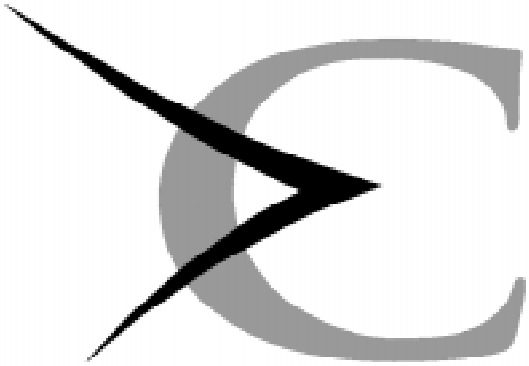

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Learning Conditions in the Context of R&D and Development Projects: Empirical Evidence from a Research Centre

Mario Bourgault, Hélène Sicotte

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Learning Conditions in the Context of R&D Development Projects: Empirical Evidence from a Research Centre*

Mario Bourgault†, Hélène Sicotte‡

Résumé / Abstract

L'environnement actuel impose une importante transformation des organisations. Ces changements sont principalement guidés par la nécessité d'accroître le niveau de compétences et de savoir-faire, tant au niveau individuel qu'au niveau collectif. Ce renouvellement constant du potentiel organisationnel s'opère par la voie d'un processus d'apprentissage qui touche tous les niveaux de l'organisation. En pratique, cet apprentissage est facilité par la réalisation de projets de développement. Ce type de projets, selon plusieurs auteurs, agit comme catalyseur et permet d'accroître plus rapidement la capacité des firmes « d'apprendre ». Par le fait même, ces projets induisent des changements importants dans les façons de faire des organisations. La présente recherche s'inscrit dans ce courant actuel qui vise à mieux comprendre le processus d'apprentissage organisationnel par la voie de réalisation de projets de développement (produits/procédés). Cette étude exploratoire s'appuie sur des données portant sur 139 projets réalisés dans une organisation québécoise dédiée à la R&D et au développement de produits.

Today's changing environment is bringing about a major transformation of the way organizations operate. Most of the discussion about such evolving environment focuses on the necessity for organizations to continuously renew their stock of knowledge and competencies. This renewal takes place through a learning process by which knowledge is acquired and transferred throughout the organization. In practice, some authors have proposed that development projects can act as catalysts on the way firms learn and accrue know-how. While these projects lead to new products, they also allow for a transformation of the organization in which they take place. This study builds on previous research and proposes an empirical exploration of how, in practice, project management can support organizational learning through development projects. Data used for this research contains information on 139 R&D projects undertaken in a large corporation located in Quebec.

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Introduction

Project management writings have traditionally dealt with efficiency-seeking practices. Techniques and insights relating to activity planning, organizing and controlling provide project managers with valuable tools for undertaking their duties. Over the years, a body of knowledge in project management has been established and made available to a broad audience. The rate at which PMI's PMBOK Guide[1] has been disseminated is a striking indication of the interest in and need for such formalized knowledge.

However, the mainstream literature is now being challenged by many authors. Some of them, such as Meredith and Mantel (1995), would like to see more writings that "[not only] identify details of how to carry out projects, [but that would also] address the larger questions of why they are required and how they all fit together." The key role of project management as a vehicle for organizational strategy implementation is better recognized now and thus more widely investigated (Grundy, 1998). Similarly, Shenhar et al. (1997) have proposed four dimensions of project success which clearly illustrate the strategic role of projects. Their empirical studies suggest that, beyond measures such as efficiency and customer satisfaction, projects must be evaluated in terms of what impact they have on the organization on a short- and long-term basis. In their investigation of product-development projects, Bowen et al. (1994) also conclude that projects must be evaluated in terms of their contribution to renewing the firm's capabilities. For all these authors, projects are intimately linked to a learning process and should be evaluated on that basis, in addition to the traditional criteria of effectiveness and efficiency.

Building on this stream of research, our study proposes an empirical exploration of how, in practice, R&D project management practices can support organizational learning, from a multi-level perspective. The data used for this research are based on 139 R&D projects undertaken within a large corporation. The preliminary results should assist both researchers and practitioners in better understanding what mechanisms come into play in this setting.

Projects as learning mechanisms

Discussions of today's environment generally emphasize the prominence of knowledge-based competition and its impact on management (Levy, 1998;

[1] Project Management Body of Knowledge Guide, published by the Project Management Institute

Nonaka and Takeuchi, 1995; Thurow, 1992). Firms must continuously improve their production technologies, while focusing on new markets and new products (Schewe, 1994). Underlying the generation of new knowledge and capabilities is the organizational learning process. Just as individuals must develop insight, knowledge, and associations between past and future actions, organizations are also seen as being able to learn (Fiol and Lyles, 1985). In a broader sense, as proposed by Garvin (1993), an organization that is able to learn can be described as "an organization skilled at creating, acquiring, and transferring knowledge, and at modifying its behavior to reflect new knowledge and insights." Although conceptually appealing, it remains difficult for firms to learn and to upgrade capabilities because neither the context nor the process are grasped.

In order to meet this challenge, more attention is being paid to project management as a way of formalizing a firm's development activities. Indeed, projects have an intrinsically strong "mobilizing power" compared to normal operations. Although projects are focused on a small number of generally well-defined objectives, they are undertaken as one-shot efforts and require extensive contributions by various specialties. Project management processes involve the mobilization of numerous resources and the creation of interconnections among team members and external partners. Moreover, since they are particularly constrained by high levels of uncertainty and specific targets (time and budget, for example), projects tend to receive much more attention from stakeholders (Midler, 1995). For all these reasons, the "project mode" represents an appropriate context for renewing a firm's know-how and offsetting organizational inertia. For example, the potential of projects as learning platforms was highlighted by Leonard-Barton et al. (1994) in their description of Kodak's Funsaver project. The development of CAD/CAM technology as a facilitating tool for teamwork was an explicit goal of that project. In addition to all the benefits gained due to the new product itself, the organization acquired new capabilites which were applied to subsequent projects.

Using projects to accomplish specific learning goals leads one to examine the various project management practices to see whether they can support such objectives. How to accumulate knowledge (about project products and project management processes) and transfer it to subsequent projects remains a critical challenge for practitioners. A recent study has provided numerous examples of such difficulties (Bartezzaghi et al., 1997). Various organizational barriers still exist and many firms repeat the same errors from one project to the next: most of the time, they do not invest enough resources in information technology, they overlook the project termination phase or they ignore the learning contribution of failure. If firms are to improve their performance through the projects they

undertake, they must investigate their own processes from the point of view of learning.

How to create a project management environment that enables learning: design of an empirical research study

Few studies have empirically investigated organizational learning, and the operationalization of this concept is an unresolved issue. Even the traditional learning curve concept, which focuses on inputs and outputs, does not provide a full picture of how learning really occurs in organizations. In general, researchers manage to identify and measure factors related to the outcome of learning, such as performance. This approach is basically that taken by theorists like Schein and Senge, who investigate and propose various "enablers" of productive learning. From this perspective, it is assumed that learning has a favorable impact on the organization and that performance should be improved whenever it occurs. Lynn (1997) provides a good example of this approach in his empirical study. He uses some factors associated with increased individual learning and aggregates them within an organizational learning context. He then relates these factors to the success/failure of certain projects. In accordance with previous studies, we therefore hypothesize that learning occurs when various mechanisms and practices are put in place and project performance is favorably influenced. In our study, which takes a cross-sectional approach (conducted at one point in time), we therefore adopt the productive-learning hypothesis and assume that, owing to a lack of direct measures for learning, we can only measure its outcome: project performance.

In terms of empirical analysis, our intent is to measure the association between some components of a firm's learning system (learning-enabling functions) and their effect on project performance, which we regard as an outcome of a successful learning process. Our research design is based on a multi-dimensional view of such a learning system, as detailed below.

A Multi-Level Analysis

In addition to the conceptual model, which describes the relationship between learning mechanisms and project performance, our approach features a three-level analysis, which reflects the various interactions between the main stakeholders of a project. In a typical development project, it is possible to identify three main interaction levels: within the team, between the team and its

parent organization and, finally, between the team and the customer. Along with Lynn (1997), we therefore assume that this three-level perspective best reflects the execution of development projects in organizations as well as the underlying learning process. This is also in accordance with Argyris and Schön's (1996) prescription that studies about learning "… must take account of the interplay between the actions and interactions of individuals and the actions and interactions of higher-level organizational entities."

From this perspective, learning mechanisms are to be described first in relation to the project team's activities and behavior. If learning is to contribute to better project management processes, it should first emerge from the level (Level 1) where the people are most directly involved in acting and decision-making. Along with other researchers, we also argue that the parent organization has a key role in the way knowledge and capabilities generated at the project level can be leveraged for future use and for the benefit of the whole organization. Since most organizations have a longer life than their own projects, they must ensure that information is processed in such a way that it is beneficial to all other projects. "Level 2 learning" therefore involves interaction between the team and its immediate environment, namely the parent organization. In this research, we also propose to include a third level of learning, which takes into account the process of exchanging information between the project team and the customer. Recent studies on networks and partnerships have examined how such organizational configurations can learn by developing shared practices among the various entities involved (Jacob et al., 1997, Batchelor et al., 1995).

Two Learning Functions

In order to characterize the learning functions at each level, we adopt the information-processing model of learning, such as proposed in previous research (Huber, 1991). This model has been applied in various settings and, in particular, in development projects (Durate and Snyder, 1997). From this perspective, the organization's ability to learn is primarily based on the way information is generated and distributed among the project participants. In order for this information (or codified knowledge) to really contribute to organizational learning, it must also be stored in such a way that it can be accessed and used in future projects. Key functions of the organizational learning system should therefore include generation, analysis and storage, and quick distribution and transfer of information (Durate and Snyder, 1997). This view of learning has been adopted by many studies. Through information processing, groups better grasp their own reality and act according to shared rational schemes.

Management of information is, in fact, critical for all projects, as indicated in PMI's PMBOK Guide and ISO standards. As a specific knowledge area, project communication management primarily deals with the generation, collection, dissemination, storage and disposition of project information.

Learning is not only about processing information, however. As many studies have suggested, learning is also about the relationships between the people involved in the process (Dodgson, 1993). Batchelor et al. (1995) argue that organizational learning is a "product of the social relationship (...) team learning is essentially one of communication." Insofar as a continuous interaction must take place between project team members and stakeholders in order to process information, the nature of the relationship between them (and the supporting structure and mechanisms) may have a major impact on the outcome. Collective scheme, trust and commitment shape the way information is perceived and processed. Any attempt to study organizational learning must therefore look at how information is processed and who is involved. This view is consistent with the dual nature of organizational knowledge, which is both codified and tacit. Whereas codified knowledge can be easily transmitted and exchanged by standard information technologies, tacit knowledge requires far more involvement by entities that hold it. Richer media must be involved (Daft and Lengel, 1986).

Our analysis therefore proposes to look at learning in terms of both information processing and relationships. Because learning is multidimensional, the system that supports it must also be multidimensional. For example, Argyris and Schön (1996) propose that the structural and behavioral features of an organizational learning system should include channels of communication, information systems (media and technology), spatial environment, procedures and routines, and systems of incentives that influence the will to inquire. In this study, we propose two groupings of variables (see Exhibit 1), which aim to characterize these two aspects of learning.

Exhibit 1

Three Levels of Investigation	Two Learning Functions Investigated
• Within team • Project team vs parent organization • Project team vs customer	• Information-processing mechanisms • Relationship regulating mechanisms

In summary, this study considers learning enablers to be defined according to two main functions and three levels, as shown above. It is hypothesized that learning enablers must be found at three levels in order to be effective, namely within the practices of the project teams, in the relationship between the project and the organization that executes it and, finally, in the relationship established with the project's final customers.

Method

Data Collection

A comparative study was conducted in a large corporate research centre in the public-utility sector. Although a single research site simplifies data collection and controls for certain confounding contextual factors, it can limit the variability of learning experiences. Prior to formal data collection, we conducted a number of preliminary interviews to verify whether the projects and procedures were sufficiently varied. There appeared to be more than enough diversity to make the proposed research meaningful. The projects included research studies, process-development projects and product-development projects for both internal and external clients. Researchers working on project teams were asked to identify two completed projects they had worked on in the last two years, one they considered a success and the other a failure. This requirement prevented the accumulation of data on exceptional projects only and ensured more variability between evaluations. Overall, 152 projects were evaluated and 252 evaluations were gathered by means of self-administered pre-tested questionnaires and interviews. Because several projects were evaluated by two or more researchers, we aggregated individual data taking into account each respondent's level of involvement.

Definition of Variables

This section briefly presents the variables used for the analysis, according to the three interaction levels and the two main learning functions. A complete list of variables is provided in Exhibit 2.

Learning-Enabler Functions at the Team Level. As mentioned above, a key function for enabling learning at each level is the information-sharing structure and the coordinating mechanisms put in place by the project stakeholders. Sharing information is central to decision-making, both at the project management and at the team level. The information-sharing structure at the team

level measures the existence of some basic practices such as interfunction meetings and employee participation in decision-making processes (Adler, 1995; Hitt et al., 1993; Keller, 1994). Variables were used to determine whether formal procedures such as the go/no go evaluation process or quality circles were used, along with a formal plan for measuring progress and evaluating the improvement to be made in the project management practices undertaken by the team. For product development projects in particular, formal evaluation processes (go/no go gates, milestones, etc.) are vital for meeting objectives. The quality movement has also created stringent requirements for new products which require formal practices for continuous improvement. This should have a major impact on a firm's capacity to learn.

As mentioned previously, the regulation of relationships among team members is vital for creating an environment that stimulates learning. On a personal basis, the necessary actions must be taken to ensure that each individual knows what the team leader expects from him/her, whether formally (Ancona and Caldwell, 1990) or informally with a champion (Bower, 1970; Maidique, 1980) who will drive the development project as his own. Team members were also asked to evaluate the general atmosphere within the team and the extent to which they could relate to each other, since communication and climate are recognized as central to all projects (Gales et al., 1992; Moenaert et al., 1995; Allen, 1986; Eisenhardt and Brown, 1995).

A within-project list of variables was completed including the major element of an information-processing vision. Information-processing technologies such as expert systems, CAD and videoconferencing were evaluated according to what role they played for a specific project. These technologies are seen as a means of coordination and communication (Hitt et al., 1993; Dean and Snell, 1991; Adler, 1995) and may be central to the learning system and the creation of a corporate memory.

As previously highlighted, management support of project teams appears to be very important to the success of a project since this kind of attention guarantees access to resources (Badawy, 1991) and lessens financial, structural or cultural problems. The support of parent organizations is crucial, particularly for projects which define products. We have therefore defined this subset of variables in order to identify the existence of common objectives and the quality of information being circulated. At the firm level, a champion will mobilize key resources and gain support from top management (Quinn, 1979; Tushman, 1979), whereas formal leadership manages the day-to-day activities of the team

with a certain amount of autonomy and decision-making authority (Ancona and Caldwell, 1990; Gupta and Wilemon, 1990).

Learning-Enabler Functions at the Team-Customer Interface. As the project unfolds, information processing structure and support appear to be essential to result in a good comprehension of the customers' needs.

Performance of Projects. Project performance may be assessed on three dimensions. Product value to the customer, as evaluated by the supplier, can be seen as one of the most critical aspects since it leads to product acceptance. The product should be technically superior, represent minimal risk for the customer and reflect previous experience with production processes and markets (Cooper, 1994; Zirger and Maidique, 1990). The achievement of goals, whether based on financial, quality or time considerations, is the focus of objective project performance, whereas researcher satisfaction with the project is another, complementary aspect, as discovered by Pinto and Pinto (1990) and Sicotte et al. (1997).

Exhibit 2: Learning Enable Framework: A Three-Level of Analysis

Level 1: Within-Team			
Factors	Definitions	Measures	Reliability of Construct[1]
Information processing structure and support	Information sharing system at the project- management level	2 items	0.56
	Information sharing system at the team level	2 items	0.59
	Overall coordinating and validating mechanisms	5 items	0.66
Regulation of team members' relationships	Quality of information provided within the team	5 items	0.81
	Feedback provided to team members	3 items	0.82
Information processing technologies	Computer-aided decision support technologies	4 items	n.a.
	Computer-aided design technologies	2 items	n.a.
	Communication technologies	5 items	n.a.
Level 2: Team-Organization			
Factors	Definitions	Measures	Reliability of Construct[1]
Information processing structure and support	Agreement on common objectives	1 item	n.a.
	Quality of information within organization	5 items	0.72
Regulation of internal stakeholders' relationships	Management support	3 items	0.81
	Formal leadership	3 items	0.68
	Project champion	3 items	0.83
Level 3: Team-Customer			
Factors	Definitions	Measures	Reliability of Construct[1]
Information processing structure and support	Level of understanding of customers' needs	1 item	n.a.
Regulation of team-customer relationships	Involvement of customers	1 item	n.a.
	Customers' approval mechanism	1 item	n.a.

1. Reliability of construct was evaluated using Cronbach alphas; n.a.: not applicable.

Results and discussion

Our findings are presented on Exhibits 3 and 4. Data analysis was carried out in two separate steps, using the learning factors (Exhibit 2) as independent variables and the three definitions of project performance as the variable to be explained. We first examine how well the learning factors can predict project performance using general linear models (GLMs) for each definition of performance. A first look at the three linear models shows a reasonable level of prediction (R^2) for all of them, although it is stronger when one considers objective performance and value to customer.

Objective performance, which is described in terms of traditional criteria such as cost and time targets, appears to be simultaneously predicted by within-team factors and team-organization factors. This result supports the view that strong interaction with the parent organization's mechanisms and resources is required to perform as a team, and this seems to be particularly true for product-development and R&D projects. Exhibit 3 shows different patterns of performance prediction, however, for the two other performance criteria. The results show similar patterns of prediction for personal satisfaction and value to customer. In both cases, within-team and team-customer learning factors have a significant impact on performance explanation. A key finding from a learning perspective is that management must recognize that its efforts to implement some kind of "learning network" may not be measurable by traditional means.

This finding may also be related to some recent studies that have suggested that performance criteria vary along the project life-cycle. For example, cost and time overruns tend to be ignored after a certain period of time by most people involved in a project, especially if the outcome provides them with many benefits. In the long run, project performance would therefore be linked to the outcome it can provide to stakeholders, rather than to the efficiency criteria used during production. In these cases, broadening the concept of performance to include team-member and customer-centred criteria (as in models 2 and 3 of Exhibit 3) emphasizes the value of interorganizational learning mechanisms.

A last key result (as seen in Exhibit 3) concerns within-team learning functions, which appear to be the only significant factor that simultaneously impacts all three types of performance. This is a strong indication that maintaining cohesive and effective learning support for team members is central to project success. Therefore, management should primarily act on the basic team functions related to project management activities in order to satisfy the most stakeholders.

Exhibit 3: General Linear rtrtr Models (only significative results appear)

		GLM1	GLM2	GLM3
Level	Main factors as per level of analysis	Objective Performance	Personal Satisfaction	Value to Customer
1	Within-Team Factor	✔	✔	✔
2	Team-Organisation Factor	✔		
3	Team-Customer Factor		✔	✔
	R^2	0.25 ****	0.15 ****	0.24 ****

$p<0.001$ ****

In order to obtain a more complete picture of the role played by the various learning mechanisms, a regression analysis was conducted on the results obtained in Exhibit 3, using the stepwise procedure. Exhibit 4 shows the results for the last model obtained, that is, after all blocks of variables had been entered sequentially.

One of the most striking results appearing in Exhibit 4 is the importance of the learning function related to the regulation of relationships for the three types of performance and particularly for personal satisfaction criteria. Except for the team-customer level, the regulation of relationships seems to prevail over functions related to information processing. This provides additional support for the importance of feedback and validation in a project, which are indeed a vital part of the learning process.

However, information-processing mechanisms are important for predicting all three kinds of performance at Level 3. This may be the result of interorganizational barriers (both physical and non-physical) that project stakeholders must overcome. Sharing information within organizations remains relatively simple (although counter-examples could be found in very large settings), but it is quite different when two or more entities are involved. Efficient information-sharing structures and coordinating mechanisms are then associated with higher performance.

As for information processing technologies, they appear to show a strong predictive power for non-traditional performance measures (personal satisfaction and value to customer). This is intriguing at first since those hard technologies are most often associated with efficiency criteria. It can be

concluded, however, that using those technologies has a positive impact on the project's quality which, on the one hand, gives personal satisfaction to team members and, on the other hand, adds value for customers.

Exhibit 4: Multiple Regression – Stepwise - Model 3 – Standarized ß value

	Objective Performance	Personal Satisfaction	Value to Customer
Level 1: Within-Team			
Information processing structure and support			
Regulation of team members' relationships	0.251 ***		
Information processing technologies		0.164 **	0.235***
Level 2: Team-Organization			
Information processing structure and support			
Regulation of internal stakeholders' relationships	0.131 *	0.222 **	0.127 *
Level 3: Team-Customer			
Information processing structure and support	0.489 ****	0.269 ***	0.506 ****
Regulation of team-customers' relationships	0.132 *	0.225 ***	
R^2	0.245 ****	0.482 ****	0.413 ****

* : p<0.1; ** : p<0.01; *** : p<0.05; **** : p<0.001

Conclusion

This study provides some preliminary results on the issue of organizational learning within the context of project management. Much has been said on this topic over the last few years but very few studies have proposed empirical data. It is suggested that more studies of this type are required in order to enrich our understanding and promote discussions between academics and practitioners.

As a preliminary step, this study measures the association between some components of a firm's "learning functions" and project performance, which is taken here to be the outcome of a successful learning process. The research design is based on an original framework where both learning functions and project performance are seen as multidimensional concepts.

Our results highlight the necessity of using various measures of project performance when evaluating learning functions since we were able to detect important variations based on the level and the type of mechanisms, for each type of performance. These results also suggest that learning mechanisms pertaining to the team (within-team factors) are the best predictors of performance, whatever measure is selected. The prominence of relationship-related mechanisms in predicting project performance is also emphasized, compared to information-processing mechanisms.

In order to move forward and improve our understanding of learning processes from a project management perspective, much more empirical research is required. Future research could investigate whether further learning patterns may emerge based on project characteristics such as size, complexity and level of cross-discipline cooperation.

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