Measuring and Enabling Learning Behaviour in Product Innovation Processes

José Gieskes and Beatrice van der Heijden

It is generally acknowledged that innovation is one of the most important predictors of firm success or failure. Successful innovation processes require creating new organizational capabilities to handle the external pressure for new products and processes (fast, good and at low costs), and the internal pressure for increased efficiency and effectiveness. Under these circumstances 'learning' is an important issue and the increased interest for topics such as knowledge management, organizational learning and continuous improvement illustrates its relevance. Within the CIMA (Continuous Improvement in Global Product Innovation Management) research project (CIMA-ESPRIT 26056) a methodology has been developed to help companies to stimulate learning behaviour of individuals and teams in product innovation processes. By studying learning behaviour in 140 product innovation projects in 70 companies in six countries, a seemingly valid and reliable scale for measuring learning behaviour has been developed. In addition, managerial activities and decisions that are predictive for improving learning behaviour have been identified.

Introduction

According to management practitioners and scholars, organizations are faced with an increasing globalization of markets, rapid developments in technology, changing norms and values in society and increasing demands for networking within and between industries. An organization's success (both in terms of survival and growth) 'more and more depends on its ability to orchestrate a range of organizational, technological and human practices and change efforts of varying scope and time-horizons' (Boer et al., 2001). Both technical and market uncertainties are high. Customer needs, the number and types of competitors, and the range of technological possibilities is all characterized by frequent and substantial change.

In many industries, product innovation is the most import factor driving firm success or failure. Most solutions to handle the increased pressure focus upon creating new organizational capabilities and innovative ways to use resources. In these surroundings the attention for 'learning' almost emerges naturally. Currently, there appears to be an increased interest in knowledge, learning and (continuous improvement) in new product and innovation processes (Bartezzaghi, Corso & Verganti, 1997; Bateson, 1972; Caffyn, 1998; Cangelosi & Dill, 1965; Imai, Nonaka & Takeuchi, 1985).

This article builds on research (CIMA-ESPRIT 26056) that was aimed to help firms to stimulate learning in their product innovation processes. Two research questions will be dealt with:

(1) How can we measure learning behaviour?
(2) What managerial activities and decisions stimulate the development of learning behaviour?

The next section provides some theoretical background to the study of learning behaviours within product innovation processes. The third section goes into the research methodology and describes, among others, the operationalization of learning behaviours and their influencing (stimulating) managerial activities and decisions, that is, the enablers. The following section goes into the outcomes of the study followed by a final section dealing with the practical and theoretical implications of the outcomes.

Theoretical Background

Cangelosi and Dill (1965) already addressed learning in and by organizations in 1965, followed by Bateson (1972), and Argyris (1977), to mention but a few key researchers. Interest in learning in organizations has increased a lot since the seventies (Argyris & Schön, 1978; Fiol & Lyles, 1985; Hedberg, 1981; Jelenik, 1979; Levitt & March, 1988; Pedler, Boydell & Burgoyne, 1989; Shristastava, 1993), not only by academics but also by practitioners (see Senge, 1990). Later on, researchers focused more and more on product innovation within the larger domain of learning by and learning in organizations (Nonaka, 1991).

Literature on learning *by* organizations, i.e. organizational learning,[1] in general, has a normative character. One has been engaged in developing models and methodologies for creating change by improving learning processes. Studies dealing with learning *in* organizations focus more on understanding the nature and processes of learning in an organizational context. It is argued (De Geus, 1988; Senge, 1990; Stata, 1989) that learning is the key to increase the firm's competitiveness and to develop structures and systems that allow the company to adapt to changing circumstances quickly and effectively (Kanter, 1989; Peters & Waterman, 1982).

Learning in and by organizations is denoted in literature as organizational learning, leading to the concept of the so-called 'learning organization'. The concept of the learning organization as an entity in itself is often dealt with in an anecdotal way by identifying characteristics or conditions for becoming a learning organization (Garvin, 1993; Jones & Hendry, 1992; Pedler, Boydell & Burgoyne, 1989). The concept is also approached by means of normative models based upon empirical research (Goh & Richards, 1997). Several authors have started studying the issue in a normative way, but over the years they have discovered that the topic was too complex to be dealt with normatively, also realizing that the assumptions they were building on were presented as facts, without being tested or falsified (Argyris, 1996; Pedler, Burgoyne & Boydell, 1991).

Despite all this interest we know relatively little about learning (processes) in organizations. Already in 1986, Fiol and Lyles had written (1985, p. 803): 'Although there exists widespread acceptance of the notion of organizational learning . . . No theory or model of organization learning is widely accepted'. Since their publication the situation has not changed much. There is still a huge lack of reports on systematic empirical research (Easterby-Smith, 1997; Gieskes, 2000; Miner & Mezias, 1996).

Perspectives on Organizational Learning

'Learning is seen as a purposive quest to retain and improve competitiveness, productivity and innovativeness in uncertain, technological and market circumstances. The greater the uncertainties, the greater the need for learning' (Dodgson, 1993). This quote includes several difficulties in studying the learning process. First, learning is a means to an end and not an end in itself. Consequently, the output of learning should contribute to goal realization. Second, there seem to be circumstances, that is, uncertainties, that trigger the need for learning while at the same time influencing (the direction of) the learning process.

A process view on organizations acknowledges that learning can be viewed as a process of information processing which can have an outcome mirroring an impact on either changes in knowledge (cognition), changes in behaviours (either individual or organizational) or both. The learning process takes place within a context (both in the meaning of the environment in which the process takes place, as well as in the form of managerial activities) that affects the process (Hedberg, 1981; Lei, Slocum & Pitts, 1997; Nevis, DiBella & Gould, 1995; Stata, 1989).

Learning can be viewed from different perspectives depending on the criteria used for differentiation (Easterby-Smith, 1997; Shristastava, 1993). The most important perspectives are characterized in Table 1 by means of a single phrase.

The *information-processing perspective* sees organizations mainly as entities processing information by acquisition, distribution, interpretation and storage of information, that is to say, knowledge (Duncan & Weiss, 1979; Huber, 1991; Nonaka & Takeuchi, 1995). Learning is a continuous process resulting in an increase and improvement of knowledge.[2]

The *contingency perspective* sees organizations as open systems constantly adapting their structures to changes in the environment. Basically, the learning process in this view is a process of adaptation (Cangelosi & Dill, 1965; Cyert & March, 1963; Hutchins, 1991).

Within the *psychology perspective* it is presumed that organizations interpret their internal and external environments in terms of

Table 1. Perspectives on Organizational Learning

Perspective	**Characterization: learning is . . .**
Information-processing perspective	Increasing and improving knowledge through processing processing information
Contingency perspective	Adapting to changes in the environment
Psychology perspective	Continuous and concerted sharing of assumptions in the context of collective action
Systems-dynamics perspective	Developing understanding of the complex causalities of osocial reality
Strategic perspective	Building unique competencies for competitive advantage
Production management perspective	Improving efficiency through experience

shared mental models (Argyris & Schön, 1978; Weick, 1996). In this view, learning is based upon two processes: reflection (analysing the situation and developing new ideas) and experimentation (testing these ideas).

The *systems-dynamics perspective* uses principles and concepts from systems theory for understanding organizational learning processes (Morgan, 1986; Senge, 1990). Senge (1990) states that organizations are characterized by dynamic complexity, for which simple models on cause-effect relationships are not appropriate. Principles from systems theory such as processes and feedback loops are used to demonstrate the reality of organizations.

Literature on organizational learning in the *strategic perspective* focuses on competition. Learning is seen as crucial in building competitive advantage, and as such, the organization should be concerned with building learning competencies.

The *production management perspective* focuses on the relationship between learning on the one hand, and efficiency and productivity on the other hand. Research on the so-called 'learning curve' and on the 'experience curve' (Argote, Beckman & Epple, 1990; Boston Consulting Group, 1968) falls into this category. The discussion on the comparison of the NUMMI and Uddevalla production plants (Adler & Cole, 1993), and the discussion around lean organizations in general are exponents of this perspective.

From literature it seems as if the above-mentioned perspectives serve as paradigms. Each perspective leads to specific conclusions on how learning in reality takes place, and on how it can be influenced. However, the perspectives are not necessarily mutually exclusive, but they can be applied complementing each other in studying organizational learning (see for example Huber, 1991; Nonaka & Takeuchi, 1995; Senge, 1990; Walsh & Ungson, 1991). Application of multiple disciplinary perspectives can lead to an increased understanding into the nature and problems of organizational learning.

The assumption that organizations are able to learn, as well as the assumption that they all learn, whether consciously or not (Kim, 1993) has not been taken for granted in literature. Walsh and Ungson (1991) have pointed to anthropomorphism in the discussion on organizational memory, and it seems to apply to the discussion on organizational learning in general:

> There is something paradoxical here. Organizations are not merely collections of individuals, yet there are no organizations without such collections. Similarly, organizational learning is not merely individual learning, yet organizations learn only through the experience and actions of individuals. (Argyris & Schön, 1978, p. 9)

At the same time, knowledge generated by the individual is not independent of organizational learning. Models of individual learning (Kolb, 1984) can be linked to theory on organizations as behavioural systems (Cyert & March, 1963), and to organizations as interpretation systems (Daft & Weick, 1984). The result is a model of organizational learning that addresses the issue of transfer of information through the exchange of individual and shared mental models (see also Argyris, 1996), that is, a model within the knowledge development perspective (Glynn, Lant & Milliken, 1994).

Within the information-processing perspective (Duncan & Weiss, 1979; Huber, 1991; Nonaka & Takeuchi, 1995; Pentland, 1995; Sligo, 1996; Walsh & Ungson, 1991; Wijnhoven, 1995), knowledge is characterized as organizational knowledge when it is accepted and exchanged by the organizations' members. Knowledge improvement is to be reached by the continuous process of learning. In the CIMA research project that is reported on, we apply a so-called combined perspective. In this perspective knowledge processing in and through the organization is seen as an important factor in the change of mental constructs, both on an individual and on a group level.

Learning in Product Innovation Processes

In literature, the relationship between learning and product innovation processes is described in different ways. First, literature can be categorized according to the different perspectives on organizational learning. One group of theories can be classified under the information-processing perspective. The common denominator for these theories is the notion that Research and Development (R&D) is a rational problem-solving process. Information is processed as a result of going through the different phases of this problem-solving process.

According to Brown and Eisenhardt (1995), in the rationalistic approach, organizational learning is seen as a predictable and controllable process where most of the learning takes place before the execution phase of the new product development process.

A second stream of literature can be characterized by the focus of research upon learning in product innovation – in general limited to R&D or (even more limited to) new product development – and has linkages with the adaptation perspective of organizational learning. Within this perspective, two ways of looking at the relationship between learning and R&D or new product development can be distinguished. *Product Innovation Processes* (especially New Product Development) can, by nature, be viewed as learning processes since they have a primary role in generating new knowledge and distributing that knowledge throughout the organization. As such the process of knowledge development and accumulation is equated with learning (Carlsson, Keane & Martin, 1976; Nelson & Winter, 1982). Product innovation processes can also be viewed as one of the focal processes in an organization, where learning is essential in order to stay competitive (Bartezzaghi, Corso & Verganti, 1997; Caffyn, 1998; Hughes & Chafin, 1996; McKee, 1992).

Within this view learning can be addressed by facilitating and stimulating a number of learning behaviours exhibited by individuals and groups related to the acquisition, generation, diffusion, storage and retrieval of knowledge. Changes in behaviour (at an individual, group and organizational level) can be seen as indicators for learning, and are often mentioned in literature, though hardly operationalized nor systematically empirically studied. The following citation summarizes this view: '. . . widely recognized belief that the acquisition, retention and retrieval of knowledge and experience from retention repositories (i.e. memory) influence subsequent individual behavior . . .'(Walsh & Ungson, 1991, p. 58).

As changes in behaviours have hardly been operationalized nor systematically studied, the development of a psychometrically sound instrument to measure (changes in) learning behaviour is one of the main goals of our study. In the following section we will go into the research methodology of our project.

Research Methodology

The Research Model

The CIMA research project adopted the approach of learning behaviours as indicators for learning processes. Starting with a state-of-the-art literature review covering product innovation, organizational learning, continuous improvement (CI), knowledge management, and performance measurement in product innovation processes, an investigation framework has been developed and used to carry out ten in-depth case studies in six countries (Australia, Ireland, Italy, The Netherlands, Sweden and the UK).

The findings of some fieldwork, together with a thorough analysis of the literature review resulted in a model for learning (and continuous improvement) in product innovation processes. This model underpinning the CIMA methodology is depicted in Figure 1. It has been tested and applied in a variety of companies. The development and application of the model and the methodology are elaborately explained and described in Boer et al. (2000), and in Boer et al. (2001).

Learning behaviours exhibited by individuals and by teams are the core elements that lead to a certain *performance*. These behaviours can be addressed through so-called *enablers*, man-

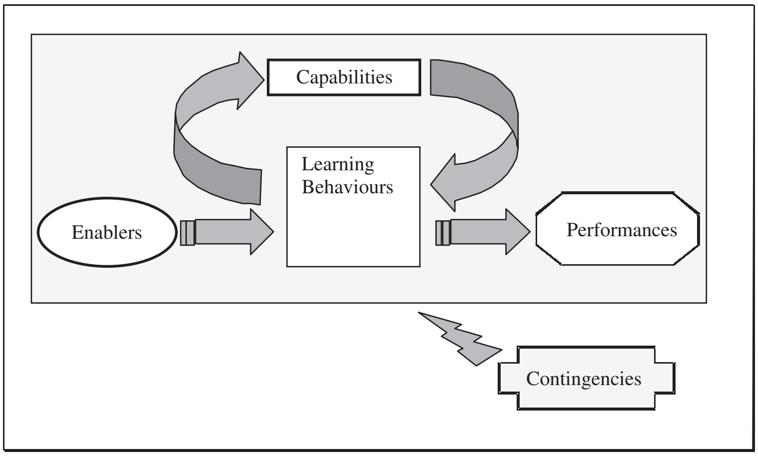

Figure 1. Elements in the CIMA Model for Learning in Product Innovation Processes

agerial decisions and activities that do have an impact (but that not necessarily need to be aimed directly at improving learning behaviour). The identification of *contingencies* is required to take into account the uniqueness of product innovation processes and organizational differences. *Capabilities* (integrated stocks of resources that are accumulated over time through learning) are built through exercising the behaviours and, in turn, help building the learning behaviours.

Based on the previously mentioned state-of-the-art literature review, together with the case studies, and the testing of the CIMA methodology eight categories of learning behaviours, and eight categories of enablers have been distinguished. Examples of *enablers* are HRM policies, project planning and control, performance management, design tools and methods. Examples of *learning behaviours* are, for instance, using strategic goals and objectives to focus and prioritize learning activities, using product innovation processes as opportunities to develop knowledge, using parts of the available time and resources to experiment with new solutions, integrating and transferring new knowledge within and between innovation processes and embedding knowledge into vehicles such as reports, guidelines and databases.

Learning behaviours were investigated by means of an e-questionnaire (to be answered by the responsible person for product innovation) that was filled out in workshops facilitated by the research team. Next to the mapping of exhibited learning behaviours, we have also investigated the enablers used for stimulating and facilitating these learning behaviours. The CIMA methodology has been used in 70 companies in the six participating countries, and the data have been centrally stored in the so-called CIMA database. This database has been analysed for different purposes: contingencies that influence firm level approaches to learning in product innovation processes have been studied (Ronchi, Chapman & Corso, 2000), as well as aspects of occupational culture and problems associated with learning (Hyland, Gieskes & Sloan, 2001), and barriers to learning in product innovation processes (Gieskes, 2003).

Sampling and Procedure

Providing answers to the questions: (1) whether the measurement of learning behaviours in the CIMA model is *reliable*, and (2) which enablers (see Figure 1) are *effective* in stimulating learning behaviour in product innovation (PI) processes has been approached in a quantitative way. Before turning to the statistical analyses that have been carried out to answer the research questions, some background information on the research model and the sample will be given.

The research model (including the operationalization of the variables and following the information-processing perspective) is depicted in Figure 2. In this model, learning behaviours are considered to be the dependents, while enablers are assumed to be the predictors.

The information-processing perspective provides a valuable means for categorizing different learning behaviours with regard to learning process:

- *Knowledge acquisition and generation*: individuals and groups use innovation

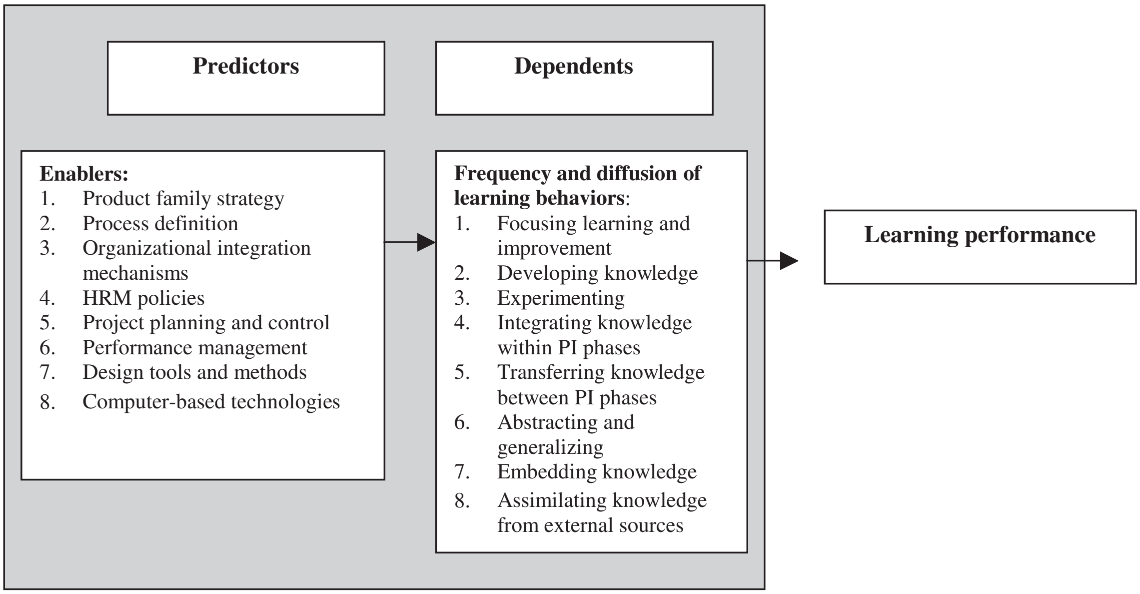

Figure 2. The Research Model Including the Operationalization of the Variables

processes as opportunities to develop knowledge, use part of the available time and resources to experiment, and try to assimilate and to use knowledge from external sources (Cohen & Levinthal, 1990; Leonard-Barton, 1992; McGill, Slocum & Lei, 1992; McKee, 1992; Miner & Mezias, 1996; Pedler, Boydell & Burgoyne, 1989).

- *Information distribution*: individuals and groups integrate and transfer knowledge within and between all the different phases of product innovation processes, and throughout the organization. People analyse their experiences in order to identify knowledge and information that is really important and may be applied in other situations (Dibella, Nevis & Gould, 1996; Pedler, Burgoyne & Boydell, 1991; Shaw & Perkins, 1991).
- *Information interpretation*: people are aware of the value of sharing knowledge acquired in different product innovation processes (Daft & Weick, 1984; McKee, 1992). As such, individuals and groups use the strategic goals and objectives of a product innovation process to focus and prioritise their learning activities, that is to say, their behaviour (Bowen et al., 1994; Dibella, Nevis & Gould, 1996; McKee, 1992; Morgan, Katsikeas & Appiaha-Adu, 1998).
- *Information storage and retrieval*: people embed knowledge and make it available to other people in the organization by incorporating it in vehicles such as reports, databases, and product and process standards that can be more widely disseminated and retained over time (Cooper et al., 1999; Dibella, Nevis & Gould, 1996).

The companies in the CIMA database are all manufacturing companies. Although the majority of the companies are medium-sized, there is a considerable percentage that can be labelled as large, that is employing at least 250 employees. Approximately 50 per cent of the companies confine their manufacturing and New Product Developmental (NPD) activities to their home countries, and their markets are either regional or national. Only 5 per cent of the companies are globally oriented in their manufacturing activities, whereas hardly any company is globally oriented in its NPD activities. About 40 per cent of the companies operate alone and are privately owned, while another 35 per cent are subsidiaries of a multinational. The typical product development time in these companies' specific industry is somewhere between six months and two years, whereas the typical product life-cycle in general is longer (> five years).

The respondents were asked to identify a product innovation process or project that was recently completed and that was exemplary for the company. Four output characteristics of the projects were distinguished. *'Newness'* refers to the degree of innovation involved in the products, *'functionality'* to the functionality that is offered by the new products. The *'product complexity'* is a measure for the complexity of the structure of the new products, that is, the number of distinct components that are needed. *'Markets served'* refers to whether both products are produced for different types of markets, customers, regions and so on.

This study relies on retrospective reports about the variables of interest. There is reason to believe that individuals are in a good position to make a valid assessment of their own learning behaviours. The person who is doing the job possesses the greatest familiarity with the job, and because of that, is appropriate for filling in the questionnaire. Studies examining job-related variables have shown that those who possess greater familiarity with the job, in this case an innovation project, and the ratee (Kozlowski & Kirsch, 1987) provide ratings that are more reliable and have fewer errors (Miller, 1996). Who else has a better understanding of the project and one's functioning in it than the employee him or herself?

Notwithstanding the advantages of self-assessments, it was assumed that attention should be paid to prevent so-called 'data inaccuracy', implying that the data are incomplete, biased or imprecise. Approaches for minimizing the occurrence or magnitude of these inaccuracies were examined and several guidelines for improving the accuracy of retrospective reports have been followed in the CIMA research project (Huber & Power, 1985). More specifically, the person that was most knowledgeable about the issue of interest was identified, informants have co-operated with the researchers (by means of the workshops) and the questionnaires have been pre-tested and structured.

The assumption that retrospective accounts of past strategies are accurate has been tested empirically, and the outcomes have indicated that substantial retrospective errors occur less in case the matter on which to report is more recent (Golden, 1992). Moreover, retrospective accounts of past behaviours are likely to be more accurate compared with the accounts of past beliefs and intentions (Golden, 1992).

Altogether, the resulting research design is quite useful and easy to administer in providing a picture of the degree of learning behaviours.

Measurements

Learning Behaviours

The CIMA model distinguishes two dimensions of learning behaviours that apply to each of its eight categories (see Figure 2): *frequency* as a measure of how often the learning behaviour is exhibited by individuals and groups, and *diffusion* as a measure of how widespread the learning behaviour is throughout the product innovation process.

The CIMA model assumes that enablers are either directed at improving the frequency or at improving the diffusion of the learning behaviour, which implies that the two dimensions are independent. This independency indicates that a change in frequency does not imply a change in the diffusion (and vice versa) of learning behaviours. Both dimensions have been measured using a five-point Likert scale. Table 2 depicts that scale anchors that have been used.

Outcomes of the Study

An investigation into the correlations structure using Pearson's *r* shows that the fre-

Table 2. Scale Anchors for Frequency and Diffusion

Frequency	Diffusion
1 The behaviour was never shown.	The behaviour was not seen anywhere within the innovation process.
2 The behaviour was shown only rarely.	The behaviour was confined to one part of the innovation process.
3 The behaviour was shown rather frequently.	The behaviour was confined to some parts of the innovation process.
4 The behaviour was shown very frequently.	The behaviour was diffused in most parts of the innovation process.
5 The behaviour was always shown as part of day-to-day work.	The behaviour was spread throughout the innovation process.

quency and the diffusion of learning behaviours are strongly related. The issue arising is whether there is a direction in the relationship between frequency and diffusion. In other words, in reality when stimulating learning behaviours through enablers, should the organization focus on frequency or on diffusion? This question cannot be answered confidently within the context of this study since the data do not allow for causal modelling (see also Jöreskog & Sörbom, 1993). In order to answer our research questions we have limited ourselves to reliability analysis, exploratory factor analysis and regression analysis.

Exploratory Factor Analysis (EFA)

Factor analysis (FA) includes a variety of correlational analyses designed to examine the interrelationships among variables (Gorsuch, 1983). As such, FA is a generic term used to describe a number of methods to analyse interrelationships within a set of variables or objects, resulting in the construction of fewer objects, called factors. These factors are supposed to contain the essential information in a larger set of observed objects. Two major dichotomies regarding FA do exist: exploratory and confirmatory FA.

Exploratory FA (EFA) is used to explore data in order to determine the number or nature of factors that account for the co-variation between variables when the researcher does not have, *a priori*, sufficient evidence to form a hypothesis about the number of factors underlying the data. Therefore, EFA is generally more thought of as a theory-generating procedure as opposed to a theory-testing procedure (Cronbach, 1990; Stevens, 1996). *Confirmatory* FA is a theory-testing model where the researcher begins with a hypothesis, prior to the analysis. The model specifies which variables will be correlated with which factors and which factors are correlated.

In the CIMA research project it is assumed that 'learning behaviour' as a generic variable can be measured in a reliable way by means of eight different learning behaviours. As no hypotheses were formulated with regard to the number or nature of factors to be identified, EFA is the appropriate method to examine whether one or more factors can be identified within the eight behaviours, including their frequency and diffusion.

Before an exploratory factor analysis was carried out, a reliability analysis using Cronbach's alpha has been performed. Cronbach's alpha is an empirical measure of the internal consistency of a scale and an estimate of the scale reliability. The results of the reliability analysis indicate that a seemingly reliable scale has been developed. Cronbach's alpha for the total scale is 0.90, while the reliabilities for the frequency items, and for the diffusion items separately, are 0.79 and 0.81 respectively. The 16 items for learning behaviour all relate to the same construct of 'learning behaviour' and are a useful measure for it. As a newly developed scale has been constructed, Table 3 provides some details of the reliability analysis' outcomes.

The eight distinguished learning behaviours with the two dimensions, that is, frequency and diffusion, were identified by means of a thorough literature study and some case studies. Principal Component Analysis was used to explore the underlying structure of the variable 'learning behaviour'. Orthogonal VARIMAX rotation (Norušis, 1993) was carried out and its results show that all sixteen items (eight for frequency and eight for distribution) load on one factor explaining 41 per cent of the variance (see Table 4). A second factor explains an additional 13 per cent of the variance, whereby only Learning Behaviour item number eight (people try to assimilate and use knowledge from external sources) loads well on this factor. The third and fourth components explain respectively 9 per cent and 8 per cent.

The results of the EFA lead to the conclusion that the psychometric qualities of the newly developed scale are sufficient enough to justify its use in a subsequent analysis aimed at testing the effectiveness of enablers for stimulating learning behaviour.

Enablers Stimulating Learning Behaviour

The majority of authors in literature on learning believe that management is the most influential factor in affecting learning behaviour, and in allowing learning to take place (Bowen et al., 1994; Cooper et al., 1999; Dixon, 1992; Huber, 1996; McGill, Slocum & Lei, 1992; Senge, 1990). In our study, we have used a more comprehensive list of different types of enablers (see Table 5).

For each learning behaviour, the respondents were asked to indicate which enablers were used to stimulate the particular learning behaviour by ticking the appropriate enabler(s) and by, if applicable, adding enablers that were not mentioned in the list. It is hypothesized that the relationship between the enablers on the one hand, and learning behaviour on the other hand, is positive. Table 6 summarizes the different hypotheses that have been tested.

The hypotheses in Table 6 can be tested empirically by means of regression analyses

Table 3. Reliability Analysis (n = 66)

Scale	Scale if item Deleted	Corrected variance if item deleted	Item-total correlation	Squared multiple correlation	Alpha if item deleted
Behaviour 1	48.64	116.24	0.58	0.62	0.89
(Freq.)	48.44	115.57	0.56	0.65	0.89
Behaviour 2	48.95	116.72	0.48	0.60	0.90
(Freq.)	48.35	116.51	0.59	0.57	0.89
Behaviour 3	48.41	113.69	0.68	0.77	0.89
(Freq.)	48.18	117.54	0.48	0.79	0.90
Behaviour 4	48.55	110.96	0.68	0.82	0.89
(Freq.)	48.50	117.76	0.44	0.68	0.90
Behaviour 5	48.58	114.71	0.60	0.61	0.89
(Freq.)	48.43	114.37	0.61	0.66	0.89
Behaviour 6	49.03	115.29	0.55	0.65	0.89
(Freq.)	48.32	112.74	0.67	0.64	0.89
Behaviour 7	48.30	111.23	0.73	0.84	0.89
(Freq.)	48.20	115.51	0.57	0.83	0.89
Behaviour 8	48.42	114.03	0.55	0.80	0.89
(Freq.)	48.83	118.88	0.37	0.69	0.90
Behaviour 1 (Diff.)					
Behaviour 2 (Diff.)					
Behaviour 3 (Diff.)					
Behaviour 4 (Diff.)					
Behaviour 5 (Diff.)					
Behaviour 6 (Diff.)					
Behaviour 7 (Diff.)					
Behaviour 8 (Diff.)					

with enablers as the predictor variable for learning behaviour in innovation projects. One might think of studying all possible relationships between enablers and behaviours, implying eight enablers by eight learning behaviours by two dimensions. The problem however with this analysis structure is that for some analyses the number of data will be very low, limiting the possibility to draw reliable conclusions. A second issue that would come up is the so-called phenomenon of 'chance capitalization' (see also Stevens, 1996).

In order to avoid these pitfalls, we have decided to build on the previous section from which we inherit the aggregated scale for learning behaviour that enables us to test and measure in a seemingly reliable way the relationship between different types of enablers and learning behaviour. In Table 7, one can see which hypotheses have been confirmed in our study.

Concerning the analyses of the effects of categories of managerial activities and decisions upon learning behaviour, our hypotheses have for the greater part been confirmed. For two enablers that were assumed to be effective in stimulating and facilitating learning behaviour, our hypothesis has been rejected. Product family strategy and computer-based technologies are not significantly related to learning behaviour. Six of the eight enablers indeed appear to be effective whereby two enablers, i.e. human-resource management policies, and project planning and control appear to have the strongest impact. In the last section we will go into the conclusions and a discussion of the outcomes of this study.

Conclusions and Discussion

The finding that product family strategy is not significantly related to learning behaviour is interesting, since literature on learning and on Continuous Improvement (CI) emphasizes the formulation and deployment of goals as being

Table 4. Principal Component Matrix

	Components			
	1	2	3	4
Behaviour 1 Frequency	0.65	0.16	–0.47	0.12
Behaviour 1 Diffusion	0.68	0.06	–0.34	–0.007
Behaviour 2 Frequency	0.63	0.12	–0.53	–0.03
Behaviour 2 Diffusion	0.69	0.03	–0.49	–0.07
Behaviour 3 Frequency	0.53	0.05	–0.07	0.60
Behaviour 3 Diffusion	0.59	0.22	0.07	0.60
Behaviour 4 Frequency	0.65	0.25	0.03	–0.23
Behaviour 4 Diffusion	0.72	0.18	0.10	–0.16
Behaviour 5 Frequency	0.76	–0.44	0.13	–0.05
Behaviour 5 Diffusion	0.81	–0.45	0.06	–0.007
Behaviour 6 Frequency	0.57	–0.64	0.30	0.14
Behaviour 6 Diffusion	0.65	–0.59	0.32	0.03
Behaviour 7 Frequency	0.73	0.12	0.11	–0.41
Behaviour 7 Diffusion	0.61	0.27	0.19	–0.50
Behaviour 8 Frequency	0.46	0.60	0.36	0.25
Behaviour 8 Diffusion	0.40	0.56	0.58	0.062

Table 5. Examples of Enablers

Enablers	Specific examples
1. Product family strategies	Product family plans, carry-over policies, standardization policies
2. Process definition	Stage-gate processes, company innovation procedures
3. Organizational integration mechanisms	Teamwork, matrix organization, and committees
4. HRM policies	Personnel rotation, departmental assessment and development plans, reward systems, empowerment programs
5. Project planning and control	Project termination reports, design reviews
6. Performance measurement	Comparison of measurements against previous results or with other subsidiaries or leading organizations
7. Design tools and methods	Standardized design methodologies and procedures, libraries of standard design solutions, integration procedures (e.g. Quality Function Deployment, Design for Manufacturability)
8. Computer-based technologies	IT systems, computer-aided technologies, prototyping technologies

Table 6. Hypotheses Underlying the CIMA Model

Hypothesis 1	Formulation and existence of a product family strategy are positively related to learning behaviour
Hypothesis 2	Definition and standardization of the innovation process are positively related to learning behaviour
Hypothesis 3	Organizational integration mechanisms are positively related to learning behaviour
Hypothesis 4	Development and execution of human-resource management policies is positively related to learning behaviour
Hypothesis 5	Planning and control of product innovation processes are positively related to learning behaviour
Hypothesis 6	Performance measurement is positively related to learning behaviour
Hypothesis 7	Standardization of design tools and methods is positively related to learning behaviour
Hypothesis 8	The implementation of computer-based technologies is positively related to learning behaviour

Table 7. Results of Regression Analyses with Enablers as Predictors and Learning Behaviour as Dependent (n = 66)

Hypothesis 1	Formulation and existence of a product family strategy are positively related to learning behaviour	Rejected
Hypothesis 2	Definition and standardization of the innovation process are positively related to learning behaviour	Confirmed Multiple R = 0.31, $R^2 = 0.10$, $F(1, 66) = 7.04$, $p < 0.05$*
Hypothesis 3	Organizational integration mechanisms are positively related to learning behaviour	Confirmed Multiple R = 0.30, $R^2 = 0.09$, $F(1, 66) = 6.74$, $p < 0.05$*
Hypothesis 4	Development and execution of human resource management policies is positively related to learning behaviour	Confirmed Multiple R = 0.44, $R^2 = 0.19$, $F(1, 66) = 15.48$, $p < 0.001$***
Hypothesis 5	Planning and control of product innovation processes are positively related to learning behaviour	Confirmed Multiple R = 0.48, $R^2 = 0.23$, $F(1, 66) = 19.82$, $p < 0.001$***
Hypothesis 6	Performance measurement is positively related to learning behaviour	Confirmed Multiple R = 0.30, $R^2 = 0.09$, $F(1, 66) = 6.28$, $p < 0.05$*
Hypothesis 7	Standardization of design tools and methods is positively related to learning behaviour	Confirmed Multiple R = 0.34, $R^2 = 0.12$, $F(1, 66) = 8.75$, $p < 0.01$**
Hypothesis 8	The implementation of computer-based technologies is positively related to learning behaviour.	Rejected

one of the key features for success (Bowen et al., 1994; Galer & Van der Heijden, 1992). An explanation for this finding can be found in the phrasing in the questionnaire of the enabler itself. The term 'product family strategy' implies the existence of a product innovation strategy on a product level, which is not formulated in all companies.

A second explanation could be that since strategy is important for directing the activities of employees towards goal realization, product family strategy does have an effect upon focusing and framing behaviour, but not necessarily upon learning. A product strategy is a management decision, as such, that is a fact and does not serve as a trigger for learning (although the strategy decision-making process might) (De Geus, 1988). It is also argued that dynamic learning is not compatible with a very strong goal alignment (Galer & Van der Heijden, 1992). The stronger the goal orientation, the more difficult it is for organizations to be open to for alternatives.

Computer–based technologies (such as IT-systems, computer-aided technologies (CAD, CAM, CAE) and Prototyping technologies) also appear not to be contributing to learning behaviour. However, some caution is called for interpreting this result, since the respondents indicated that to them the difference between computer-based technologies and design tools and methods[3] was not always clear, and that it was not always possible to clearly distinguish between the two. Hypothesis 7, referring to the contribution of design tools and methods is confirmed with the enabler explaining 12 per cent of the variance in learning behaviour. Few scientists have studied the impact of computer tools and systems upon innovation processes (and as such their continuous impact upon learning) (Hanseth & Monteiro, 1997; Henfridsson & Soderholm, 2000; Tyre & Orlikowski, 1994). The authors demonstrate that computer tools and systems do not always result in learning. On the contrary, they more than once observed negative learning implications.

Project management and control is an enabler that explains 23 per cent of the variance in learning behaviour. From research in the fields of Project Management and R&D Management, it is known that project planning and control are very effective in performance improvement. However, it is also known that the major benefit of project planning and control is realized during the start of its implementation and the more disseminated the implementation is, the better the effect. In fact, planning and control help to manage the product innovation process and when it is not effective, management is involved in operational activities in the project. Once the process becomes more under control, time (and often budget too) becomes available that can be used for additional, new activities. Particularly in freeing up energy for learning activities, project planning and control appear to be effective. It would be interesting to find out in future research if this enabler still has a strong impact on learning behaviour in product innovation processes that for a long time already have been subjected to effective planning and control.

The last result to discuss concerns the impact of HRM policies, such as job rotation, reward systems, empowerment programmes, development plans. In general, HRM policies are aimed at helping people to develop, grow and empower themselves in such a way that they can contribute effectively to realizing both the organizations' and their own goals. HRM policies can help people to learn and learn how to learn, and as such have a double effect.

Work on learning styles (Honey & Mumford, 1986; Kolb, Fubin & McIntyre, 1973) has shown that individuals have a natural preference for the way they learn. Distinct ways of learning should be recognized and acknowledged as a prelude to broadening individual repertoires. This is necessary since different settings and different situations favour different learning styles (Brown & Duguid, 1991). HRM policies are important means in helping people to broaden their repertoire and help them perform well under different circumstances. At the same time HRM can address different learning styles in such a way that learning as a whole is improved.

An interesting outcome is the fact that it is precisely these HRM policies that have been used least frequently in the CIMA research project to stimulate learning behaviour (Caffyn et al., 2000). In discussions on the outcomes of our study with practitioners, one indicated that HRM policies were perceived to be the expertise area of the HRM or personnel department, and that product innovation managers disqualified themselves from using enablers in this HRM category.

Analyses on country-related differences by Hyland, Gieskes and Sloan (2001) indicated that there were no outstanding differences in the use of enablers that could be attributed to cultural differences among countries. Although the type of enablers that are applied may differ, this does not seem to be the case in terms of 'how' the enablers are applied. While the data do not provide information on this 'how', we cannot go into a further analysis of it.

Analysis of the company and product-related characteristics by Chapman et al. (2000) with the aim to identify and analyse the main contingent variables influencing firm-level approaches to learning in product innovation, reveals that four cluster of companies can be identified:

- The first cluster (12 companies) consists of entrepreneurial firms with less than 30 employees and with a low labour turnover. Their customers are located in a domestic market and provided with highly customized products. The operations and R&D activities are confined. The product life cycle is very long, although their development time is very short, and their complexity rather high. In these companies, management is very much involved in technological and customer issues.
- The second cluster (24 companies) mainly concerns companies with less than 250 employees and an average labour turnover. Their market is national or restricted to a few countries in the same geographical area, while manufacturing and R&D sites are confined to the home country. The products' level of complexity in general is not high, and the life cycle is medium, with a rather long development time.
- The third cluster (20 companies) in general consists of large industrial groups with more than 250 employees and a high labour turnover. Their market is a geographical area (Europe, Asia) while their operations and R&D activities, however, are confined to their home countries. Products and processes are not complex, with a long life cycle for products, and a short development time.
- The fourth cluster (14 companies) consists of large multinationals with more than 1,000 employees with a high labour turnover. Their market, operations and R&D activities are globally oriented. The product development time and product life cycle are short.

In their research, Chapman et al. (2000) analysed the enablers typically associated with each of these clusters and found that a certain emphasis on particular enablers can be identified for especially the first two clusters. Companies in the first cluster particularly employ project planning and control, as well as computer-based technologies. This indicates that for small companies producing niche, customized products, good project management procedures, resources' allocation and scheduling are important means in affecting learning behaviour. The second cluster shows a similar preference, that is, a lot of managerial effort in project planning and control, and design tools and methods. However, in these companies computer-based technologies seem to be lagging behind. Companies in the third and fourth cluster do not really show a preference for particular enablers, but for these companies, relations with other companies and research centres seem to be important for their innovation activities.

Before making statements on the correctness of existing theory, the issue of validity of measurement instruments has to be discussed. The problem of validity is probably most critical in empirical research since it goes into the question whether the indicators that are used indeed reflect the abstract concept that is to be measured. In the CIMA research project, it is assumed that the operationalizations of learning behaviour and enablers have content validity as their development is based upon an extensive literature review, in-depth discussions among academics and practitioners within expert communities and peer groups, and upon field testing.

In order to answer our research questions regarding the psychometric qualities of the operationalization of learning behaviour, and what managerial decisions and activities are effective in stimulating learning behaviour require exploration and verification of a theory. A first important conclusion that can be drawn from our study is that the two dimensions of learning behaviour, i.e. frequency and diffusion, are not independent. From an analytical point of view this indicates that there is no necessity in distinguishing between them. In practice, this seems to indicate that for managers to improve learning behaviour there is no major difference in which dimension to target first. A second conclusion is that the statistical analyses reveal that it is possible to constitute a reliable scale for measuring learning behaviour (from an information-processing perspective) by means of 16 items.

A third conclusion of our study is that six of the eight enablers as distinguished within the CIMA model appear to be effective in stimulating learning behaviour: process definition, organizational integration mechanisms, HRM policies, project planning and control, performance management and design tools and methods. Contrary to what is stated in literature, product family strategy and computer-based technologies are not significantly related to learning behaviour. Explanations for these findings can be found in the wording of the questionnaire, but also in the way the respondents perceived these enablers.

Discussing the results of the CIMA methodology with practitioners has revealed that, in general, managers in product innovation processes are not always aware of the possibilities of using enablers for improving learning. Much too often managers are aimed at realizing (short-term) project goals, more specifically performance within budget and time constraints, and thereby neglecting long-term effects of improving learning behaviour.

In future research several interesting issues can be explored. First of all, one could think of an in-depth study of the process of changing behaviour as a result of applied enablers. This type of research might give more insight into the way the enablers operate. This will also require further research into the effectiveness of more specific enablers in specific contexts.

Another interesting study could be aimed at improvement of the measurements and might consist of asking raters to give concrete examples of learning behaviours that could illustrate why they give a particular rating to a particular item. It is expected that a certain amount of sifting of responses will occur. The differentiation between item meanings will probably increase and the scale homogeneities will less, but the end result will be that the ratings are explicitly founded on empirical verifiable observations of learning behaviour. If this proves successful, the validity of the instrument will increase and be easier to clarify. The latter refers to the fact that demonstrative examples given by raters could give an insight into the intrinsic content of learning behaviours in organizations. The way in which this can be done is by means of highly structured interviews. They are more dynamic in that possibilities for putting extra questions on a certain topic are within the researcher's reach.

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Notes

1 See Gieskes (2001, p. 35) for a variety of definitions on organizational learning indicating the scattered nature of the field.

2 In line with Huber (1991), the words information and knowledge will be used interchangeably. It is recognized that on theoretical grounds a distinction is possible (for instance knowledge being information with a context), but for the line of argument in this contribution this discussion is not called for.

3 Such as standardized design methodologies and procedures, libraries of standard design solutions and integration procedures.

References

Adler, P.S., and Cole, R.E. (1993) Designed for learning: A tale of two auto plants. *Sloan Management Review*, 34(3), 85–94.

Argote, L., Beckman, S.L. and Epple, D. (1990) The persistence and transfer of learning in industrial settings. *Management Science*, 36(2), 140–54.

Argyris, C. (1977) Double Loop Learning in Organizations. *Harvard Business Review*, 55(5), 115–25.

Argyris, C. (1996) Actionable knowledge: design causality in the service of consequential theory. *Journal of Applied Behavioral Science*, 32(4), 390–406.

Argyris, C. and Schön, D. (1978) *Organizational Learning. A Theory of Action Perspective*. Addison-Wesley Publishing Co, Reading MA.

Bartezzaghi E., Corso M. and Verganti R. (1997) Continuous improvement and inter-project learning in new product development. *International Journal of Technology Management*, 14(1), 116–38.

Bateson, G. (1972) *Steps to an ecology of mind*. Jason Aronson Inc., Northvale.

Boer, H., Caffyn, S., Chapman, R., Coughlan, P., Corso, M., Gieskes, J., Harbison, A., Hyland, P., Magnusson, M.G., Pavesi, S., Ronchi, S. and Sundgren, N. (2000) Developing continuous innovation as an organization-wide process. In Proceedings of the 7th EurOMA conference, Ghent, Netherlands, June.

Boer, H., Caffyn, S., Corso, M., Coughlan, P., Gieskes, J., Magnusson, M.G., Pavesi, S. and Ronchi, S. (2001) Knowledge and continuous innovation: the CIMA methodology. *International Journal of Operations & Production Management*, (21)4, 490–503.

Boston Consulting Group (1968) *Perspectives on experience*. The Boston Consulting Group Inc., Boston.

Bowen, H.K., Clark, K.B., Holloway, C.A. and Wheelwright, S.C. (1994) Development projects: The engine of renewal. *Harvard Business Review*, 72(5), 110–20.

Brown, J.S. and Duguid, P. (1991) Organisational learning and communities of practice. *Organisa-*

tion Science, 2(1). Reprinted in Cohen, M.D. and Sproull, L.W. (eds) (1996) *Organizational Learning*. Sage Publications, Thousand Oaks CA, pp. 58–82.

Brown, S.L. and Eisenhardt, K.M. (1995) Product development. Past research, present findings and future directions. *Academy of Management Review*, 20(2), 343–78.

Caffyn, S.J. (1998) *The scope for the application of continuous improvement in the process of new product development*. PhD Thesis, University of Brighton.

Caffyn, S., Gieskes, J., Mellor, R. and Sloan, T.R. (2000) Learning across boundaries within product innovation processes. EUROMA Conference, June 4–7, Leuven Belgium.

Cangelosi, V.E. and Dill W.R. (1965) Organizational Learning. Observations toward a theory. *Administrative Science Quarterly*, 16, 413–28.

Carlsson, B., Keane P. and Martin, J.B. (1976) R&D organizations as learning systems. *Sloan Management Review*, 17(3), 1–15.

Chapman, R.L., O'Mara, C.E., Ronchi, S. and Corso, M. (2000) Continuous product innovation: A comparison of key elements across different contingency sets. *The First International Research Conference on Organisational Excellence in the Third Millenium* – A New Renaissance Multinational, Multidisciplinary & Performance-Focused, Estes Park, Colorado, 6–9 August, pp. 206–16.

Cohen, M.W. and Levinthal, D.A. (1990) Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, 35, 128–52.

Cooper, R., Charlton, J., Roberts, C., Whitelock, J. and Souder, W. (1999) New product development: leadership and learning. A comparison of UK and US high-technology companies. *International Journal of Continuous Engineering Education and Life-long Learning*, 9(1), 88–114.

Cronbach, L.J. (1990) *Essential of Psychological testing*, 5th edition. Harper Collins Publishers, New York.

Cyert, R.M. and March, J.G. (1963) A *behavioral theory of the firm*. Prentice Hall, Englewood Cliffs NJ.

Daft R.L. and Weick K.E. (1984) Toward a model of organizations as interpretation systems. *Academy of Management Review*, 9(2), 284–95.

De Geus, A. (1988) Planning as learning, *Harvard Business Review*, 66(2), 70–4.

Dibella, A.J., Nevis, E.C. and Gould, J.M. (1996) Understanding organizational learning capability. *Journal of Management Studies,* 33(3), 361–79.

Dixon, N.M. (1992) Organizational Learning: A review of the literature with implications for HRD professionals. *Human Resource Development Quarterly*, 3(1), 29–49.

Dodgson, M. (1993) Learning, trust and technological collaboration. *Human Relations,* 46(1), 77–95.

Duncan R. and Weiss A. (1979) Organisational learning. Implications for organisational design. *Research in Organisational Behavior*, 1, 75–123.

Easterby-Smith, M. (1997) Disciplines of organizational learning. Contributions and critiques. *Human Relations*, 30(9), 1085–113.

Fiol C.M. and Lyles M.A. (1985) Organizational learning. *Academy of Management Review*, 10(4), 803–13.

Galer, G. and Van der Heijden, K. (1992) The learning organization. How planners create organizational learning. *Marketing Intelligence and Planning*, 10(6), 5–12.

Garvin, D.A. (1993) Building a learning organization. *Harvard Business Review*, 71(4), 78–91.

Gieskes, J.F.B. (2000) Organizational learning in product innovation. An information processing process in a contingency perspective. T&M research report 2000W-003 T&O-007. University of Twente, Enschede.

Gieskes, J.F.B. (2001) *Learning in product innovation processes. Managerial action on improving learning behavior.* PhD thesis University of Twente, Enschede, PrintPartners Ipskamp, The Netherlands.

Gieskes, J.F.B. (2003) Learning barriers in continuous product innovation. *International Journal of Technology Management*, 26(8), 857–70.

Glynn, M.A., Lant, T.K. and Milliken, F.J. (1994) Mapping learning processes in organizations. A multi-level framework linking learning and organizing. In: *Advances in Managerial Cognition and Organizational Information Processing, Vol. 5.* JAI Press, Greenwich CT.

Goh, S. and Richards, G. (1997) Benchmarking the learning capability of organizations. *European Management Journal*, 15(5), 575–83.

Golden, B.R. (1992) The past is the past – or is it? The use of retrospective accounts as indicators of past strategy. *Academy of Management Journal*, 35(4), 848–60.

Gorsuch, R.L. (1983) *Factor analysis,* 2nd edition. Lawrence Erlbaum, Hillsdale NJ.

Hanseth, O. and Monteiro, E. (1997) Inscribing behaviour in information infrastructure standards. *Accounting Management & Information Technology*, 7(4), 183–211.

Hedberg, B. (1981) How organizations learn and unlearn. In Nyström P.C. and Starbuck W.H. (eds), *Handbook of Organizational Design*. Cambridge University Press, London.

Henfridsson, O. and Söderholm, A. (2000) Barriers to learning: on organizational defences and vicious circles in technological adaptation. *Accounting Management and Information Technology*, 10, 33–51.

Honey, P. and Mumford, A. (1986) *The manual of learning styles.* P. Honey, Berkshire.

Huber, G.P. (1991) Organizational learning: the contributing processes and the literatures. *Organization Science*, 2(1), 88–115.

Huber, G.P. (1996) Organizational learning. A guide for executives in technology-critical organizations. *International Journal of Technology Management*, Special Publication on Unlearning and Learning, 11(7/8), 821–32.

Huber, G.P. and Power, D.J. (1985) Research notes and communications. Retrospective reports of strategic-level managers: guidelines for increasing their accuracy. *Strategic Management Journal*, 6, 171–80.

Hughes, G.D. and Chafin, D.C. (1996) Turning new product development into a continuous learning process, *Journal of Product Innovation Management*, 13, 89–104.

Hutchins, E. (1991) Organizing work by adaptation. *Organization Science*, 2, 14–19.

Hyland, P.W., Gieskes, J.F.B. and Sloan, T.R. (2001) Occupational clusters as determinants of organisational learning in the product innovation process. *Journal of Workplace Learning*, 13(5), 198–208.

Imai, K., Nonaka, I. and Takeuchi, M. (1985) Managing the new product development process: How Japanese companies learn and unlearn. In K.B. Clark, R.H. Hayes and C. Lorenz (eds), *The uneasy alliance. Managing the productivity-technology dilemma*. Harvard Business School Press, Boston MA, pp. 337–75.

Jelinek, M. (1979) *Institutionalizing innovation. A study of organizational learning systems*. Praeger, New York.

Jones, A.M. and Hendry, C. (1992) *The learning organization: a review of literature and practice*. London: HRD Partnership.

Jöreskog, K.G. and Sörbom, D. (1993) *Lisrel VIII: User's reference guide*. Scientific Software, Mooresville.

Kanter, R. (1989) The new managerial work. *Harvard Business Review*, 76(6), 85–92.

Kim, D.H. (1993) The link between individual and organizational learning. *Sloan Management Review*, 35(1), 37–50.

Kolb, D.A. (1984) *Experiential learning. Experience as the source of learning and development*. Prentice Hall, Englewood Cliffs NJ.

Kolb, D., Fubin, I. and McIntyre, J. (1973) *Organizational psychology. A book of readings*. Prentice Hall, Englewood Cliffs NJ.

Kozlowski, S.W.J. and Kirsch, M.P. (1987) The systematic distortion hypothesis, halo, and accuracy: An individual-level analysis. *Journal of Applied Psychology,* 72, 252–61.

Lei, D., Slocum, J.W. and Pitts, R.A. (1997) Building co-operative advantage: managing strategic alliances to promote organizational learning. *Journal of World Business,* 32(3), 203–23.

Leonard-Barton, D. (1992) The Factory as a Learning Laboratory. *Sloan Management Review*, 34(1), 23–37.

Levitt, B. and March, J.G. (1988) Organizational learning. *Annual Review of Sociology,* Vol. 14. JAI Press, Greenwich CT.

McGill, M.E., Slocum Jr., J.W. and Lei, D. (1992) Management practices in learning organizations. *Organizational Dynamics*, 21(1), 5–17.

McKee D. (1992) An organizational learning approach to product innovation. *Journal of Product Innovation Management*, 9, 232–45.

Miller, M.J. (1996) *Rater individual differences and accuracy in performance appraisal.* A PhD thesis submitted to the office of Graduate Studies of Texas A&M University.

Miner, A.S. and Mezias, S.J. (1996) Ugly duckling no more. Pasts and futures of organizational learning research. *Organization Science*, 7(1), 88–100.

Morgan, G. (1986) *Images of Organizations*. Beverly Hills, Ca: Sage.

Morgan, R.E., Katsikeas, C.S. and Appiaha-Adu, K. (1998) Market orientation and organizational learning capabilities. *Journal of Marketing Management*, 14, 353–81.

Nelson, R. and S. Winter (1982) *An evolutionary theory of economic change*. Harvard University Press, Cambridge MA.

Nevis, E.C., DiBella, A.J. and Gould, J.M. (1995) Understanding organizations as learning systems. *Sloan Management Review,* 36(2), 75–85.

Nonaka, I. (1991) The knowledge creating company. *Harvard Business Review*, 69(6), 96–104.

Nonaka, I. and Takeuchi, H. (1995) *The knowledge creating company*. Oxford University Press, New York.

Norušis, M.J. (1993) *SPSS for Windows. Base System User's Guide. Release 6.0*. SPSS Inc., Chicago.

Pedler, M., Boydell, R and Burgoyne J. (1989) Towards the learning company. *Management Education and Development*, 20(1), 1–8.

Pedler, M., Burgoyne, J. & Boydell, T. (1991) *The learning company: a strategy for sustainable development*. McGraw-Hill, London.

Pentland, B.T. (1995) Information systems and organizational learning: the social epistemology of organizational knowledge systems. *Accounting, Management & Information Technology*, 5(1) 1–21.

Peters, T.J. and Waterman, R.H. (1982) In search of excellence: lessons from America's best-run companies. Harper & Row, New York.

Ronchi, S., Chapman, R. and Corso, M. (2000) Knowledge Management in Continuous Product Innovation. A Contingent Approach. Proceedings 3rd International CInet conference on Continuous Improvement, Aalborg Denmark, 18–20 September, pp. 375–388.

Senge, P.M. (1990) The Fifth Discipline: Mastering the five practices of the learning organization. Doubleday, New York.

Shaw, R.B. and Perkins, D.N.T. (1991) Teaching organizations to learn. *Organizational Development Journal*, Vol. 9(4), 1–12.

Shristastava, P. (1993) A typology of organizational learning systems. *Journal of Management Studies*, 20(1), 7–28.

Sligo, F. (1996) Disseminating knowledge to build a learning organization. *The International journal of Human Resource Management*, 7(2), 508–19.

Stata, R. (1989) Organizational learning – The key to management innovation. *Sloan Management Review*, 30(3), 63–74.

Stevens, J. (1996) *Applied multivariate statistics for the social sciences,* 3rd edition. Lawrence Erlbaum Associates, Mahway NJ.

Tyre, M.J. and Orlikowski, W.J. (1994) Windows of opportunity: temporal patterns of technological adaptation in organizations. *Organization Science*, 5(1), 98–118.

Walsh. J.P. and Ungson, G.R. (1991) Organizational Memory. *Academy of Management Review*, 16(1), 57–91.

Weick, K.E. (1996). The role of renewal in organizational learning. *International Journal of Tecnology Management*, Special Publication on Unlearning and Learning, 11(7/8), 738–46.

Wijnhoven, F. (1995) *Organizational learning and information systems*. PhD Thesis University of Twente, The Netherlands.

José F.B. Gieskes (MSc, PhD) worked as a consultant and researcher at the School of Business, Public Administration and Technology of the University of Twente. She has been involved in projects on developing time standards for professionals, quality management, improvement management and organisational learning. Her PhD was on how to stimulate learning behaviour in product innovation processes. Currently she works as a manager of a number of outdoor patient clinics of Medisch Spectrum Twente, a large hospital in Enschede, The Netherlands.

Beatrice I.J.M. van der Heijden (PhD) is a professor of Organizational Behaviour at the Maastricht School of Management, The Netherlands. She graduated in 1990 from the Department of Work and Organizational Psychology at the Catholic University of Nijmegen and has a PhD (1998) in career development from the University of Twente, where she is still part-time employed as a professor at the department of HRM, School of Business, Public Administration and Technology. Her main research areas are (1) career development (2) employability and (3) aging at work. Currently she co-ordinates, among others, a cross-cultural European study on career success among ICT-professionals. She serves as a member of the editorial boards of *Career Development International*, *Human Resource Development International*, and *SAM*, *Advanced Management Journal*. She also does some consultancy work on Human Resource Management topics.

E-mail address for correspondence: B.I.J.M.vanderHeijden@sms.utwente.nl; or heijden@msm.nl.