in a specialized fashion, its use to achieve high living standards requires that a specialist somehow uses the knowledge of other specialists. This cannot be done only by learning what others know, for that would undermine gains from specialized learning.

Or, as Grant (1996b, p. 114) coins it:

> [T]ransferring [knowledge] is not an efficient approach to integrating knowledge. If production requires the integration of many people's specialist knowledge, the key to efficiency is to achieve effective integration while *minimizing* knowledge transfer through cross-learning by organizational members.

Consequently, Grant (1996b) identifies conditions that reduce the need for knowledge exchange: *common knowledge* such as a common language and other symbolic systems such as computer software or accounting systems facilitates coordination between specialists like musical notation enables musicians to perform together without knowing how to play instruments other than their own. In product innovation projects software systems can support coordination between specialists in a similar way by providing a common language (D'Adderio, 2001). Common knowledge that essentially is not overlapping specialist knowledge allows coordination between specialists while reducing the need for knowledge transfer. Specialists also generate routines and the essence of routines is that individuals develop sequential patterns of interaction which permit the integration of their specialized knowledge without the need for communicating that knowledge"(Grant, 1996a, p. 379). However, Grant does not specify what kind of routines these are and how they come into existence. In the following, we discuss mechanisms that contribute to reducing the need for knowledge transfer between specialists in product innovations: modularization, prototyping and transactive memory.

2.3. Modularization as a device to reduce knowledge transfer

Modularization refers to the breaking down of complex entities (products or processes) into simpler components (modules) (see, e.g., Baldwin and Clark, 1997; Simon, 1973). These modules can be developed relatively independently by specialists and can still be composed into a functioning whole (Baldwin and Clark, 1997). Modularization reduces the need for knowledge transfer between specialists:

> If all components must be tightly integrated and optimized for each other, their production often requires that all individuals involved in such design and production also work in close contact. A modular product design, in contrast, can enable the production process to be decentralized. (Schilling, 2000: 320)

To a large extent, specialists can work on "their" components without having to acquire the knowledge of specialists working on other components. The architecture

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