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Developing a dynamic project learning and cross-project learning capability: synthesizing two perspectives

Sue Newell* & Linda F. Edelman†

*Bentley College, 175 Forest Street, Waltham, MA 02452, USA, and Warwick Business School, The University of Warwick, Coventry, CV4 7AL, UK, email: snewell@bentley.edu, and †Bentley College, 175 Forest Street, Waltham, MA 02452, USA, email: ledelman@bentley.edu

Abstract. *Driven by the complexity of new products and services, project work has become increasingly common in all types of organizations. However, research on project learning suggests that often project teams do not meet their stated objectives and, moreover, there is limited organizational learning from the experiences of project work. We use the dynamic capabilities framework to argue that building a dynamic project learning capability is useful for organizations that make extensive use of projects. We use both survey and interview data to discuss the key ways in which such a dynamic capability can be built. Our survey data demonstrate the importance of documenting project learning, but our interview data show that teams are often remiss at documenting their learning. The results from the two different approaches are synthesized using Boland & Tenkasi's notions of perspective-making and perspective-taking. Importantly, combining the results from the two sets of data suggests that organizations need to emphasize the benefits from project reviews and documentation and explore ways in which the documents produced can be made more useful as boundary objects to encourage the sharing of learning across projects.*

Keywords: project learning, cross-project learning, knowledge transfer, case studies, structural equation modelling

INTRODUCTION

In today's dynamic environment, motivated by the need for flexibility and speed, cross-functional project work has become common in all organizations (Salas *et al*., 2000; Van der Gerben *et al*., 2002). Unfortunately, many cross-functional projects often fail to meet their deadlines, or fail to deliver output that meets expectations (Cozijnsen *et al*., 2000; Matta & Ashkenas, 2003). While clearly a problem, an even more widespread issue is that organizations fail

to learn from their different project experiences (Lyytinen & Robey, 1999; Kearns, 2004). Thus, whether a project team has been effective or ineffective in its attempt to create new ideas/products or design and implement new systems or practices, there should be something that the team can learn from the experience; moreover, it should be possible to share this learning across the distributed organization so that either the successes are replicated or the failures are avoided by a better understanding of what led to the failure (Irani & Love, 2000).

In this paper, we look at both qualitative and quantitative data from a study exploring the barriers and facilitators to project learning and cross-project learning transfer. We define project learning as the creation and acquisition of knowledge within projects (Ayas & Zeniuk, 2001; Berends *et al*., 2003) and cross-project learning transfer as the subsequent transfer of such knowledge to other projects within the organization (DeFillippi & Arthur, 1998). We consider the ability to transfer knowledge across projects to be an example of a dynamic capability, since this activity is focused on modifying operating routines, in this case operating routines associated with project work (Teece *et al*., 1997). Mechanisms to support project and cross-project learning will facilitate the creation and evolution of this dynamic capability. These mechanisms can rely on either personal networks and networking or the creation and transfer of documents where the learning has been codified (Hansen, 1999). Our research is focused on assessing the relative usefulness of personal networks and codified documents for encouraging the development of a dynamic capability related to project working within an organization.

Interestingly, the qualitative interview data indicate that individual project team members do not feel that documenting their learning has been helpful. Instead, team members stressed the importance of personal networks. This finding is consistent with other research (Von Zedtwitz, 2002). However, the survey data paint a different picture. Here the evidence suggests that creating and sharing documents related to what has been learnt on a project was significantly related to the degree of project learning and cross-project learning transfer, and to project success. This finding is consistent with Zollo & Winter (2002) who argue that knowledge codification processes can play an important role in the development of dynamic capabilities. We discuss the findings using Boland & Tenkasi's (1995) notions of perspective-making and perspective-taking, seeing the documents of learning as a type of boundary object (Carlile, 2002).

BACKGROUND AND HYPOTHESES

Research indicates that it can be difficult to capture and share learning across projects (Prencipe & Tell, 2001). The 'stickiness' of project-based learning (von Hippel, 1994; Szulanski, 1996) means that organizations often 're-invent the wheel' across different projects (Lyytinen & Robey, 1999). That is, each project goes through its own cycle of exploration in order to solve problems, rather than exploit knowledge that is already potentially available in the organization (March, 1991). Many organizations have tried to address this problem, so that it is common for organizations to have established practices that are aimed at retaining what has been learnt on a project so that it can be leveraged by other projects (Raelin, 2001). These practices

assume that a project team should not only learn and share this learning with others but also use the learning from past projects to improve its own efficiency. In this way, on any particular project learning can be both shared with others to improve other projects' working and received from others to improve the focal project work.

Typically project learning practices involve each project undertaking regular project reviews and maintaining project documentation. This documentation is then made available to other projects so that they may benefit from the learning which has already occurred within the organization. Thus, project teams are expected to engage in project reviews, where project members are asked to reflect on the learning that has taken place on the project, which is then documented for others to use (Schindler & Eppler, 2003). These reviews are typically done at the end of the project; however, they also occur when a project has met a series of predetermined milestones (Kotnour, 1999).

Once learning has been captured and codified through the project review process, the reviews are stored in databases, which are typically available to others through some kind of groupware system or intranet, regardless of time and space proximity (Kock & McQueen, 1998). The rationale for codifying the review process is that these documents can supplement the sharing of project lessons through personal networks. In this way, project reinvention will be avoided through capturing, storing and distributing what has been learnt on different projects (Sharp, 2003). Indeed, such project-learning reviews and documentation capture practices could be considered to be 'best practice' because they are prescribed in most project management methodologies. However, the emphasis is typically on procedures to ensure that project teams undertake the reviews and document and store their learning for others, rather than procedures which mandate that project teams ensure that they are using learning from past projects (Project Management Institute, 2002). This is also the case with respect to knowledge management (KM) more generally, where again the emphasis is typically on the supply rather than the demand for knowledge (Scarbrough & Swan, 2001). Our qualitative case research illustrates the problem with this one-sided mandate for project learning and cross-project learning transfer.

The work of Zollo & Winter (2002) would suggest that the deliberate practices of project review and documentation of learning would be helpful in building the dynamic capabilities of an organization. They define a dynamic capability as 'a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness' (p. 340). Winter (2003) notes that a dynamic capability is qualitatively different from other change mechanisms such as 'brilliant improvisation' or '*ad hoc* problem-solving' in that, unlike the other change methods, a dynamic capability is a patterned collection of routines concerned with change. Winter (2003) recognizes that *ad hoc* problem-solving is a viable alternative to developing a dynamic capability, given the expense of sustaining such a capability over time. However, in organizations where projects are regularly used, institutionalizing systems and procedures, with the help of IT, that make the capture and sharing of learning across projects routine is likely to be beneficial (Williamson & Iliopoulos, 2001), despite the cost. This can help an organization to exploit the learning achieved from individual and group learning processes (intuiting, interpreting and integrating) which are more geared towards exploration than exploitation (Crossan & Berdrow, 2003).

In terms of the development of a dynamic capability, Zollo & Winter (2002) argue that while informal experience accumulation can facilitate development, this will typically not be as effective as a more systematic approach to capability enhancement through processes of knowledge articulation and knowledge codification. Experience accumulation refers to the tacit accumulation of experience by individuals over time and the use of that experience to improve practice in an incremental fashion. In relation to enhancing project learning and cross-project learning transfer, experience accumulation refers to the reliance on individuals moving from project to project, taking their accumulated experience with them (Senge, 1990). If an individual was in a project where learning from a previous experience was relevant, they could then use this in the context of the new project. Strategically utilizing accumulated experience, so that people are assigned to projects where their previous experience is going to be applicable, would mean that there may be more efficient team learning on a project, because the individuals involved have been assigned based on the fact that they have learnt how to solve the problems that are likely to be faced (Cohen & Levinthal, 1990) and so have greater ability to learn. In relation to cross-project learning transfer, we can predict that experience accumulation is also likely to significantly enhance this, since assigning staff based on their experience is used precisely because it can enhance learning transfer across projects. This leads to our first two hypotheses:

H1a: Experience accumulation – achieved through individuals sharing experiences from past projects – leads to team learning.
H1b: Experience accumulation – achieved through individuals sharing experiences from past projects – leads to cross-project learning.

Relying on experience accumulation, however, according to Zollo & Winter (2002) is not the most effective way to build up a dynamic capability. Rather they suggest that knowledge articulation is a more effective mechanism for doing this. Knowledge articulation is defined as the 'deliberate process through which individuals and groups figure out what works and what doesn't in the execution of an organizational task' (p. 341). Knowledge articulation thus occurs when individuals or teams make a cognitive effort to enhance their understanding of the causal links between actions and outcomes. The requirement for teams to engage in deliberate project reviews and reflection sessions in order to develop a collective understanding of what works and what does not, is an example of a knowledge articulation process that should aid in the development of an enhanced dynamic project-working capability. In this sense, knowledge articulation can be thought of as a process of perspective-making (Boland & Tenkasi, 1995). Perspective-making refers to the processes involved in strengthening the unique knowledge of a particular community of knowing. The project team then, in its lessons-learnt review, is engaged in perspective-making, with the review encouraging the project team to develop and strengthen its own knowledge and practice about what makes for a successful or unsuccessful project. In essence, the team is creating a joint understanding about the causal links between actions taken and outcomes. Knowledge articulation should help a team to make sense of their own actions and outcomes and in doing so, enhance team learning. This in turn should make individuals within the project team more able to transfer team learning to other projects through

various kinds of networking events, because if the team has not clearly articulated what has been learnt as a collective, there will be little to transfer over and above what individuals have accumulated from their experience. This leads to the hypotheses:

H2a: Knowledge articulation – achieved through project meetings and reviews – leads to team learning.
H2b: Knowledge articulation – achieved through project meetings and reviews – leads to cross-project learning transfer.

Moreover, Zollo & Winter (2002) argue that if teams are also required to codify this reflective learning, this should be even more useful in terms of developing this dynamic capability, because 'Knowledge codification is a step beyond knowledge articulation' (p. 342), allowing the knowledge to be accessed and used by others sometime in the future and is not dependent on personal networking. While they recognize some of the costs associated with codifying knowledge, which explains why so much knowledge is not codified, they nevertheless argue that it can help support the development of dynamic capabilities and is particularly useful in rapidly changing environments where such dynamic capabilities are important. The actual activity of creating a document to capture learning may further enhance perspective-making within the project team, as well as then be available for other teams to learn from, through a process of perspective-taking (Boland & Tenkasi, 1995) that reaches well beyond the potential of individual networking. As Boland & Tenkasi (1995) point out, perspective-taking can only occur if the knowledge of others has been represented in some form and made available to others as a boundary object (Star, 1989; Carlile, 2002). Documented lessons learnt, as boundary objects, potentially provide this knowledge representation that will enable other groups to engage in a perspective-taking process, as long as others actually identify and attempt to make sense of this prior learning. The demand to codify lessons should thus enhance team learning and cross-project learning transfer. This leads to the hypotheses:

H3a: Knowledge codification – achieved through documenting project learning – leads to team learning.
H3b: Knowledge codification – achieved through documenting project learning – leads to cross-project learning transfer.

It is also important to consider the relationships between knowledge articulation and knowledge codification. Organizations can utilize experience accumulation as a mechanism to support cross-project learning independently of either knowledge articulation or knowledge codification. However, in order to codify team knowledge and learning from a project, it is necessary that this knowledge is first articulated; while it is possible to articulate knowledge but not to move to the next step of codifying the knowledge, it is not possible to codify without first articulating. This leads to our next hypothesis:

H4: Knowledge articulation precedes knowledge codification.

Finally, it seems reasonable that project teams which learn from previous experiences are more likely to be successful since this learning ability will help them to solve problems that are

inevitably encountered in project work. More importantly, in relation to a cross-project learning dynamic capability we hypothesize that where there is more cross-project learning transfer, there will be greater project success as projects are able to learn from past projects. Of course, this assumes that knowledge is both sent and received and used. Thus, we hypothesize:

H5a: Team learning is likely to lead to project success.
H5b: Cross-project learning transfer is likely to lead to project success.

We turn next to the empirical study that focuses on exploring and testing these hypotheses.

METHODOLOGY

Sample

This investigation is a multiple-method study of a large utility organization in the UK, hereinafter referred to as Utilityco. The research presented in this inquiry is part of a larger project based in the UK that involved six organizations in diverse economic sectors. Using multiple methods allows us to triangulate our findings (Jick, 1979), thereby providing us with unique insights from the rich detail from the interview data coupled with survey data that allow us to more systematically explore linkages across variables. We chose to focus on one organization in this paper because of our interest in firms that were operating in dynamic environments. This particular organization has undergone significant environmental changes because of privatization and the ensuing increased competition. This organization also makes extensive use of project teams for a variety of different work activities.

Case study data

We collected both qualitative (interview) and quantitative (survey) data from Utilityco. The focus of our inquiry was on understanding the processes by which project-based learning and knowledge is created and transferred and the role of experience accumulation, knowledge articulation and knowledge codification in doing this. While we asked similar questions in both the interviews and survey, the nature of interviews allows us to probe questions more deeply than in the survey questionnaire. Appendix A compares questions from the interview protocol with the survey questions that comprise our measures.

Qualitative data collection

In our interviews at Utilityco, we focused on two projects. Projects were chosen by the organization based on a set of guidelines set by the research team. Since we were interested in general project-based learning issues, we asked the organization to provide us with typical projects. We also recognized the difficulties in comparing projects at different phases in their life cycle (Leonard-Barton, 1990), so we requested mature projects that were well established

in the organization and where we were likely to be able to follow the project to completion. In Utilityco, the two projects chosen for our investigation were both complex, multi-phase projects nearing the end of their life cycle. Such projects were very common in the company; however, they did have projects of all lengths and levels of complexity.

Interviewing was chosen as the method of investigation because there is a strong indication in the organizational learning and knowledge transfer literatures that the context in which the transfer occurs is extremely important (Szulanski, 1996). We interviewed 21 project members across the two projects. In each case, we interviewed the project manager and a large number of people involved in the project, thereby providing a holistic understanding of the challenges involved in project learning. We asked these individuals not only about their specific experiences on the case projects but also about their more general experiences of project work in Utilityco. Interviews lasted, on average, approximately 1 h and 15 min. At each interview, the researcher gave a brief example of project learning and cross-project learning transfer to help the respondent understand the general phenomenon of interest. In addition to the interview data, we also collected archival project documentation to include project process charts as well as minutes from previous project meetings.

Qualitative data analysis

As is typical in inductive studies, writing the two case studies was an iterative process in which the data were constantly revisited (Eisenhardt, 1989; Yin, 1989). Our first step was to write a descriptive account or 'story' about each case (Wolcott, 1994) in order to begin to determine what the critical elements were within each project in relation to both learning within the project and sharing learning to and from other projects. Subsequently, the data were revisited and coded using NVivo. Data coding was also an iterative process in which the research team searched the data for regularities and patterns and then recorded these key words and phrases to represent topics or themes which became the categories for further study (Bogdan & Biklen, 1992). Within each category, if inconsistencies occurred among the data collected, third party sources were consulted for clarification. Triangulation across the different sources of primary and archival data revealed a high level of data consistency. In this paper, we have selected case vignettes that provide us with the clearest example of the particular issues of interest (see Orlikowski, 1993). In addition, we adopt Locke's (2001) approach of alternating between 'telling' and 'showing' by weaving together the data from the transcripts with the theoretical elements.

Survey data collection

To collect our quantitative data, we contacted a senior manager at Utilityco who provided us with a list of 400 projects[1] that were ongoing in the company. We sent each of the 400 projects an electronic questionnaire, and using Dillman's (2000) multiple contact method, we sent

[1]Our respondents were principally engineers.

numerous electronic reminders. We received 147 responses in total; however, we eliminated three responses because of missing data, leaving us with a useable sample of 144 or a 36% response rate. We ran *t*-tests on key parameters to determine if there were any differences between early and late respondents in our sample and found no significant differences.

Measures

Independent variables

Each of our independent variables measures respondents' perceptions with respect to project learning and cross-project leaning transfer. The independent variables were measured using a 7-point Likert scale. We ran principal components analysis on all of the questions of interest and they divided into the six variables below.[2] We report confirmatory factor analysis scores and Cronbach's alpha for each variable.

Experience accumulation. Experience accumulation examines the extent to which respondents perceived that learning is shared through the movement of people across projects. This definition follows Senge (1990) who argues that learning is transferred within organizations by the movement of individuals across project teams. We measured experience accumulation using two questions (Appendix A). The variable was factor analysed with factor scores at 0.89 or higher and a Cronbach's alpha of 0.73.

Knowledge articulation. Knowledge articulation examines the extent to which respondents perceived that learning is captured and shared by deliberate project meeting and review processes, in which the team figures out what works and what does not in the execution of an organizational task (Zollo & Winter, 2002). We measured knowledge articulation using two questions (Appendix A). The variable was factor analysed with factor scores at 0.86 or higher and a Cronbach's alpha of 0.73.

Knowledge codification. Knowledge codification examines the extent to which respondents perceived that learning was captured and shared by documenting lessons (Zollo & Winter, 2002). We measured knowledge codification using three questions (Appendix A).[3] The variable was factor analysed with factor scores at 0.72 or higher and a Cronbach's alpha of 0.79.

Mediating variables

Team learning. Team learning measures the extent to which the team has changed the way it operates based on knowledge gained. We measured team learning using four questions

[2]A table of the exploratory factor analysis is available from the authors.

[3]Questions for Knowledge Articulation and Knowledge Codification were derived from Edelman (2000).

(Appendix A). Each question utilized a 7-point Likert scale. The variable was factor analysed with factor scores at 0.77 or higher and a Cronbach's alpha of 0.79.

Cross-project learning. Cross-project learning examines perceptions of the movement of learning across team boundaries to other project teams. We used two questions to examine cross-project learning (Appendix A). Each question utilized a 5-point Likert scale. The variable was factor analysed with factor scores at 0.78 or higher and a Cronbach's alpha of 0.71.

Dependent variable

Project success. To measure project success, we used six questions (see Appendix A). Each question utilized a 5-point Likert scale. The variable was factor analysed with factor scores at 0.65 or higher and a Cronbach's alpha of 0.81.

Control variables

In addition to our independent, mediating and dependent variable(s), we also controlled for the *size of the project team* (Edelman, 2000), the *phase of the project* (Leonard-Barton, 1990) and whether or not the project was identified as *producing a product or a service* (Newell *et al*., 2003). Previous literature on projects and learning has indicated that these variables may influence project-based learning. Table 1 presents the mean, standard deviation, alpha and correlation table for each variable used in the analysis.

DATA ANALYSIS AND RESULTS: SURVEY DATA

To best capture the theoretical interdependencies between knowledge, learning and project success, we analysed the data using Structural equation modelling (Amos 5.0 statistical package). This procedure allows for a fine-grained analysis of the hypothesized relationships within the context of the entire model. Structural equation modelling is a particularly attractive choice

Table 1. Descriptive statistics, reliability and zero-order correlations ($n = 144$)

Scale	Mean	SD	Alpha	1	2	3	4	5	6
Experience accumulation	4.97	3.46	0.68	1.000					
Knowledge articulation	4.20	4.90	0.64	0.157	1.000				
Knowledge codification	3.86	4.91	0.79	0.408*	0.280*	1.000			
Team learning	2.77	3.18	0.85	0.238*	0.181†	0.381*	1.000		
Cross-project learning	1.40	3.45	0.73	0.297*	0.191†	0.372*	0.264*	1.000	
Project success	3.06	3.21	0.85	0.102	0.061	0.193†	0.222†	0.258*	1.000

*Correlation is significant at the 0.01 level (two-tailed).

†Correlation is significant at the 0.05 level (two-tailed).

SD, standard deviation.

when testing mediating variables as all of the relevant paths are directly tested and complications such as measurement error and feedback are incorporated directly into the model (Baron & Kenny, 1986).

Before running the model, we inspected the data for any possible abnormalities. We followed Kline (1998, p. 89) and checked the data for missing data points, the normality of the data distribution, outliers and multi-collinearity using the SPSS statistical data analysis package. To handle the problem of missing data, we used mean substitution (Afifi & Elashoff, 1966). Mean substitution is a popular method of managing missing values in structural equation modelling. In addition, it is a conservative technique in that it makes the data less reactive. The missing value substitution procedure did not cause any statistically significant bias in the data; no statistically significant differences between the original and the missing value mean substituted data series were observed.

We ran a fully mediated model which posits that the two mediating variables*, team learning* and *cross-project learning*, completely mediate the relationship between the independent variables: *experience accumulation*, *knowledge articulation* and *knowledge codification.* To insure that the indirect, fully mediated model fits the data well, we used multiple fit criteria to rule out measuring biases inherent in the various methods (Hair *et al.*, 1995). These criteria are presented in Table 2.

In hypotheses 1–3, we make predictions about the specific paths in the fully mediated (indirect) model. To test these hypotheses, we examined the path coefficients, and the critical ratios for the indirect, fully mediated model. In hypotheses 1a and 1b, we predicted that there would be a significant relationship between experience accumulation and the mediating variables: team learning and cross-project learning. Hypothesis 1a was not supported, but hypothesis 1b was. In hypotheses 2a and 2b, we predicted positive and significant relationships between knowledge articulation and the mediating variables: team learning and cross-project learning. We found no significant support for these hypotheses. In hypotheses 3a and 3b, we predicted a positive and significant relationship between knowledge codification and the mediating variables: team learning and cross-project learning. We found strong support for both hypotheses. In hypothesis 4, we predicted a positive and significant relationship between knowledge articulation and knowledge codification. This hypothesis was also strongly supported. For hypotheses 5a and 5b, we predicted positive and significant relationships between the mediating variables, team learning and cross-project learning, and the dependent variable project success. We again found strong support for these hypotheses. Table 2 shows the hypotheses, standardized estimates and the critical ratios for the independent variables and mediating variables in the indirect, fully mediated model. Figure 1 presents the model.

DATA ANALYSIS AND RESULTS: INTERVIEW DATA

In this section, we discuss the project learning and cross-project learning transfer initiatives which Utilityco had introduced. We then provide specific examples of learning and cross-project learning from the two specific projects that we studied.

Table 2. Structural parameters, hypotheses and model measurement values*†

Path	Hypothesis	Standardized estimate	*P*-value
Experience accumulation → Team learning	H1a	0.123	0.131
Experience accumulation → Cross-project learning	H1b	0.055	0.022
Knowledge articulation → Team learning	H2a	0.104	0.169
Knowledge articulation → Cross-project learning	H2b	0.047	0.136
Knowledge codification → Team learning	H3a	0.054	0.000
Knowledge codification → Cross-project learning	H3b	0.024	0.000
Knowledge articulation → Knowledge codification	H4	0.168	0.000
Team learning → Project success	H5a	0.085	0.039
Cross-project learning → Project success	H5b	0.188	0.004
Industry type → Project success		–0.317	0.966
Project size → Project success		0.164	0.349
Project phase → Project success		0.042	0.662

Model measurement values

Model	Value	Recommended value
χ^2 (d.f.)	12.42 (18)	
χ^2/d.f.	0.69	≤2.00
P	0.83	≥0.05
GFI	0.98	≥0.90
AGFI	0.95	≥0.90
RMR	0.44	Low values (0 = perfect fit)
Hoelter critical N	401	>200

*Recommended values are derived from Hair *et al.* (1995).

†*P*-values are two-tailed tests.

AGFI, Adjusted goodness of fit; GFI, Goodness of fit; RMR, Root mean square residual.

Project learning and cross-project learning transfer initiatives

Utilityco recognized the importance of project learning and cross-project learning transfer and had introduced a number of initiatives, many fairly recently, to try and improve these capabilities, recognizing that in the past projects had not always managed to learn collectively or share what they had learnt with other projects in order to avoid reinvention, as described by one engineer:

> As I say we do learn from it [the project] because just about every meeting that I attend there is something that the engineers have said – this has not worked – that is probably more important to feed back, it is not the positives but the negatives. We don't want to repeat our mistakes – which we have a history of doing. The company does repeat mistakes.

These initiatives are described next, categorized as initiatives that facilitated experience accumulation, knowledge articulation and knowledge codification, in line with our theoretical framework. The problems associated with these different initiatives are explored in the case projects.

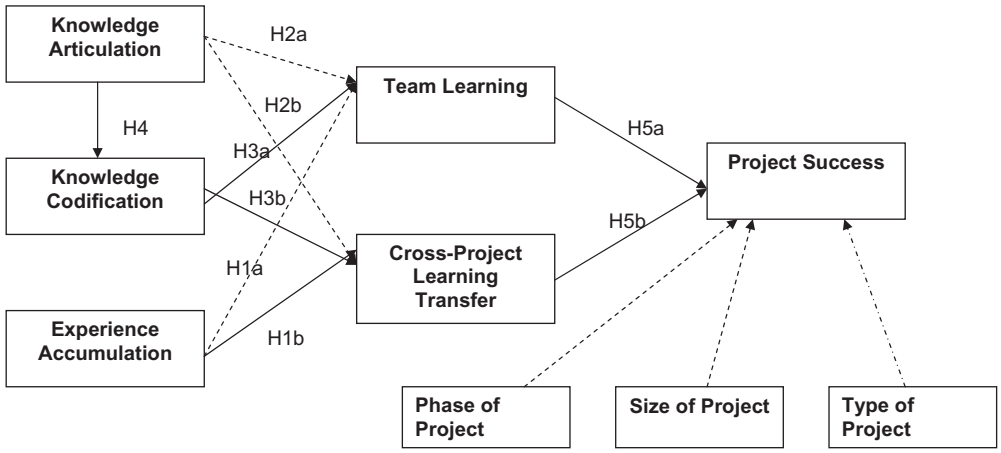

Figure 1. A mediated model between knowledge, learning and project success. The figure depicts a structural model with standardized maximum likelihood estimates. Path coefficients for error terms were set at one. Solid lines indicate significant paths.

Experience accumulation

Almost all people interviewed for this research claimed that they had personally learnt from their project experience, and that this accumulated experience was extremely important, as described by a project manager:

> There is a wealth of information as I have seen within the company with some very knowledgeable individuals who can answer issues almost immediately that would take several other individuals who have not had the experience and the exposure many weeks to resolve. . . When we have got the really key personnel at the right place at the right time discussing the appropriate problematic issues, they have come up with a solution that has had a significant saving to the company by that individual being present.

The extent to which this accumulated experience at the individual level was available across projects was, however, more problematic, as succinctly described by one interviewee who was asked about what happened to a specific example of project learning that he had just described, to which he replied: 'It stops basically with the individual'. Given this context, initiatives had been put in place in order to facilitate the more systematic use of the accumulated experience of individuals across projects. These related to trying to assign people to projects based on their previous experience and batching projects together so that individuals could share experience across the batch.

Knowledge articulation

The respondents also suggested that there was learning that was articulated at the project level, which went beyond the mere individual accumulation of experience, even if this was not necessarily always defined as project-level knowledge articulation:

> There are review meetings as to the [project] progress. . . so lessons learnt are shared throughout that project, but it is not possibly flagged up under the lessons learnt banner. It is just flagged up as delivering the project. It is business as usual rather than a specific lessons-learnt.

Interviewees described how this project-level knowledge articulation was accomplished by using formal reviews to articulate what had been learnt from a project and forums to share this learning across projects.

Knowledge codification

Knowledge gained from past project learning was codified in this company in the form of documents and manuals, described by a design manager and engineer:

> So we tend to use things, use the ways that it has been done for a long time. And that comes in to us from a document, from the design manual – that is the designers bible it gives you the framework of what you need to do and says when you build that tank you need to build a slope of 20 degrees on the base. Because we know that 20 degrees there is sludge inside that will fall through. So that gives all the sort of must haves if you like. From the design point of view the primary reference document – no doubt about it.

However, while these documents were clearly important, there were also limitations in their use, first simply because of the sheer volume of information they contain:

> You find out that people have not actually used it [the design manual] or read it. They come and ask you a question; well it is actually in there, that is the way we have done it for years, it is in there, why haven't you read it? But I think that is probably an issue that the thing is so massive for people to get their head around and know where the information is.

More importantly, these documents described standard processes, which were fine when things went to plan and were within normal tolerances. However, when the particular project circumstances were unique in some way, new solutions had to be found:

> Every work is different, every work has got a history and is built up, you rarely get a greenfield site. Everything is actually built on an existing site normally; it is very difficult to standardize as such.

In the past, this had meant that often solutions had been reinvented across projects because unless the manual itself had been updated, and this often took a long time, the solutions that had been adopted had not been codified and shared more formally. Again, initiatives had been put in place to try and better address this. In particular, a KM tool had been introduced where projects were supposed to document learning lessons and processes had been introduced to increase standardization so that projects followed standard procedures rather than each time develop new solutions to problems faced.

The company had, thus, recognized the importance of improving project learning and cross-project learning transfer and had attempted to introduce procedures to encourage this; these initiatives were focused on improving the use of accumulated experience, encouraging better articulation and codifying of knowledge at the project level and improving the sharing of this knowledge across projects. Interviewees noted, however, the limitations of these more formal processes and their *ad hoc* use in practice and continued to stress the importance of more informal processes. This is illustrated by describing what took place on the two projects which we studied in depth.

EWT project

This project was concerned with the development of a new enhanced water treatment (EWT) process for mains supply at 16 water treatment works in one region of the UK. The new treatment process was designed and a trial treatment facility was built by the utility company in partnership with a principal contractor. Once the process had been developed and successfully tested, there was an open bidding process to identify contractors for rolling out the project to the other 15 sites. The original partner contractor initially won the bid for the next eight sites, and subsequently for the final seven sites. This batching of projects created continuity of engineering and process development staff involved in the roll-out across the different sites. However, each site was managed as an independent project with the works operation teams that actually conducted the work at each of the subsequent 15 sites, unique to each site.

The implementation of the new process across the targeted water treatment works proved to be more difficult than expected with each site experiencing problems in actually implementing the process solutions. The roll-out was done in sequence rather than in parallel with the idea that lessons learnt from each site would be passed on to the next site. In other words, the expectation was that experience would be accumulated at one site, and that this would be articulated, codified and shared with other sites so that there was significant cross-project learning transfer. However, in reality cross-project learning transfer was limited: 'So you would hope that the lessons learnt would have been passed through these teams, the contractors and the engineers. I am not convinced that has worked very well . . . The trouble is we have our local meeting where we discuss our local sites [problems], not knowing that all these problems are quite manifest and consistent across other ones as well' (Area Works Manager).

This indicates that learning was occurring at the local level, with individuals involved in the particular project discussing problems and defining solutions to these problems, in other words articulating knowledge, but that this was not shared across the different project sites. The explanation provided for not encouraging more sharing of learning across sites was related to time pressures. More specifically, it was felt that encouraging interaction between different sites would create too much noise: 'And every time you put another forum in there, which can throw a few more hand grenades in there, you slow everything down. And I guess at the end of the day they still have to hit that due by date. So I can see why it has happened' (Works Area Manager).

In terms of knowledge codification, the company did patent the new treatment process and articles about it were published for external consumption. However, there was very little captured for internal consumption despite the existence of the KM system: 'Only the major items have been put on KM, which won't be as much as what we have learnt . . . It is more of a cultural thing, not writing something down on paper' (M&E Design Engineer) and 'I don't know how much, if any, has been captured by the company' (Process Development Project Manager). A reason given for this was that the ETW project was so unique that there would be little that others could learn from it: 'Probably 20% of what we do is general to everything; 80% is specific to this project' (M&E Design Engineer). Moreover, it was felt to be too time-consuming to write lessons learnt down: 'I think you can't write it all down anyway. You could probably tell them in five minutes and can answer the question for them rather than spending half a day or a day trying to write it and put it down on paper' (M&E Design Engineer).

In terms of learning from the codified knowledge of other projects, those interviewed stated that they had not used the KM system to search out lessons learnt from previous projects for this EWT project: 'Well I want to get this job sorted out so while I am looking at other jobs or looking at what other people are doing I am not doing this one. Probably waste more time to be honest. In my opinion I should be doing this one, get this one done and then move on to the next job' (Process Development Project Manager). A key reason provided for not looking at previous lessons learnt was because the uniqueness of this project meant that there would be nothing useful: 'The process on this project, I have got to sort that out. There would be no information on there [KM system]' (M&E Design Engineer).

Sewage project

This project was a very large (60 million pounds), multi-phase project set up to replace filter beds with new activated sludge plant, complete with new sludge treatment facilities at a sewage treatment works. The technology being developed was new and high profile because it was focused on producing a more environmentally friendly sewage treatment process. The deadline for the project was tight, but the sewage treatment work was successfully redeveloped to the new specifications on time and to higher standards than any previous project.

Team members were selected who were cherry-picked for their experience and expertise, and all worked full-time on the project. The project team included external engineering and architectural consultancies and contractors, who were all colocated at a site separated from the main company buildings. This high level of accumulated experience on the project team, together with the relative isolation provided the project team with much more autonomy than was usual: 'in large part we paddle our own canoe with design and development and construction just to get things done. I think we made our own rules on a lot of what we did here' (Site Supervision Team Leader). It was this isolation that allowed them to develop new practices, especially in terms of developing a more integrated approach to design, procurement and construction with the principle contractor: 'there is much more exchange of information with the contractor, there is much more openness in all manner of areas. In part that is because

we have been sharing the same office for three years and there is a degree of trust built up and there is a good relationship there' (Site Supervision Team Leader).

Moreover, interviewees described how they had learnt across phases of the project: 'We trialled some of these smart panels which were a more software base control system on a couple of sites in phase one. So like I said that was successful, so that design, whereas phase one had more traditional kit, on some sites had a couple of sites with this newer one that was looked at and reviewed in terms of operating costs and capital costs. . . And that was built into phase two, so all of phase two had got that particular design. I am not sure – there were other small things which were probably flagged up but I am not sure what specifics they were' (Contract Manager).

However, while there was thus a significant amount of knowledge articulation within the project team, that was shared across the phases of the project, the codification and dissemination of this learning was considered to be relatively *ad hoc*, even within the project itself: 'I have not seen a schedule of lessons learnt if you like where you can say O.K. those are the ones we met on phase one, we must make sure that we don't engineer them into phase two. I think it is a little more *ad hoc* than that' (Contract Manager); 'I think most of it was just requests on things like risk management on negotiating contracts. And experiences that we have had with the contractor, in particular because we have a number of different contractors and whilst performing well we would like to feed that back, or performing badly. But they were just *ad hoc* requests. Somebody else was looking at risk management, so they come and ask us how we dealt with it and it was very much anecdotal, we never set out with the intention of becoming subject experts in any particular field' (Design Manager). Many of the participants made similar comments and also suggested that it was not helpful to share their learning with other projects across the organization: 'Most of what we are learning is specific to that site and specific to the sewerage that [Derby] receives. So most of what we learn is not going to be of use to anybody else. So most things are dealt with, done and dusted and got out of the way, and nobody gets to hear about them. . . Rather than the lessons being disseminated to everybody the lessons are being kept very much within the team' (Design Manager). In a similar vein a contract manager, having described how they had learnt something associated with laying pipes on the project, commented that they could have put it onto the KM database but did not and followed this with: 'But I think a lot of knowledge is exchanged by personal contact more than people imagine'.

These project descriptions and the account of systems introduced to support team learning and cross-project learning transfer can be linked to the hypotheses developed and tested using the survey data. The qualitative data suggest that experience was accumulated by individuals on projects that could potentially be useful to other projects in the future, if the particular individuals moved to projects where this experience would be useful. Indeed, individuals were assigned to the sewage project team specifically to take advantage of particular individuals' previous accumulated experience and this appeared to be very helpful. However, in this organization the assignment of people to the sewage project was unusual, despite the attempt to make this more systematic. More typically personnel were assigned to project teams on a more *ad hoc* basis, as on the EWT project teams, so that accumulated experience was not neces-

sarily supportive of either team learning or cross-project learning transfer. In order to ensure that accumulated experience was more effectively utilized to support team learning and cross-project learning transfer, the company had introduced batching of projects. The Derby case illustrates how useful this can be as the experience accumulated in Phase 1 of the project was very helpful during Phase 2, as many of the people were reassigned to Phase 2. In EWT, where the continuity of personnel was not maintained, despite the phased roll-out across sites, this experience accumulation did not facilitate cross-project learning as experience accumulated at one project site was not available to other project sites.

Moreover, in both cases knowledge was articulated at the team level in the sense that project meetings were used to resolve problems and think about lessons learnt from particular project episodes. This was supported by the project review structure that had been instituted in the company, which included a formal review process to support learning within each project as well as the institution of forums to share learning across projects. However, in the EWT case this knowledge articulation was not undertaken systematically and sharing across the different site projects rare. Even on the sewage case, lessons learnt were not collected systematically at the project level and even though lessons were learnt that were shared across the company, for example, in relation to risk management, those involved admitted that this was very *ad hoc*.

Finally, in terms of codification the individuals on both projects admitted that they did not systematically attempt to capture the lessons that had been learnt and put them on the KM database, or indeed any other system. Nor did they make use of the KM system to identify whether lessons had been learnt on other previous projects that might be useful to them on this project. However, in the sewage case, this lack of codification was not an inhibitor to the transfer of learning at least across the phases of the project because of the continuity of personnel. The transfer of learning to completely independent projects was more problematic because of the limited codification of lessons learnt. On the EWT project, they had used standard procedures in an attempt to increase learning transfer across the different site projects. However, these standards had failed to address all the problems that each site faced. The transfer of learning that accumulated in the face of these problems was problematic because of the independence of the project sites, even though each site was facing similar problems given that they were each implementing the same technology.

DISCUSSION

This paper uses two different methods to explore the development of a dynamic team learning capability. Interestingly, different conclusions with respect to the importance of experience accumulation and knowledge articulation and codification can be drawn from the two types of data. This suggests that the interview and survey data need to be examined in concert, so that a holistic perspective on project and cross-project learning can be developed.

The interviewees in Utilityco believed that they had accumulated useful experience as a result of their project involvement and the sewage case illustrated how this was very helpful in sharing learning across the phases of this project. The survey data also showed that experi-

ence accumulation can facilitate cross-project learning, but it was not significantly related to team learning. The EWT case illustrates the problems of using experience accumulation to foster team learning and cross-project learning. In this case, people were not assigned to the site projects based specifically on accumulated experience. Moreover, the overall programme was not able to foster the sharing of accumulated experience across the different site projects, even in this integrated programme where each project was implementing the same technology. Thus, while our survey results support our hypothesis in relation to experience accumulation supporting cross-project learning, our case data illustrate that this can be a rather haphazard way of fostering a dynamic project working capability. This finding is consistent with the Zollo & Winter (2002) framework.

The fact that experience accumulation did not encourage team learning may, in retrospect, not be surprising, given that individuals are often assigned to teams based on supply and demand, rather than based on their previous experiences. To rely on experience accumulation for learning in projects and sharing lessons across projects would require the use of sophisticated human resource systems that collect data about a person's past experiences and match this to the demands of each new project. This company did not systematically use such a system and even if such a system was adopted, the realities of project demand and geographical distribution would likely make such a matching process very difficult.

The survey finding that knowledge articulation was not related directly to either team learning or cross-project learning transfer was more unexpected. Formal project review processes provide the mechanism for teams to engage in reflective practices (Ayas & Zeniuk, 2001), which can enhance learning. Forums for sharing lessons across projects are commonly used to encourage the transfer of this learning between projects. However, our survey results raise questions about the efficacy of these review processes on their own. They are clearly important as a precursor to knowledge codification – it is not possible to produce codified knowledge unless it has been articulated, but mere articulation alone appears to be insufficient. The qualitative data point to an explanation for this, with interviewees noting that reviews did not always happen in a systematic manner, despite the formal process, because of pressures of time and perceptions that such reviews and forums were a distraction.

Nevertheless, the survey results do confirm the importance of a formal review process (knowledge articulation) for feeding the documentation process (knowledge codification), which in turn is positively related to both learning within the team and the transfer of learning across teams. Capturing learning is also shown to significantly influence project success, as others have found (Kock & McQueen, 1998). The survey data thus indicate that it is codifying knowledge that is most influential in terms of increasing learning within a team. It appears to be the discipline of writing that is important for team learning, with mere reflection being insufficient to nurture this alone. As Zollo & Winter (2002) point out, the discipline of having to write something down is very helpful in terms of clarifying ideas: 'Through the writing process, one is forced to expose the logical steps of one's argument, to unearth the hidden assumptions, and to make the causal links explicit' (p. 342). Fulwiler (1987) makes a similar point: '. . . the very act of writing is an act of thinking. It is good to start writing and watch where the writing takes you: to digress when you're exploring an idea; to witness your thought, visibly on paper

(or computer monitor), and have a dialogue with it – because that helps you find out what you know, what you don't know, and what you need to know' (p. 23). Thus, this activity can be a 'capability building exercise . . . even if the individual minds, and not the finished tool are the key repository of the improved understanding' (Zollo & Winter, 2002, p. 349).

Moreover, the survey data also indicate that it is codifying knowledge that facilitates the sharing of learning across project teams. Having a written document available for others to read potentially provides the opportunity for sharing the lessons across projects so that learning is institutionalized across the organization rather than restricted to members of the particular project team where the learning took place (Lyytinen & Robey, 1999; Crossan & Berdrow, 2003). It is the development of this cross-project learning transfer capability, building on the learning that occurs within a team, that can constitute a dynamic capability for a firm (Zollo & Winter, 2002). Certainly our results support this insofar as both team learning and cross-project learning transfer were associated with project success. This is important as there have been few empirical studies that have explicitly focused on this, despite the theoretical developments related to dynamic capabilities and organizational learning. However, the qualitative data illustrate that team members do not necessarily always recognize the benefit of these learning capture and sharing practices, which may be one reason why previous research has failed to identify the significance of these project learning and transfer processes (e.g. Ayas & Zeniuk, 2001). We discuss this next.

Organizations that require project teams to undertake learning reviews and then to document this learning, are investing considerable resources in this effort. It takes time to meet and discuss what has been learnt on a project and then longer again to write this down and make it available to others through intranets. Our survey evidence suggests that this is time well-spent. This finding supports Zollo & Winter's (2002) argument that knowledge articulation and knowledge documentation can promote the development of dynamic capabilities. The fact that those involved in the process did not fully appreciate that the team was learning from this process, is not relevant insofar as it was having an impact. However, we should not dismiss the results from the interview analysis for two main reasons. First, if project members feel that the reviews and documentation of learning are a waste of time, they are likely to avoid them as far as possible, even when they are mandated. The qualitative data certainly suggest that, given the negative view of the learning review and documentation requirement, project teams did not tend to spend as much time on these processes as they might. Other research has similarly found that participants do not perceive project review and capture processes to be helpful. For example, Keegan & Turner (2001), studying 18 different companies that used project-based work, found that all had end-of-project review and capture practices in place, but they also report that: 'In no single company did respondents express satisfaction with the process' (p. 90). Given our survey results, which demonstrate the benefits of these processes, this negative participant reaction is unfortunate. Second, the case data identify the reasons why interviewees believed that the reviews and documents were not helpful and this provides insights about the ways in which the review and documentation processes could be modified to improve even further the usefulness of these learning capture and transfer processes.

One reason why interviewees believed that the review and documentation processes were largely irrelevant was because they did not see other teams read and learn from these documents, nor did they make extensive use of the KM system themselves. However, Zollo & Winter (2002) argue that codifying knowledge should not simply be seen as important in relation to the transfer of knowledge. This is because knowledge is very difficult to transfer, given that the recipients of the knowledge do not necessarily have the background knowledge and understanding to actually make use of it (Newell *et al*., 2003). So, Zollo & Winter (2002) argue that even if the codified knowledge does not transfer well, it has nevertheless helped those involved in the codification process to develop a more refined mental model of how actions relate to outcomes in what conditions. In this sense, the discipline of being required to codify learning can be seen as facilitating perspective-making within the particular project team community, even if it does not help others to perspective-take and learn from this (Boland & Tenkasi, 1995). The survey data certainly confirmed the importance of documentation (knowledge codification) for team learning. Nevertheless, the fact that most interviewees stated that they did not tend to look on the KM database for previous learning suggests that for perspective-taking to complete the learning cycle, organizations need to consider mechanisms and incentives to support project teams in more systematically using what has been shared by others, as well as mechanisms and incentives that encourage project teams to make their knowledge available to others. This is likely to require the introduction of specific initiatives that can facilitate this knowledge intake from past projects, for example, by including in the project management protocol a mandate that lessons-learnt databases should be regularly reviewed to identify relevant lessons from past projects, as well as the mandate that projects should articulate and codify their own learning.

Another reason why interviewees felt that capturing and codifying learning was not going to be helpful was because of the uniqueness of the project on which they were engaged. However, Zollo & Winter (2002) suggest that knowledge articulation and codification is actually likely to be more helpful in relation to rare situations, because it is precisely in such situations that relying on memory is likely to prove problematic. Similarly, they argue that where the task involves heterogeneity and causal ambiguity, it is more likely to be fruitful to deliberately attempt to articulate learning from the situation and write this down. These three features – low frequency, high heterogeneity and high ambiguity – are very common in project team situations (Project Management Institute, 2002), since project teams are often working on unique problems, involving a lot of diversity and where there is a high degree of ambiguity about what would be the best solution, or even what the problem is. Interviewees actually gave this as the reason for not writing down what they had learnt precisely these points about uniqueness and ambiguity. This suggests that, given the counter-intuitive nature of the importance of reviews and documenting learning in these situations, organizations are going to need to develop mechanisms to encourage teams to understand their importance. Rewards and examples of where sharing learning in such situations has been helpful may be important in this respect.

Zollo & Winter (2002), while acknowledging the benefits of knowledge codification, also suggest that it should be 'done right' and suggest a number of elements that this will involve. First, codification should include a focus on 'know-why' as well as 'know-how', so that action–

performance links are exposed. Second, the timing of codification should be carefully considered so that learning opportunities are maximized. Third, the analysis that has been codified needs to be tested to ensure that the causal understanding is validated. And, finally, there is a need for some supporting structure that reviews and approves the codified learning to ensure that it will be helpful to enhance dynamic capabilities. Many of these elements were not present in the case company (or indeed the other five companies in our research), so that clearly the documentation was not as helpful as it might have been in improving dynamic capabilities related to team working. Done right, we would argue, these learning review and documentation processes can promote not only perspective-making within the team, but also result in a document that can be a useful boundary object (Carlile, 2002) for subsequent perspective-taking by other teams (Boland & Tenkasi, 1995). Only when these documents are 'done right' will the thousands of documents on most corporate intranets actually promote the sharing of learning that is anticipated. Further research exploring in more concrete terms what should be included in documents to promote knowledge sharing across project teams would thus be helpful, as would an analysis of what reward structures are most effective for encouraging both the sharing with and the learning from project teams.

LIMITATIONS AND CONCLUSIONS

Encouraging project teams to reflect on what has been learnt and to document this learning appears to be a useful process encouraging team learning as well as cross-project learning transfer, even if participants do not perceive, at the time that they are particularly helpful. These learning processes go beyond the mere accumulation of individual experience. That these processes in turn relate to overall project success, is an indication that developing project learning and cross-project learning transfer processes can help to nurture a dynamic capability of project working that can be particularly important for organizations working in dynamic environments and using projects for a variety of different organizational tasks.

The interview and survey data compliment each other in two important ways. First, the interviews illustrate that individuals often cannot see the importance of project reviews and especially the need to write down what has been learnt, because they do not see these documents being widely shared. This suggests that an important role for management is to educate project members that the review and documentation process is useful in its own right, thereby helping project teams understand what works well and what does not work so well in different situations. This supports the idea that team learning within the context of the particular project can enhance project success. This perspective-making facility of creating the team boundary object is thus useful in and of itself, regardless of how the document subsequently gets used. Second, the qualitative case data suggest that the documents produced were not always useful as boundary objects, facilitating perspective-taking across other project teams. Drawing upon the work of Boland & Tenkasi (1995), it may be useful to encourage project teams to give examples and tell stories about their project experiences, because such narrative framing is likely to provide the contextual infor-

mation that will allow others to interpret the experiences with reference to their own situation.

However, as with all research, our study is not without limitations. Future empirical research should focus on clearly identifying the units of analysis through which learning and knowledge is transferred. It seems likely that knowledge at the organizational level is different from that at the individual and group levels, and that a delineation of the different types of knowledge, across levels of the organization, would be an important addition to our understanding of knowledge movements. Also, from an empirical perspective, while the measures developed for this study are a start, future research could usefully develop stronger measures.

Limitations notwithstanding, this paper attempts to combine two perspectives on learning and knowledge transfer within and across projects. The findings from the quantitative data that support the importance of documentation, and then the findings from the qualitative data which indicate that documentation is not an activity that is valued, provide important insights on many of the traditional arguments in the KM literature. Our synthesis of these views is an attempt to combine these two perspectives into a meaningful whole which is useful for future academic research as well as for practicing managers.

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Biographies

Sue Newell is the Cammarata Professor of Management, Bentley College, USA and a part-time Professor of Information Management at Warwick University, UK. She has a BSc and PhD from Cardiff University, UK. Sue is currently the PhD Director at Bentley. Her research focuses on understanding the relationships between innovation, knowledge and organizational networking (ikon) – primarily from an organizational theory perspective. She was one of the founding members of ikon, a research centre based at Warwick University. She has been involved in many of the ikon projects and is currently working on a project titled 'The evolution of biomedical knowledge: interactive innovation in the UK and US'. She is also involved in research which focuses on exploring the implementation and use of packaged information systems, for example, to support distributed project work or health records. Her research emphasizes a critical, practice-based understanding of the social aspects of innovation, change, knowledge management and inter-firm networked relations. Sue has published more than 70 journal articles in the areas of organization studies, management and information systems, as well as numerous books and book chapters.

Linda F. Edelman is an Assistant Professor of Strategic Management at Bentley College, USA. Prior to her position at Bentley, she was a Research Fellow at the Warwick Business School in Coventry, UK where she is a member of the ikon research team. She received her MBA and DBA from Boston University, USA. She is the author of six book chapters and over 20 scholarly articles. Her current research examines intra-organizational relationships in project groups and teams around topics such as knowledge and innovation. She is also involved in research which examines the strategic capabilities of nascent entrepreneurial firms.

APPENDIX A

Survey measure and interview questions

Measures	Survey questions	Interview questions
Experience accumulation	Lessons are shared by project team members moving on to new projects. By sharing experiences, new knowledge is brought into the project.	What influences learning within the project team? How do lessons get shared across projects? (prompts related to movement of team members)
Knowledge articulation	In order to capture and share project learning: We have project meetings at specific project milestones. We have project review meetings at the completion of a project.	What influences learning within the project team? How do lessons get shared across projects? (prompts related to project reviews and meetings)
Knowledge codification	In order to capture and share project learning: Paper-based reports that describe learning from the project are circulated. Reports from projects are shared with others outside the project in a timely manner. We find written documents useful for sharing learning across projects.	What influences learning within the project team? How do lessons get shared across projects? (prompts related to documenting lessons learnt)
Project team learning	Learning in the project has enabled the project team to: identify new ways of working; develop new routines for dealing with problems; extend internal organizational networks that will be useful for sharing learning; extend inter-organizational networks that will be useful for sharing learning.	What have you learnt on this project team?
Cross-project learning	How satisfied are you with the transfer of learning from other projects into this project? How satisfied are you with the transfer of learning from this project into other projects?	Have you shared your project learning with other project teams? Do you think this has been useful to them? Have you used what has been learnt on other project teams on this project? Has this been useful?
Project success	How effective has the project been with respect to: creating innovative solutions to problems; meeting project time scales; meeting project objectives; adding value to the business; staying within project budget; satisfying the client.	How successful has this project been, to date?

