Proceedings of the 17th International Product Development Management Conference, Murcia, Spain, 13-15 June 2010.

TACIT KNOWLEDGE DEVELOPMENT IN A NEW PRODUCT DEVELOPMENT TEACHING SIMULATION

Keith Goffin †, David Baxter, Marek Szwejczewski, Alan Cousens, and Chris van der Hoven

Cranfield School of Management, Cranfield, Bedfordshire, MK43 0AL, UK
† k.goffin@cranfield.ac.uk

ABSTRACT

This paper describes our evaluation of whether participants perceive that they have developed new tacit knowledge during a New Product Development simulation. We assess this by asking the participants their key lessons learnt during the exercise, followed by the perceived level of 'tacitness' of those lessons. We find that participants do not perceive these lessons learnt to be tacit. A second questionnaire finds that participants believe that the practical experience gained during the simulation would improve the performance of a subsequent project, but that extended classroom teaching would not. This discrepancy is thought to highlight the lack of a suitable measure for tacitness. Future studies should focus on experience variables rather than codification variables when assessing the development of tacit knowledge in teaching activities.

INTRODUCTION

Knowledge is crucial to enabling an organization to compete successfully through innovation and especially New Product Development (NPD) (Kogut and Zander, 1992). NPD, as a key management responsibility, is an essential topic included in the teaching of graduate degrees in business and engineering, and in executive education (Rosenau, 2002). Several pedagogical approaches have been adopted. Teaching case studies are widely used (Goffin and Mitchell, 2006), in addition to stories and sharing experiences (Hernandez-Serrano et al., 2002). Project work that uses a sponsoring company can bring 'real-world' issues into the classroom (Cardozo et al., 2002). Whilst these methods may refer to real-world experiences or issues, they remain academic exercises. If tacit knowledge is critical to NPD and is closely related to practice, then NPD teaching should attempt to contribute towards the development of tacit knowledge by incorporating *practical experience* to complement the theoretical knowledge gained in the classroom.

In teaching operations management, comparatively complex practical issues have often been taught using simulations (Goffin, 1998). An advanced NPD simulation may combine practical experience of several disciplines, such as the analysis of a specific market, the development of a product concept, and the production of a product prototype (Silvester et al., 2002). The 'Cranfield CityCar' simulation was designed with that in mind; to give MBA students and managers intensive 'hands-on' experience of NPD, concentrated into a few hours. The simulation has now been used with several thousand

managers and students and has proved to be not only an effective learning tool but also a very popular approach (Cousens et al., 2009).
In this paper we report on how the simulation was designed, and how it is run. In addition, we present empirical data describing the extent to which the participants believe the simulation relies upon and develops their tacit knowledge. Specifically, our research indicates the view of the participants on the 'tacitness' of the key lessons learnt during the simulation. The aim of the paper is to stimulate academics to think about the extent to which tacit knowledge is developed and applied during a practical NPD simulation, when considered in contrast to a classroom based activity. We discuss the advantages and limitations of this pedagogical approach, and the implications. In addition, the paper gives recommendations for teaching practice and for further research.
The next section describes some perspectives on tacit knowledge in innovation. We then review existing methods in the literature for measuring tacitness, and select one for our study. Next, the research methodology is detailed, alongside a description of the teaching simulation. The results, discussion, and conclusion follow.

TACIT KNOWLEDGE IN INNOVATION

A great deal of the knowledge applied in NPD is tacit in nature (Pitt and MacVaugh, 2008). Practice is a critical element of tacit knowledge development (Nightingale, 2003). To the extent that tacit knowledge can be shared through collaboration, networking and informal exchange, these processes generally occur at local levels among individuals and small teams (Pitt and MacVaugh, 2008). Tacit knowledge can be thought of as practical know-how; the possession of a skill; the capability to carry out a task. Acquiring and sharing these skills is a key issue in NPD. Describing a process to another person does not result in them having the ability to carry it out. Nightingale provides an excellent example: "…no amount of reading is going to make me a good ballet dancer" (Nightingale, 2003).
Tacit knowledge is also a necessary 'background' component to understand and learn about a new task (Sherwood and Covin, 2008; Byosiere and Luethge, 2008), and to understand explicit knowledge (Guzman, 2008; Balconi et al., 2007). In fact, the best performing NPD teams effectively combine both tacit and explicit knowledge. That is, they combine experience based know-how (developed through doing, using and interacting) and the production and use of explicit knowledge. This combination leads to superior performance (Jensen et al., 2007).
We have described tacit knowledge as being developed through experience, and as an important basis for learning. Our practice focused NPD simulation attempts to develop tacit knowledge through practical experience. This practical experience is combined with teaching, which largely emphasizes explicit knowledge. This combination should support innovation performance.

IDENTIFYING A MEASURE FOR TACITNESS

Identifying a suitable measure for the perceived tacitness of a teaching activity is problematic, since no such measure exists in the literature. It has been noted that tacit knowledge cannot be measured directly almost by definition (Lee, 2000). Cavusgil et al. suggested that the major obstacle in conducting their empirical study was "the creation of measures to test the extent of tacitness" (Cavusgil et al., 2003), and Foos et al. were

unable to find existing measures for tacit knowledge transfer, so constructed their own (Foos et al., 2006). Various measures for tacitness have been applied in the context of product development and innovation, however many of them only publish the results of their studies and not the measures themselves (i.e. the questionnaire).

Rhodes et al. (Rhodes et al., 2008) apply Nonaka and Takeuchi's knowledge creation model (Nonaka and Takeuchi, 1995) as a theory of tacit knowledge transfer. They assume that social interactions provide a workable proxy for measuring tacit to tacit knowledge transfer. They do not describe the degree of tacitness. Their questions were not available. Density of social interactions is a proxy measure also applied by Lee (Lee, 2000). Since we aim to discover the degree of tacitness, rather than the channel capacity for tacit knowledge transfer, this measure is not suitable.

Foos et al. (Foos et al., 2006), studying tacit knowledge transfer, created measures focused on the ability to apply knowledge without the help of an external partner. They suggested that this measure needs additional validation. Since this measure focuses on the degree of success of tacit knowledge transfer, it could usefully be applied to our teaching simulation. However, it does not indicate a degree of tacitness, and their questions are not available.

Cavusgil et al. studied the effects of tacit knowledge transfer on innovation capability. They indicate that tacit knowledge is measured by four items "used to capture the complexity, codifiability, and observability of the information transferred" (Cavusgil et al., 2003). This is somewhat confusing, since it claims to measure the tacitness of knowledge but focuses on information. Their questions are not available.

McEvily and Chakravarthy measure tacitness in technology innovation in a way that aligns with causal ambiguity, as the lack of "a formulator's ability to explain and predict the relationships between components, design choices, and product performance" (McEvily and Chakravarthy, 2002). They identify tacitness as an inability to communicate such that a firm activity can be reproduced, with two dimensions: procedures and principles. Their 4 questions on tacitness ask the degree to which an engineer can predict which (1) varieties and (2) quantities of a component to use to improve performance (the procedure), and their ability to explain why these component (3) varieties and (4) amounts result in specific performance characteristics (the principles). Whilst these questions measure the certainty (tacitness) of knowledge, the specific nature of the questions (relating to product performance analysis) makes it difficult to apply them to our study.

Sternberg and Horvath (1999) indicate that tacit knowledge is acquired from experience. Building on this work and following the same logic, Hedlund et al. (2003) developed the Tacit Knowledge Inventory for Military Leaders. The inventory was developed to assess the amount of (tacit) knowledge military leaders possess. However, what it actually appears to test is the degree of correspondence with a senior officer, which may indicate decision quality (or without appropriate quality measures it might simply test the degree of indoctrination), but does not necessarily correspond to tacitness. Wagner and Sternberg had previously published the Tacit Knowledge Inventory for Managers (Wagner and Sternberg, 1991), which also built on the idea that tacit knowledge is developed through experience and is of practical use.

Simonin (2004) suggests that tacitness is the main source of ambiguity. They developed questions relating to tacitness. The questions include: Your partner's technology/process

know-how is easily codifiable (in blueprints, instructions, formulas, etc.); Your partner's technology/process know-how is more explicit than tacit. The responses on tacitness correlated the responses regarding ambiguity, which include: The technology/process know-how held by your partner is easily transferable back to your company; The association between causes and effects, inputs and outputs, and actions and outcomes related to the technology/process know-how held by your partner is clear. The focus on partners makes it difficult to apply these measures directly.

The selected method for measuring knowledge tacitness

(Market knowledge competencies are difficult to)…

1. Comprehensively document in manuals or reports
2. Comprehensively understand from written documents
3. Identify without personal experience in using them
4. Precisely communicate through written documents

5-point scale (1 = strongly disagree; 5 = strongly agree)

De Luca and Atuahene-Gima (2007) applied this scale in investigating how market knowledge influences innovation success. They found that market knowledge tacitness is not related to innovation performance. It is also not related to the use of knowledge integration mechanisms, which was an unexpected finding since tacitness was thought to make knowledge transfer more difficult. Tacitness, here, is an inability to document, understand and communicate knowledge through written documents, and a difficulty in understanding knowledge without personal experience.

Rijsdijk et al. (2009) later applied the same scale, with some success. They found that the effectiveness of management method varies with knowledge tacitness. They also found that formal methods are better suited for managing explicit knowledge, and informal methods (clan controls) are better suited for managing tacit knowledge. We will apply the scale to identify the degree of tacitness of the key lessons learnt in our teaching simulation.

<u>Problems identified with the scale</u>

De Luca and Atuahene-Gima (2007), in measuring tacitness, claim to follow Szulanski (1996). However, the questions applied by Szulanski were developed to investigate knowledge 'stickiness' and not 'tacitness'. Stickiness is a much broader term describing the difficulty of knowledge transfer. As an example, the three most important contributors to knowledge stickiness were: the absorptive capacity of the recipient; causal ambiguity (the degree to which factors and relationships are precisely known); and an arduous relationship between the source and the recipient. There was no mention of the difficulty in comprehensively documenting or understanding a particular lesson. In fact, the first two items in the scale are clearly related to Nonaka's SECI model (Nonaka and Takeuchi, 1995). Item 1 in the scale describes the *conversion* of tacit knowledge into explicit knowledge, and item 2 refers to the *internalization* of explicit knowledge. Item 3, personal experience, is somewhat related to Szulanski's questions on recipient absorptive capacity. Item 4, precise communication, again does not have a clear link to Szulanski's work.

De Luca and Atuahene-Gima (2007) also suggest that the knowledge based view of the firm (KBV) suggests that knowledge is sticky *because of its characteristics*. However, Szulanski (1996) found that three of the most important factors in knowledge stickiness clearly relate to the recipient and source, and not to the knowledge itself. Only causal ambiguity indicates knowledge tacitness. Szulanski (1996) asked the following illustrative question in assessing causal ambiguity: "we know why a given action results in a given outcome". This was also pursued by McEvily and Chakravarthy (2002) in their measure of tacitness.

We have identified that the source of the scale is questionable. Further, our description of tacit knowledge as being developed through practice and realised through skills is only partially addressed, by question 3. However, in the absence of another more suitable scale, this one will be adopted and evaluated.

METHODOLOGY

In our research, we asked two groups of students to complete our tacitness questionnaire as part of the NPD simulation. The overall flow of the simulation is shown in figure 1.

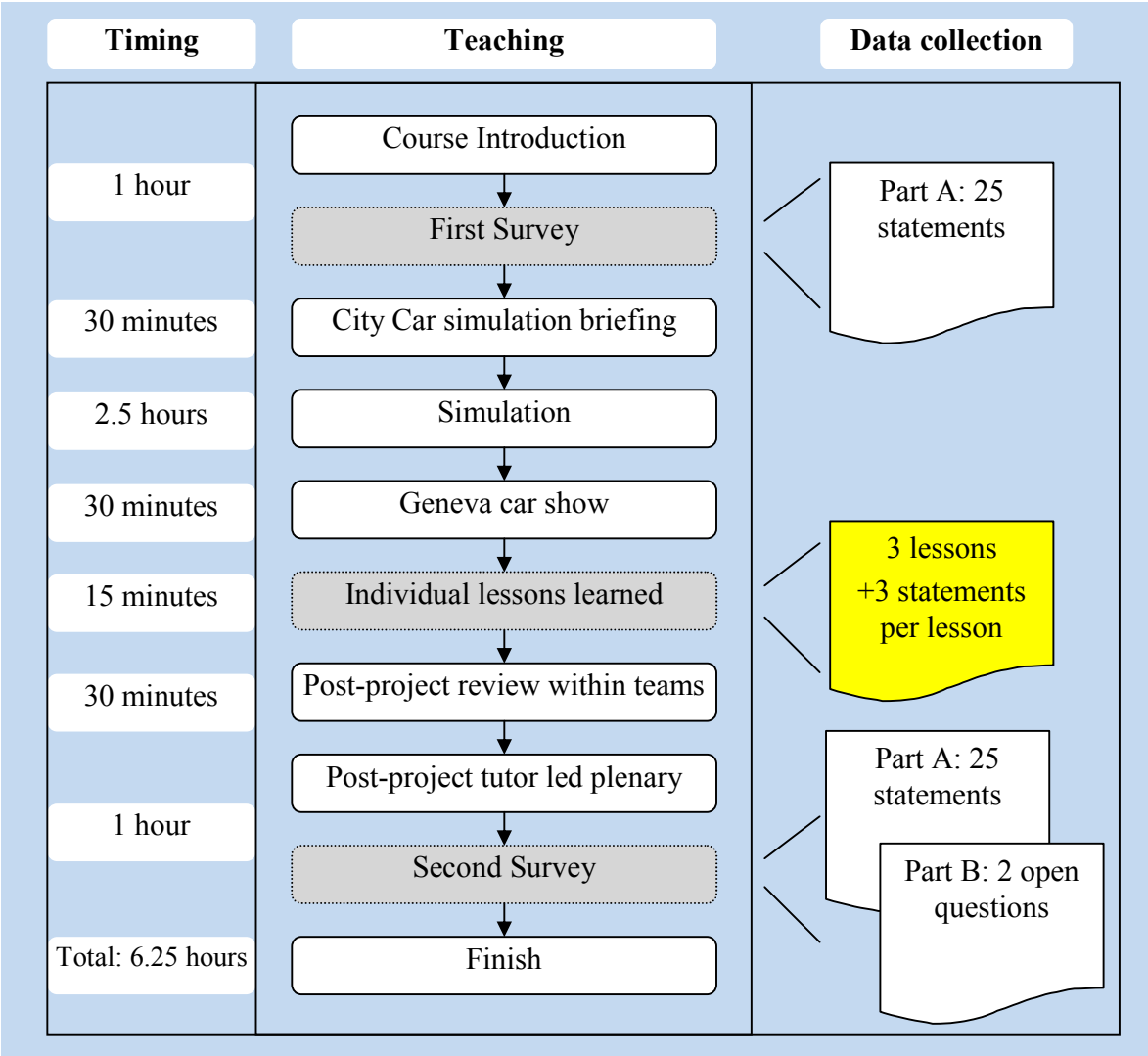

Figure 1: City Car simulation sequence of events

The box in figure 1 highlighted in yellow is our tacitness questionnaire. Here, we ask students to identify three key lessons that they learnt during the simulation activity. We then ask: "Please indicate the extent to which you agree with each of the following statements on the knowledge requirements of each lesson". The statements are:

- The knowledge of the team on lesson 1 would be easy to comprehensively **document** in manuals or reports
- The knowledge of the team on lesson 1 would be easy to comprehensively **understand** from written documents
- The knowledge of the team on lesson 1 would be easy to precisely **communicate** through written documents

Responses are indicated on a 7-point likert scale, with 1 being 'strongly agree' and 7 representing 'strongly disagree'. A score of 1 would therefore indicate low tacitness: I

agree that the knowledge would be easy to document / understand / communicate. Scores are given for each of the three statements for three lessons.
The reason we reversed the nature of the question (knowledge is difficult → knowledge is easy) was due to some feedback we got from a pilot exercise. In our first attempt at using the scale, the students indicated that they found it hard to understand what was being asked, when the question read "The knowledge of the team on lesson {1; 2; 3} is difficult to {comprehensively document; comprehensively understand; precisely communicate} in manuals or reports". The final version of the questionnaire used in this study also uses a reversed likert scale compared to the original scale, since this corresponds to the other questionnaires we use in the simulation exercise, as shown in figure 1 as 'part A' and 'part B'.
We chose not to include the question "Knowledge competencies are difficult to… identify without personal experience in using them".

RESULTS

We asked two groups of students to complete our questionnaire. The first group included 42 full time Masters level students. In the first group, the mean overall **tacitness score is 2.5**. This indicates that the participants *agree* that their key lessons are *easy* to document, understand and communicate in written documents. That is, they are **not very tacit**. The second group included 21 part time Masters students, most of whom were working full time. The mean overall **tacitness score is 1.7**. This indicates more strongly that the participants felt that the lessons learnt during the activity were **not tacit**.

Further analysis

In addition to the mean tacitness scores, we applied qualitative coding to categorise the lessons learnt. In the first group 126 individual lessons were categorized. In the second group, a further 60 lessons were categorized. The results are shown in table 1.
The categories of lessons learnt indicate substantial alignment with the intended learning outcomes (ILOs) for the simulation (Cousens et al., 2009). However, compared with the categories of lessons learned identified in innovation practice (Goffin and Koners, 2010), they do not demonstrate such close alignment. The eight categories of lessons identified in innovation practice were: budget and costs, problem solving, product specifications, potential to apply learning, organizational complexity, project objectives, resources, and time. This may explain the low reported degree of tacitness, i.e. the feeling that the learning could be easily documented, understood and communicated through written reports, since the simulation did not enable the participants to discover the same type of issues that would arise in innovation practice. Further, we described tacit knowledge as being developed through experience. We would therefore expect a simulation activity in which the participant is active to contribute a greater degree of tacit learning than a classroom based activity, but to a lesser degree than an extended period of time spent taking part in product development.
Since we had identified a low perceived degree of tacitness from the first group, in the second group we added an additional questionnaire instrument.

Table 1: categories of lessons learnt

Category	Group 1	Group 2

Communication	41	21
Project management	28	2
Market information	19	21
Roles	17	-
Coping with change	6	-
Budget / Finance	5	6
Specifications	5	6
Service	2	-
Skills	-	4
Fun	2	-
Novelty	1	-

Assessing experience: the second questionnaire

This additional questionnaire instrument was intended to evaluate whether the low perception of *tacitness* corresponded with a low perceived value of *experience*. Since we have stated that tacitness and experience are closely aligned, this will also indicate the degree to which we are actually measuring experience. Our second question is shown below, along with the results from 20 respondents:

There is a new project about to start, where teams will compete to make a new zero emissions City Bus. You have been nominated as the project manager.

- In my opinion, the performance of the new City Bus project team would be improved by:

People with no practical experience, but extended classroom teaching	2.9 (somewhat disagree)
People with no practical experience who have read the City Car lessons learned reports	4.4 (slightly agree)
People with practical experience of the City Car project	5.6 (agree)

- As manager of the new City Bus project, I would prefer to select somebody for my team with:

Exceptional academic performance	1
Previous experience of the City Car project	19

The scores shown above demonstrate that a high value is placed on experience over classroom teaching, written reports, and academic performance. On average, respondents consider that practical experience would improve the performance of a subsequent project, but that extended classroom teaching would not. They also express a preference for recruiting people with experience, over people with an excellent academic record.

Limitations of the study

- There was some difficulty in identifying a suitable test for tacitness in the literature.
- Our sample size is also relatively small, so the findings are not conclusive.
- Our sample groups are significantly different in terms of their experience levels of NPD – the second groups was mostly professional NPD people with 10+ years of experience, but the first group had relatively little experience. Our future analysis should seek to account for this.

DISCUSSION

We have identified that participants in our NPD simulations do not believe that the key lessons that they learn during the exercise are tacit. However, we also identified that there is something that the people think is being gained from the experience but not from classroom teaching. It is therefore somewhat confusing that those things that they describe as the key lessons learnt are thought of as being easy to write down. This suggests that the lessons learnt are not themselves tacit. That is, a written record of a lesson is partial and incomplete, and always needs experience in order to interpret and apply it. We can not verify this claim, since we did not ask how well another person could *apply* that lesson based only on the written record. A second possibility is that the respondents people are misinterpreting the degree of difficulty that would be experienced in writing down the key lessons.

The conflicts identified between our description of tacit knowledge and our survey instrument become apparent when evaluating the results specifically addressing *experience*. We therefore recommend that a modified questionnaire design evaluating tacitness be developed, focusing on the perceived value of the experience and the perceived ability to apply learning based on the experience.

REFERENCES

Balconi, M., Pozzali, A. and Viale, R. (2007), The "codification debate" revisited: a conceptual framework to analyze the role of tacit knowledge in economics. Industrial and Corporate Change, 16(5), 823-849.

Byosiere, P. and Luethge, D. J. (2008), Knowledge domains and knowledge conversion: an empirical investigation. Journal of Knowledge Management, 12(2), 67-78.

Cardozo, R. N., Durfee, W. K., Ardichvili, A., Adams, C., Erdman, A. G., Hoey, M., Iaizzo, P. A., Mallick, D. N., Bar-Cohen, A. and Beachy, R. (2002), Perspective: experiential education in new product design and business development. Journal of Product Innovation Management, 19(1), 4-17.

Cavusgil, S. T., Calantone, R. J. and Zhao, Y. (2003), Tacit knowledge transfer and firm innovation capability. The Journal of Business and Industrial Marketing, 18(1), 6-21.

Cousens, A., Goffin, K., Mitchell, R., Van der Hoven, C. and Szwejczewski, M. (2009), Teaching New Product Development Using the 'CityCar' Simulation. Creativity and Innovation Management, 18(3), 176-189.

De Luca, L. M. and Atuahene-Gima, K. (2007), Market knowledge dimensions and cross-functional collaboration: examining the different routes to product innovation performance. Journal of Marketing, 71(1), 95-112.

Foos, T., Schum, G. and Rothenberg, S. (2006), Tacit knowledge transfer and the knowledge disconnect. Journal of Knowledge Management, 10(1), 6-18.

Goffin, K. (1998), Operations management teaching on European MBA programmes. International Journal of Operations and Production Management, 18(5), 424-451.

Goffin, K. and Koners, U. (2010), Tacit Knowledge, Lessons Learnt, and New Product Development. Journal of Product Innovation Management, Accepted for publication.

Goffin, K. and Mitchell, R. (2006), Cases and the challenge of teaching innovation management. ECCHO, 36(Autumn 2006), 5-6.

Guzman, G. (2008), Sharing practical knowledge in hostile environments: a case study. Journal of Workplace Learning, 20(3), 195-212.

Hedlund, J., Forsythe, G. B., Horvath, J. A., Williams, W. M., Snook, S. and Sternberg, R. J. (2003), Identifying and assessing tacit knowledge: understanding the practical intelligence of military leaders. The Leadership Quarterly, 14(2), 117-140.

Hernandez-Serrano, J., Stefanou, S. E., Hood, L. F. and Zoumas, B. L. (2002), Using experts' experiences through stories in teaching new product development. Journal of Product Innovation Management, 19(1), 54-68.

Jensen, M. B., Johnson, B., Lorenz, E. and Lundvall, B. Å. (2007), Forms of knowledge and modes of innovation. Research Policy, 36(5), 680-693.

Kogut, B. and Zander, U. (1992), Knowledge of the firm, combinative capabilities, and the replication of technology. Organization science, 3(3), 383-397.

Lee, L. L. (2000), Knowledge sharing metrics for large organizations. in Daryl Morey, Mark Maybury and Bhavani Thuraisingham (eds.) Knowledge management: classic and contemporary works. MIT Press, USA, 403-420.

McEvily, S. K. and Chakravarthy, B. (2002), The persistence of knowledge-based advantage: an empirical test for product performance and technological knowledge. Strategic Management Journal, 23(4), 285-305.

Nightingale, P. (2003), If Nelson and Winter are only half right about tacit knowledge, which half? A Searlean critique of codification. Industrial and Corporate Change, 12(2), 149-183.

Nonaka, I. and Takeuchi, H. (1995), The knowledge-creating company: How Japanese companies create the dynamics of innovation. Oxford university press, Oxford, UK.

Pitt, M. and MacVaugh, J. (2008), Knowledge management for new product development. Journal of Knowledge Management, 12(4), 101-116.

Rhodes, J., Hung, R., Lok, P., Ya-Hui, B. and Wu, C. (2008), Factors influencing organizational knowledge transfer: Implication for corporate performance. Journal of Knowledge Management, 12(3), 84-100.

Rijsdijk, S. A., de Jonge, R. and van den Ende, J. (2009), Knowledge tacitness and the effects of formal and informal control mechanisms on NPD project outcomes. In: Proceedings of the 16th International Product Development Management Conference. 7-9 June 2009, Twente, Netherlands.

Rosenau, M. D. (2002), From experience: teaching new product development to employed adults. Journal of Product Innovation Management, 19(1), 81-94.

Sherwood, A. L. and Covin, J. G. (2008), Knowledge Acquisition in University-Industry Alliances: An Empirical Investigation from a Learning Theory Perspective. Journal of Product Innovation Management, 25(2), 162-179.

Silvester, K. J., Durgee, J. F., McDermott, C. M. and Veryzer, R. W. (2002), Perspective: integrated market-immersion approach to teaching new product development in technologically-oriented teams. Journal of Product Innovation Management, 19(1), 18-31.

Simonin, B. L. (2004), An empirical investigation of the process of knowledge transfer in international strategic alliances. Journal of International Business Studies, 35(5), 407-427.

Sternberg, R. J. and Horvath, J. A. (1999), Tacit knowledge in professional practice: Researcher and practitioner perspectives. Lawrence Erlbaum Associates, New Jersey, USA.

Szulanski, G. (1996), Exploring internal stickiness: Impediments to the transfer of best practice within the firm. Strategic Management Journal, 17(1), 27-43.

Wagner, R. K. and Sternberg, R. J. (1991), Tacit knowledge inventory for managers. The Psychological Corporation, San Antonio, USA.