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Knowledge integration at the edge of technology: On teamwork and complexity in new turbine development

Cecilia Enberg, Lars Lindkvist *, Fredrik Tell

KITE, Department of Management and Engineering, Linköping University, Sweden

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Abstract

This paper takes an empirical point of departure in the development of a new steam turbine. Project work here relied on a process of iteration between a small core group of team members with extensive experience and team members with less of that currency. In this project, the core group had a major integrative role, whereas other team members were mainly responsible for the specific tasks assigned to them. Quite a few of the latter category felt uneasy about their role and felt 'decoupled' from the project. In our analysis we use the Teamwork Quality (TWQ) construct proposed by Hoegl and Gemuenden (2001). In conclusion, our findings suggest that in highly complex projects of this type, team-based knowledge integration need not presuppose equality of participation and we introduce the notion of a Segregated Team to account for these findings.

Keywords: Knowledge integration; Product development; Projects; Teamwork

1. Introduction

Product development projects typically call for the integration of a wide range of specialised knowledge bases. Moreover, it has been suggested that the degree of integration of such dispersed knowledge can explain differences in product development performance and that the firm's knowledge integration capabilities can be vital to attaining competitiveness (Carlile and Rebentisch, 2003; Hoopes, 2001). However, the question of how knowledge integration is enabled in different types of project settings has not received much attention. Instead, there has been a tendency to treat all projects as similar and equal (Shenhar, 2001; Sauser et al., 2009). Carlile and Rebentisch (2003, p. 1182) suggest that "current frameworks of knowledge transfer and integration do not apply with equal explanatory power to both simple and complex knowledge integration tasks" and that those frameworks which exist seem mainly to mirror situations which would be characterised as being rather simple and comprising limited uncertainties.

In this vein, the specific purpose of this paper is to explore the issue of team-based knowledge integration in a product development project — the Turbine project — characterised by high levels of uncertainty and complexity. The project managers and project members repeatedly stressed that the task assigned to them involved "working at the edge of technology" or "at the edge of what is possible".

> [In this project] you are really at the leading edge of technology and knowledge. […] The nature of work is such that you always try to push the frontiers of what is possible. (Experienced project member, aero)

Although, their subjective opinions cannot be taken as a fact, our case study observations largely substantiate them. Among the risks associated with the project were limited knowledge about issues that concerned extensive vibration excitation at high volume flows and only partly validated tools for aerodynamic calculations. In order to develop the new steam turbine, many different domains of technical expertise were needed, ranging

* Corresponding author.
E-mail addresses: cecilia.enberg@liu.se (C. Enberg), lars.lindkvist@liu.se (L. Lindkvist), fredrik.tell@liu.se (F. Tell).

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from knowledge about mechanical integrity and aerodynamics to blade design, design layout and testing. Project members were strongly specialised and all of them had deep knowledge of their domain of expertise. One basic challenge facing the project was how to handle the contradictory demands of aerodynamic efficiency and mechanical integrity (MI). Thus, apart from working at the edge of their competences, project members from 'aero' and 'MI' had to manage a difficult trade-off, which could not be resolved in a classical optimization manner.

2. Team-based knowledge integration

Turning first to the issue of integration, we should first acknowledge its very long history in the literature. Lawrence and Lorsch (1967), Thompson (1967) and Perrow (1970) were all concerned with the issue of how to achieve activity integration. With regard to what would affect the mode of integration that should be adopted, using slightly dissimilar terminologies, they all recognized contingencies such as complexity, uncertainty, and interdependencies. Building on these classical sources, Grant (1996) took integration-thinking a step forward by adding the 'knowledge' issue to the previous focus on activity integration. In his view, due to the difficulties and high cost of transferring and sharing tacit knowledge, such transfer should be avoided where possible. Hence, knowledge integration should be concerned with the use of appropriate mechanisms for managing knowledge complementarities to be chosen in a cost-economizing manner (Grant, 1996; Postrel, 2002; Enberg, 2007; Schmickl and Kieser, 2008). For example, while contingencies such as minimal interdependencies and limited complexity would allow for the use of cheap mechanisms (such as rules, roles and routines), severe "team interdependencies" would call for expensive and communication-intensive mechanisms, such as "group problem solving and decision making" (Grant, 1996, p. 114). As our interest lies in high complexity contexts, his advice would thus be that we have to rely on the communication-intensive and expensive team option.

A similar reliance on the team recipe is suggested by Grandori (2001). Like Grant she acknowledges the tacit-explicit knowledge distinction and looks upon the choice of (knowledge) integration mechanisms as an economizing endeavour. However, unlike Grant, who takes type of interdependences as a main contingency, she focuses on knowledge-related contingencies, such as the degree of knowledge differentiation and knowledge complexity. The first dimension, differentiation, refers to differences in technical specialities and cognitive orientations among individuals and includes differences in languages, the perception of relevant information, the theories and practices used and the types of results pursued. As differentiation increases, "the possibility of mutual understanding, of succeeding in decoding the messages, of utilizing the knowledge of others, decreases" (Grandori, 2001, p. 390). The second dimension comprises two components; namely computational complexity and epistemic complexity. Computational complexity refers to the number of elements and symbols involved and the possible connection between them. The second component, epistemic complexity, adds the aspect of knowledge tacitness. Thus, when knowledge differentiation is high and is combined with high computational/epistemic complexity — teams are appropriate, says Grandori (2001, p. 394). However, neither Grant nor Grandori provide much detail as to the nature or characteristics of teamwork that may actually bring about a functioning process of knowledge integration in such kinds of difficult development contexts.

Typically, in the literature on teams and project teams, the need for close interaction between all members is emphasized. Katzenbach and Smith (1993, p. 9), for example, state that "real teams are deeply committed to their purpose, goals, and approach. High-performance team members are also very committed to one another. Both understand that the wisdom of teams comes with a focus on collective work-products, personal growth…". Moreover, Nonaka and Takeuchi (1995, p. 242) argue that "the product development project emerges from the constant interaction of a multidisciplinary team whose members work together from start to finish". These accounts of teamwork promote the image of an interaction and communication context that underlines its compositional homogeneity and the equality of its members with regard to their authority and ability to contribute. Yet, while such features may be both common and benefit practice, they are expressed quite generally, making it difficult to use to them in order to discriminate between teamwork practices which mirror those characteristics more or less closely.

Furthermore, as shown by the extensive overview provided Hoegl and Gemuenden (2001), while the general importance of teams to the success of innovative processes is well documented in the literature, prevailing studies have a tendency to demonstrate the link between the *mere existence* of a team-based organization and innovative performance, and pay little attention to specifying in more detail what facets of teamwork may have contributed. As a remedy, they propose a Teamwork Quality (TWQ) construct comprising 6 facets: communication, coordination, balance of member contributions, mutual support, effort, and cohesion. Based on their survey study, they also report that TWQ was positively related to project success (including team performance and team members' personal success). In our view, this is a very helpful construct, which is useful in characterising team operations in the Turbine case.

In the following analysis, we will use this construct to indicate to what extent a team should be considered 'integrated' or 'segregated'. As defined in most dictionaries, segregation refers to the, more or less voluntary, physical separation of groups and individuals (NE, 2010). This concept is often used in analyses of segregated housing areas, racial segregation, etc. In such contexts, it often carries an additional connotation of lack of interaction and non-equal opportunities among various groups. In the Turbine project, all the team members were co-located, and our choice to use the TWQ construct to account for segregation facets in the Turbine project is thus a means to recognize these additional interaction/equality aspects.

Focusing on its quality of interaction and equality features, we below present the six facets that make up the TWQ construct in a shortened version (Table 1).

As will be detailed in the case section below, the Turbine project team relied very much on a process of iteration between