Closing the Research Cycle

Verifying the Underlying Assumptions of the Cima Model on Stimulating Learning in Product Innovation Processes

José F.B. Gieskes
The Continuous Innovation Network

The Continuous Innovation Network (CINet) is a global network that brings together researchers and industrialists working in the field of Continuous Innovation. CINet is a continuation of the European Continuous Improvement Network, started in 1993. In 2000, the mission of EuroCINet was reformulated and its name changed to CINet, a research network on Continuous Innovation. These changes facilitate the dissemination, not just within but beyond Europe, of a new way of thinking about the integrated management and organisation of day-to-day operations, improvement and learning, and innovation and change.

The CINet PhD Network

CINet has developed a PhD network, which promotes research collaboration among PhD students and their institutions on topics of interest to CINet. In detail, the network objectives are as follows:

- To promote the development of research on continuous innovation and its applications to enhance companies' effectiveness and better use of human resources for more sustainable organisation of work.
- To facilitate research integration and mobility on a global level.
- To enhance research quality and, in particular, to promote synergy and collaboration on empirical research.
- To promote a better quality of PhD training and supervision.
- To promoting joint research programmes involving companies and academia offering the prospect of rigorous training and exposure of PhD students.

The CINet is unique for its focus on innovation management as well as for the specific vision that is shared by partner institutions concerning the role and potential contribution to innovation and improvement of human resources at all levels.

Characteristic for the CINet PhD network, relative to other PhD networks, is its strong emphasis on implementation and collaboration with industrial users. Students work in close collaboration with companies to analyse and solve management problems. Research designs involving in-depth empirical studies and action or clinical research are therefore encouraged. The PhD students involved in the CINet receive an intensive training to cope with concrete management issues. All the students who were so far rewarded a CINet-based PhD degree easily found their way to highly valued positions in industrial companies, in research institutes or as consultants.
CLOSING THE RESEARCH CYCLE

VERIFYING THE UNDERLYING ASSUMPTIONS OF THE CIMA MODEL ON STIMULATING LEARNING IN PRODUCT INNOVATION PROCESSES

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1. Problem definition and purpose of the study

1.1 Introduction

“Industries world-wide are being confronted with a number of intertwined changes in their environments. Markets are making more stringent demands, competition is increasing and, in effect, companies are required to meet demands for efficiency, quality and flexibility simultaneously” (Boer, 1990).

In this environment the subject of “learning and improvement” emerges almost naturally and, indeed, lately we have seen an increased interest in knowledge, learning and (continuous) improvement in new product innovation processes, and more broadly, product innovation processes.

This contribution reports on research, which was aimed at helping companies, support and facilitate learning and improvement in their product innovation processes. The research especially focused on (a) managerial activities and decisions that help stimulating learning and improvement and (b) disablers that prevent learning and improvement to take place. The research arrived at propositions on effective managerial activities and decisions aimed at enhancing, or reducing the effects of disablers hindering learning and improvement in product innovation processes. The research built on data collected with the so-called CIMA methodology, a methodology that was the result of an ESPRIT project (CIMA¹) and that was to develop scientifically robust and empirically useful and usable knowledge on supporting mechanisms for learning and improvement in product innovation processes.

1.2 The basis of the study

¹ Continuous Improvement in global product innovation MA nagement
In 1997 the EC decided to fund a research initiative called CIMA\(^2\) (Continuous Improvement in Global Product Innovation Management) – ESPRIT project 26056. The project started September 1st 1997 and finished September 1st 1999. Its initial overall objective was to develop, test and disseminate a methodology to support knowledge transfer in product innovation processes. The resulting methodology should suggest to companies which enabling mechanisms (levers) they could use to support continuous improvement and learning in product innovation.

The author participated as a researcher in the project (representative of the University of Twente).

By the end of the CIMA project in September 1999, the CIMA methodology had been developed, tested and applied in 70 companies in Australia and Europe. The results of the applications were stored in a computerised database that comprised company specific information on:

1. Contingencies related to:
   - the organisation itself (such as size and ownership).
   - the innovation processes that were subject of research (such as process complexity).
   - the products resulting from the processes (such as product complexity, markets).
2. Learning behaviours shown by individuals working in these innovation processes.
3. Enablers exercised by management to stimulate learning behaviours.
4. Disablers preventing learning and CI to take place, and
5. Information on improvement performance of the innovation process, as well as performance of the innovation process itself.

The data on all these elements (except for the capabilities\(^3\)) were analysed with the aim to find (a) which levers in the CIMA model indeed are effective in stimulating learning behaviour, (b) what the influence is of disablers on learning behaviour and (c) whether performance is improved due to improved learning behaviours.

The research questions are as follows:

<table>
<thead>
<tr>
<th>Research questions:</th>
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<tbody>
<tr>
<td>Which managerial activities and/or decisions (levers) have a stimulating effect on learning behaviour exhibited by individuals and groups in product innovation processes?</td>
</tr>
<tr>
<td>Which disablers or barriers for learning in product innovation processes can be identified and which effects do they have on learning in product innovation processes?</td>
</tr>
</tbody>
</table>

\(^2\) CIMA Consortium partners were: Politecnico di Milano (I), MIP (I), ETASS (I), Trinity University Dublin (IRL), CORE Chalmers University Gothenburg (S), CENTRIM University of Brighton (UK), University of Twente Enschede (NL), INCITE University Western Sydney Macarthur (AUS), Monash University Melbourne (AUS), Edith Cowan University Perth (AUS).

\(^3\) The capabilities were not operationalised in the CIMA research project and are subject to further research at this moment. They are therefore excluded from further analysis.
Does an improvement in learning behaviour result in an increased improvement performance in product innovation processes?

Statistical analysis of data from the CIMA database was carried out to provide the answer to the first research question. The second research question was answered through analysis of information on open-ended questions from the CIMA questionnaire. Subsequently, the CIMA database was used as the source for trying to find an answer to the third research question.

The results in turn formed the basis for conclusions and recommendations. Based on insight into the relationships between levers, disablers and performance improvement, propositions on the relationship between levers, learning processes and product innovation processes were formulated, that can be tested in further research and are expected to increase knowledge on stimulating learning behaviour in product innovation processes. Furthermore, although the present research considered only a subset of the data of the CIMA model, improvements to the CIMA model and methodology were suggested.

Figure 1 is a graphical representation of the research model (see last page).
2. Theoretical background on CI and learning in product innovation processes

This section provides a brief summary of the literature research that was carried out for the PhD project and which covered the areas of continuous improvement, organisational learning, disablers to learning and the relationship between learning and product innovation processes. Each of these areas will successively be dealt with.

2.1 Continuous Improvement

Continuous improvement (as a form of learning), although the subject has its roots way back (Robinson 1991), still seems to be more of an art than a well-grounded theory (De Lange-Ros, 1999 and Boer et al., 2000). According to De Lange-Ros (1999), literature on continuous improvement (CI) can be divided into three mainstreams. First, quite some literature stresses the importance of CI for improved performance and provides (prescriptive) guidelines for successful implementation (Imai, 1986; Robinson, 1991; Bessant et al. 1993, 1994). A second group of literature describes CI tools, techniques and practices and their implementation, application and diffusion (Imai, 1986; Bessant 1997; Boer et al., 2000). The third category of publications attempts to categorise empirical observations and uncover the mechanisms and rules explaining empirical reality (Lillrank and Kano, 1989; Berger 1986; De Lange-Ros, 1999, Savolainen, 1999; Rijnders et al., 2000).

Much of the emphasis of literature on CI has been on manufacturing and assembly operations. This is hardly surprising given its origins in production processes. Although some writers have emphasised the importance of continually improving development processes (Wheelwright and Clark, 1992; Karlsson and Ahlstrom, 1996) few firms have tried to apply CI to their product innovation processes. Yet, several studies have supported the suitability of the CI concept for the new product development environment, while at the same time stressing the need for implementation strategies that take into account the particular context of NPD when compared to manufacturing and assembly processes (May and Pearson, 1993; Fisher et al., 1995; Miller, 1995; Debackere et
al., 1997). More recently, empirical research reported by Caffyn (1998) showed that the application of CI to product innovation processes is appropriate in practice as well as in theory, albeit that for successful implementation companies need to be creative in turning theory into practice.

Bessant and Caffyn (1997) define CI as an organisation-wide process of focused and sustained incremental innovation. In line with Teece and Pisano (1994) they consider CI to be a “dynamic capability”, a collection of attributes which are built up in the organisation over time and which provide the basis for achieving and maintaining competitive edge in a dynamic environment. According to Tidd et al. (1997) three elements constitute dynamic capability: paths, positions and processes. The last element is of particular interest since it concerns the bundle of firm-specific behavioural routines which characterise “the way things are done” in a specific organisation and describe the way the organisation deals with renewal, learning and innovation. Bessant and Francis (1999) state that CI represents an important element in such a dynamic capability since it offers mechanisms whereby a high proportion of the organisation can become involved in innovation and learning processes.

In the CIRCA research project Bessant et al. (2001) developed a behavioural model describing the evolution of CI capability in a company. This model provides a specification for particular behaviours which need to be acquired and embedded in order to enable CI capability. The building of the capability is an evolutionary process with a gradual accumulation and integration of key behaviours over time. This process of moving towards full CI capability is essentially a learning process (Savolainen, 1998).

2.2 Organisational learning

A relevant issue is whether organisations are able to learn at all. In this research the basic assumption is that there is no organisational learning without individual action. At the same time, however, the organisation does not automatically act when one of its members acts. Organisational learning consists of more than individual employees gaining knowledge. For the organisation to learn, knowledge captured by individuals must be shared, disseminated throughout the organisation and applied, creating a culture embracing change. As Hedberg (1981) observed, “Although organisational learning occurs through individuals, it would be a mistake to conclude that organisational learning is nothing but the cumulative result of their members’ learning. In order for organisational learning to contribute to realisation of organisational goals, the learning process must be managed and controlled (De Leeuw, 1982). Behaviour by individuals is presumed to be the key element in the learning process.

There is hardly agreement as to what learning is and how it occurs. Fiol and Lyles (1986: 803) conclude that “Although there exists widespread acceptance of the notion of organizational learning … no theory or model of organizational learning is widely accepted”. In spite of all the conceptual descriptive writings on organisational learning and the more normative models on learning organisations today there still is a high degree of fragmentation in the field and various authors have called for the development of an agreed theory of organisational learning (Fiol and Lyles, 1985; Huber, 1991; Huysman, 1996; Easterby-Smith, 1997).
Huber (1991: 95) expressed his concerns on the fact that there are very few formal and systematic field studies, whereas the existing studies do not build on each others' results and that there is hardly any intellectual interaction among investigators. It seems that researchers today have not been able to “learn” from these concerns and from each other since the situation has not changed much since (see Easterby-Smith, 1997; Tsang, 1997).

In the field of organisational learning there are areas where there appears to be consensus among theorists and areas where their ideas not seem able to meet. Fiol and Lyles (1985) note three areas of consensus:
- The relevance of environmental alignment.
- The distinction between individual and organisational learning.
- The presence and influence of four key contextual factors in the learning process (culture, strategy, structure and environment).

Inkpen and Crossan (1995: 597) mention as the major areas of disagreement:
- Whether organisational learning occurs at individual, group or organisational level.
- Whether learning refers to cognitive change, behavioural change, or both, and how the two are related.
- Whether learning refers to content or process.
- Whether learning should be tied to performance.

Learning can be viewed from different perspectives depending on the criteria used for differentiation (Shrivastava, 1983; Huysman, 1996; Dillen and Romme, 1995; Easterby-Smith, 1997). The most important perspectives are characterised in table 1 by means of one single phrase.

### Table 1: Perspectives on learning.

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Characterisation: learning is ....</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information-processing perspective</td>
<td>Increasing and improving knowledge through processing information</td>
</tr>
<tr>
<td>Contingency perspective</td>
<td>Adapting to changes in the environment</td>
</tr>
<tr>
<td>Psychology perspective</td>
<td>Continuous and concerted sharing of assumptions in the context of collective action</td>
</tr>
<tr>
<td>Systems-dynamics perspective</td>
<td>Developing understanding of the complex causalities of social reality</td>
</tr>
<tr>
<td>Strategic perspective</td>
<td>Building unique competencies for competitive advantage</td>
</tr>
<tr>
<td>Production management perspective</td>
<td>Improving efficiency through experience</td>
</tr>
<tr>
<td>Incremental innovation perspective</td>
<td>Innovation = learning</td>
</tr>
</tbody>
</table>

The different ways of viewing organisational learning can be linked to the academic disciplines the authors stem from. The perspectives need not necessarily be mutually exclusive, but they can be applied complementing each other in studying organisational learning (see Huber, 1991; Walsh and Ungson, 1991; Senge, 1990b and Nonaka and Takeuchi, 1991) which helps increasing the understanding of the nature and problems of organisational learning.
Learning concerns the acquisition, generation, diffusion, storage and retrieval of knowledge (including cognitive knowledge, experiences, attitudes and insights, both explicit, codified and implicit/tacit) that affects behaviour in order to realise organisational goals. This process is defined as the learning process. It is debated if the actual learning result, the output of the learning process, can be measured. It is generally acknowledged that the amount and content of learning depends on organisational characteristics and can be influenced by different managerial actions (enablers).

Literature presents a rather fragmented picture with regard to enablers for stimulating learning as they appear under different headings, such as learning orientations (Shrivastava, 1983; Nevis et al., 1995), learning modes (Hedberg, 1981), learning skills (McKee, 1992), organisational learning mechanisms (Popper and Lipschitz, 1998), and on different organisational levels.

A wide variety of enablers for learning is mentioned and authors point out that these enablers do not necessarily need to be used to specifically stimulate learning, but that the learning can be a consequence of enablers used to organise and manage (parts of) the product innovation process.

The following categorisation can be made:

- **Clarity of strategy and goals** guides and focuses learning processes through communication on strategic decisions and activities (Senge, 1990a; Leonard Barton, 1992; McGill et al., 1992; McKee, 1992; Dixon, 1992; Dodgson, 1993; Bowen et al., 1994; Goh and Richards, 1997; Methé et al., 1997; Cooper et al., 1999). Apart from the presence of a clear strategy and goals, strategic development processes also are regarded as crucial activities (de Geus, 1988: 70 “Planning as Learning”; Pedler et al., 1989; Hedberg, 1991; Slater and Narver, 1995; Morgan et al., 1998; Crossan et al., 1999).

- **Performance management**, including benchmarking and reward systems, facilitates the development of a shared perception of a gap between actual and desired state of performance. Performance gaps are seen as opportunities for learning. A second contribution lies in the monitoring of improvement (Hedberg, 1981; Stata, 1989; Pedler et al., 1989; Leonard-Barton, 1992; McGill et al., 1992; Pedler et al., 1992; Ulrich et al., 1993; Adler and Cole, 1993; Slocum et al., 1994; Nevis et al., 1995; Locke and Jain, 1995; Lei et al., 1997; Goh and Richards, 1997; Hameri and Nihtilä, 1998).

- **Human resource management** such as human resource development, job rotation, teamwork, education and training, bringing in people from the outside with new knowledge, provide opportunities to develop and change behaviours, skills and increase knowledge (Stata, 1989; Pedler et al., 1989; Senge, 1990a; Shaw and Perkins, 1991; Jones and Hendry, 1992; Dixon, 1992; Leonard-Barton, 1992; McGill et al., 1992; Ulrich et al., 1993; Adler and Cole, 1993; Lei et al., 1997; Duarte and Snyder, 1997, 1993; Garvin, 1993; Locke and Jain, 1995; Inkpen and Crossan, 1995; Goh and Richards, 1997; Leroy and Ramanantsoa, 1997; Hameri and Nihtilä, 1998; Crossan et al., 1999; Paciti et al., 2000).

- **Organisational arrangements (structural integration mechanisms)** such as small teams, temporary teams, appointment of “gate-keepers” or “boundary spanners”, connect the organisation to the realisation of its goals and relate parts of the organisation and processes (Hedberg, 1981; Stata, 1989; Pedler et al., 1989; Jones and Hendry, 1992; Levinthal and March, 1983; Dodgson, 1993; Ulrich et al., 1993; Lei et al., 1997;
Dodgson 1993; Inkpen and Crossan, 1995; Duarte and Snyder, 1997; Methé et al., 1997; Crossan et al., 1999; Cooper et al., 1999).

- **Project planning and control** such as standard operating procedures, protocols, etc. constitute behaviour repertoires (Hedberg, 1981; Adler and Cole, 1993; Lei et al., 1997; Duarte and Snyder, 1997; Leroy and Ramanantsoa, 1997; Hameri and Nihtilä, 1998; Cooper et al., 1999; Paciti et al., 2000)

- **Computer-based technologies**, including ICT and design tools and methods, can function as an opportunity for communication, co-operation and at the same time act as standardisation and normalisation means (Hedberg, 1981; McGill and Slocum, 1991; Huber, 1996; Hameri and Nihtilä, 1998; Adams et al., 1998; Crossan et al., 1999).

Despite the number of enablers in this categorisation, there is hardly any information on what or where and how these enablers impact. Most authors assume that the effectiveness of enablers is shown in different patterns of behaviours, decisions and improved output and performance. Empirical research is required to develop in-depth knowledge on how enablers have an impact on the learning process: what makes a certain enabler to start, continue, enhance, speed up and/or improve a learning process indeed?

Next to enablers to influence the learning process, also disablers can be identified that hinder the learning process to take place.

### 2.3 Disablers to organisational learning

Literature on organisational learning basically is optimistic of tone. It is suggested that learning is a natural process that once implemented, is self-sustained. Practice however proves that this is hardly the case. There are a number of factors that “disturb” the natural process. Unfortunately (similar to organisational learning in general) there is relatively little empirical research into learning disablers. Several terms have been introduced to refer to problems that organisations face when trying to learn such as learning disabilities (Senge, 1990a), learning errors (Marsick & Watkins 1990), barriers to innovation (Quinn, 1985), learning barriers (Shaw & Perkins, 1992), learning obstacles (McGill & Slocum, 1994) and organisation learning disorders (Snyder and Cummings, 1998). Factors that can hinder the learning process can be distinguished into three major categories:

- Factors that interrupt the learning process
- Psychological and cultural barriers to learning
- Barriers related to the leadership within and structure of the organisation.

These factors however are poorly conceptualised and often of a fragmentary character. Apart from several conceptual writings, there appears to be mainly anecdotal “evidence” of obstacles. Evidence has been found of disablers such as information systems, reward systems, human resource practices, leaders’ mandate, departmental structures, measurement and control systems, the (learning) culture; lack of management support, short-term orientation (Morgan, 1986; Stata, 1988; Hayes et al., 1988; Dixon, 1992; Dodgson, 1993; McGill and Slocum, 1993; Bowen et al., 1994; Miner and Mezias, 1996).

Systematic empirical research into disablers as perceived by people in organisations can help further development of theory in these areas.
2.4 Learning and product innovation processes

The relationship between learning and product innovation is described in literature in different ways. First, literature can be classified according to the perspectives on organisational learning described above. Theories can be classified under the information processing perspective and the common denominator is the notion that R&D work is a rational problem-solving process. Information is processed through the different phases of the problem-solving process. A second stream of literature can be characterised by the focus of research into learning in product innovation (in general limited to R&D or even more limited new product development) and has linkages with the adaptation perspective of organisational learning. Within this perspective two ways of looking at the relationship between learning and R&D/new product development can be distinguished. The first is looking at product innovation (or new product development) as a learning process by nature. R&D has a primary role in generating knowledge through the use of internal and external sources of information, distributing that information throughout the organisation, and thus enabling the organisation to maintain (or even improve) its competitive advantage through new product development. The second perspective basically sees the product innovation process as one of the focal processes in the organisation. In order to stay competitive new products need to be developed, for which learning is essential. (Imai et al., 1985; McKee, 1992; Verganti, 1997; Hughes and Chafin, 1996; Bartezagghi et al., 1997; Corso and Pavesi, 1998; Adams et al., 1998; Caffyn, 1998).

Carlsson et al. (1976) have (implicitly) tried to integrate both views on the relationship between learning and R&D. They applied Kolb’s model of individual learning (1984) to the organisational learning process of an R&D organisation and found that the learning model of Kolb provided a useful description of the R&D process. By doing so they treated the R&D process as a learning processes in itself. Subsequently they diffused this model throughout the R&D organisation and as such introduced a learning process within R&D processes. By studying the effects they concluded that the R&D process could be improved through actions identified by looking at R&D from a learning point of view.
3. Research methodology

As explained in the first section the PhD research built on the data gathered in the CIMA research project with the aim to find an answer to the following research questions:

- Which managerial activities and/or decisions (levers) have a stimulating effect on learning behaviour exhibited by individuals and groups in product innovation processes?
- Which disablers or disablers for learning in product innovation processes can be identified and which effects do they have on learning in product innovation processes?
- Does an improvement in learning behaviour result in an increased improvement performance in product innovation processes?

Before describing the methodology of the PhD research project, the development and testing of the CIMA model and methodology are described.

3.1 The development and testing of the CIMA model and methodology

Underlying the CIMA methodology is the so-called CIMA-model (depicted in figure 2), to help describe and analyse learning by individuals and teams within product innovation processes in terms of a number of interrelated variables:

- Performance (related to learning).
- Behaviours underpinning learning (learning behaviours).
- Levers (enabling mechanisms) that can stimulate and facilitate these learning behaviours.
- Capabilities with regard to learning.
- Contingencies, both company specific and product innovation project specific.

The model explains that the (learning) performance of a product innovation process is realised by individuals and teams enacting certain learning behaviours. These behaviours can be influenced by the implementation and application of levers or mechanisms that managers can use when managing the product innovation process. The people in the product innovation process over time build integrated stocks of resources that have been
accumulated through learning, or established through deliberate decisions (stocks like internalised behaviours, technical skills, organisational routines, databases, handbooks). The level of a company’s learning capabilities determines the efforts needed to stimulate behaviours. Finally, contingencies are factors that influence learning behaviour, the choice of levers and the way the levers impact on learning behaviours and the way capabilities can be built.

![Figure 2: Elements in the CIMA model of learning and CI in product innovation processes.](image)

This model was initially developed through combining the CI Maturity model developed by Caffyn and Bessant (1996 and 1998), with the Continuous Product innovation (CPI) model for intra- and inter-project learning presented by Bartezagghi et al. (1997). The latter emphasises the inclusion of all phases of the product life cycle into the product innovation process (and not just the new product development phase) and identifies behaviours in the organisation exhibited by individuals and groups (teams) that can foster product development.

The development of the CIMA model is depicted in figure 3.

First a literature study was carried out with two objectives:
- To describe the state of the CIMA consortium's understanding of the areas of CI, learning and product innovation.
- To extract from existing empirical and conceptual works in these areas the basis for a theoretical framework.

The literature study enabled the development, use and interpretation of an investigation framework (the second step) for data collection and user requirements analysis. This investigation framework provided the basis for the first empirical research. In-depth, explorative case studies in companies in different countries were carried out for several purposes:
- To establish which enabling mechanisms or levers were used to support learning in product innovation processes.
- To determine why or why not such levers had been adopted.
- To determine main disablers to CI and learning as experienced by the companies.
- To identify the relationship between organisational context and appropriate levers.
- To generalise findings and validate them on further case studies.

![Diagram of research methodology]

**Figure 3: Phases in the development of the CIMA methodology.**

The case studies were carried out by means of interviews and studying documents. All the information was analysed by the researchers and discussed within the CIMA consortium. The interviews provided valuable information and the researchers identified a number of contingencies, behaviours, levers, learning capabilities and categories of performances. In addition, the case studies also provided valuable information on research methods and techniques for the CIMA methodology. To be able to apply the model the variables (behaviours, performances, contingencies, levers, capabilities) were operationalised (see figure 4).

Two dimensions can be distinguished for each of the (learning) behaviours: the *frequency* with which the behaviour is shown and the *diffusion* of the behaviour throughout the product innovation process.

Not encapsulated in the model depicted in figure 4, but important for understanding learning processes and improvement of CI and learning in product innovation processes, are disablers for learning. A disabler is not (automatically) the absence of a lever for
stimulating and fostering learning, which indicates that separate research into the disablers is called for. But the literature study left little theory to provide useful suggestions. The researchers decided to ask respondents for disablers for learning as they experience them by means of an open-ended question.

C1 Knowledge generation capability
C2 Learning alignment capability
C3 Knowledge transferring and diffusion within PI process capability
C4 Knowledge transferring and diffusion among PI process capability
C5 Knowledge retaining capabilities

<table>
<thead>
<tr>
<th>Levers</th>
<th>Behaviours</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 Product family strategy</td>
<td>B1 Focus improvement and learning</td>
<td>P1 Project performance</td>
</tr>
<tr>
<td>L2 Process definition</td>
<td>B2 Develop knowledge</td>
<td>P2 Improvement</td>
</tr>
<tr>
<td>L3 Organisational integration mechanisms</td>
<td>B3 Experiment with new solutions</td>
<td>P3 People performance</td>
</tr>
<tr>
<td>L4 HRM policies</td>
<td>B4 Integrate knowledge within PI phases</td>
<td></td>
</tr>
<tr>
<td>L5 Project planning &amp; control</td>
<td>B5 Transfer knowledge between PI phases</td>
<td></td>
</tr>
<tr>
<td>L6 Performance measurement</td>
<td>B6 Abstract and generalise knowledge</td>
<td></td>
</tr>
<tr>
<td>L7 Design tools and methods</td>
<td>B7 Embed knowledge into vehicles</td>
<td></td>
</tr>
<tr>
<td>L8 Computer-based technologies</td>
<td>B8 Assimilate knowledge from external sources</td>
<td></td>
</tr>
</tbody>
</table>

Contingencies
E1 Degree of globalisation
E2 Product customisation
E3 Position in the supply chain
E4 Product complexity
E5 Technical intensity
E6 Size
E7 Ownership and inter-firm relations
E8 Localisation

Figure 4: Variables and their operationalisation in CIMA model.

The questionnaire was transformed into a computerised version that automatically stored the response in a computer file, to which the researchers had sole access. Next to the questionnaire, also a report generator was developed that used the response file to carry out the analysis and generate a company-specific feedback report with the results (see figure 5).

By the end of the CIMA project in September 1999, the CIMA methodology had been applied in 70 companies in Australia and Europe.
3.2 The methodology of the PhD project

Basically the CIMA model represents a number of assumptions on relationships between variables in reality. This requires that before the research questions are addressed the reliability and validity of the measurement instrument and the data that it generates are evaluated. Only on the basis of reliable and valid data can statements be made on its relationship to existing theory. Actually this issue refers to the quality of the research design of the CIMA research project.

"A research design is the logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of a study" (Yin, 1994:18). As Yin (1994:19) also states, "Colloquially, a research design is an action plan for getting from here to there, where here may be defined as the initial set of questions to be answered, and there is some set of conclusions (answers) about these questions". To establish the quality of empirical social research four tests are commonly used (Yin, 1994, referring to Kidder & Judd, 1986):

- Construct validity: establishing correct operational measures for the concepts being studied.
- Internal validity (for explanatory or causal studies only, not for descriptive or exploratory studies): establishing a causal relationship, in which certain conditions are shown to lead to other conditions, as opposed to spurious relationships.
- External validity: establishing the domain to which a study's findings can be generalised.
- Reliability: demonstrating that the operations of a study - such as the data collection procedures - can be repeated, with the same results.
Construct validity is often problematic in case study research. The critique points to the fact that case study investigators often use "subjective" judgements to collect the data and fail to develop a sufficiently operational set of measures. Three tactics are available to increase construct validity (Yin, 1994: 35-36):

- The use of multiple sources of evidence, in a manner encouraging convergent lines of inquiry.
- To establish a chain of evidence.
- To have the draft case study report reviewed by key informants.

In the CIMA research project all three tactics were employed.

Internal validity is a concern for causal (or explanatory) case studies. The CIMA project concerned causal relationships, since the research tried to determine whether application of levers results in improved learning behaviour, which in turn was expected to result in an improved performance. The first in-depth case studies were much more of an exploratory character than of an explanatory character. Internal validity here is less an issue. However, the final CIMA model assumes causal relationships between a number of variables and thus the internal validity is relevant. For case studies Yin (1994) presents three tactics to address internal validity:

- Pattern matching.
- Explanation building.
- Time-series analysis.

The CIMA research used pattern matching in comparing the empirically based patterns in levers, behaviours and performances with a predicted pattern (in the form of categories deduced from literature). However, this pattern matching was very rudimentary and it can be concluded that internal validity was not very explicitly and well addressed in the CIMA project.

External validity deals with the question if the findings of the study can be generalised beyond the immediate study. External validity in case study research is often perceived as a problem. Critics state that single cases offer a poor basis for generalising. Yin (1994:36) argues that comparison of the two types of research on this issue is incorrect. He points towards the fact that survey research relies on statistical generalisation, whereas case studies rely on analytical generalisation. In the latter case, the goal is to generalise results to some broader theory and not to generalise it to the empirical world. Both types of generalisation are relevant for the current research thesis. Analytical generalisation is related to the in-depth case studies and the case studies that were carried out in applying the methodology. Statistical generalisation is related to the statistical analyses that will be carried out on the CIMA data to find an answer to the first research question. External validity is dealt with at a later stage in this contribution.

Reliability refers to the question whether the research can be repeated with the same results. For case studies this means that all the steps and procedures followed by the researcher need to be documented. For the CIMA case studies a detailed case study protocol was developed.

For survey instruments it is common to look at internal consistency as an indicator of how well different items in the survey measure the same concept. This internal consistency is measured by calculating Cronbach’s alpha (a statistic that reflects the
homogeneity of a scale). This test was used to test the reliability of the way learning behaviours are measured in the CIMA methodology.

The CIMA database contains data of 70 companies with regard to:
- Characteristics of the organisations and for each company two product innovation processes.
- Learning behaviours exhibited by individuals and teams.
- Levers that management has applied to stimulate learning behaviour.
- Disablers that respondents have identified as hindering learning.
- Information on performance measurements and performance improvement.

Figure 6 provides information on the country of origin of the companies in the database.

All the company data were stored in an Excel file that could be accessed in different ways through different statistical methods and techniques.

Verifying the assumptions underlying the CIMA model was done through these different statistical methods and modelling techniques. The data in the CIMA database were not gathered with the purpose of testing the assumptions and as such were not modelled for sophisticated statistical techniques such as LISREL (structural equation modeling technique). It was therefore decided to limit the present study to analyses that can be obtained by correlation, regression and factor analysis using SPSS (for the statistical techniques, see Cronbach, 1990; for the statistical techniques and SPSS see De Geus et al., 1999; Huizingh, 1999).

Descriptive statistics helped develop a picture of what the characteristics are of the companies in the database. This picture provided the background for interpreting the findings.

It was researched if the two dimensions of learning behaviour - frequency and diffusion - indeed were independent as assumed in the CIMA methodology by means of Correlation analysis. Second, it was researched whether a structure in the data on learning behaviours could be found that support the analysis of the impact of levers in such a way that it is
possible to draw reliable conclusions. Instead of analysing $64 \times 2$ relationships ($8$ levers x $8$ learning behaviours x $2$ dimensions of learning behaviour, see figure 4) with possible empty cells or cells with a very low number of entries, it was investigated if the number of learning behaviours could be decreased through forming clusters. For that purpose an exploratory factor analysis was carried out. Reliability analysis (Cronbach’s $\alpha$) helped establishing whether the inter-item-correlations of the different behaviours were high enough to construct a scale for learning behaviour. With these results the next step was made: testing the effectiveness of levers in stimulating learning behaviour. For this, a regression analysis for every single lever (as the independent variable and learning behaviour as the dependent variable) was carried out. Next, the responses with regard to disablers hindering learning behaviour were categorised, interpreted and discussed which enabled to formulate an answer to the second research. Subsequently improvement performance was investigated with the aim to establish if improved learning behaviour indeed resulted in improved performance.
4. Results of the different phases of the research project

This section explains each of the steps in the research project as described above. More information on methodological issues is provided, results of analyses are presented and discussed leading to answers to the research questions.

4.1 Characteristics of the companies in the database

All the companies in the database were selected from the manufacturing sector through convenience sampling. Some characteristics of the sample are:

- In terms of size (based on employee numbers) the 70 companies cover all categories from small through to large. In 48% of the companies there were more than 250 employees.
- Approximately 50% of the companies are nationally oriented; i.e. their manufacturing activities and new product development activities in general are confined to their home countries, the markets are regional or national. Only 5% of the companies are globally oriented in their manufacturing activities, whereas very few companies have globalised their new product development activities.
- About 40% of the companies are privately owned by a single individual or family, whilst another 36% are subsidiaries of a multinational.
- In the majority of the companies less than 40% of the managerial staff are involved in issues related to product technology, process technology and customer interface.
- The typical product development time in the companies’ specific industry can be labelled as medium (between six months and two years).
- The typical product life cycle in general is longer. A third of the companies in the sample report a long (5-10 years) product life cycle and 23% have a very long product life cycle (>10 years).
- Over 60% of the companies report a reliance on inter-firm relationships to a fairly large degree. These inter-firm relationships are important for accessing new knowledge. Over 35% of the companies rather frequently access new knowledge from external organisations. A further 35% report access sometimes. Only 16% of the companies in the sample never or rarely ever access external knowledge.
The labour turnover in the majority of the companies (73%) is either normal or lower than normal when compared to industry averages, which is relevant from the point of view of knowledge entering or leaving the company.

In each company the respondents were asked to map the eight categories of learning behaviours for two product innovation processes/projects:
- Project A: a project that was completed recently.
- Project B: a project that was completed before project A.
The characteristics were determined for the projects that were chosen to be the reference for filling in the CIMA questionnaire, see table 2.

Table 2: Comparison of product characteristics developed under Projects A and B (N=70).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Similar</th>
<th>Different</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newness</td>
<td>48 (68.6%)</td>
<td>22 (31.4%)</td>
</tr>
<tr>
<td>Functionality</td>
<td>39 (55.7 %)</td>
<td>31 (44.3%)</td>
</tr>
<tr>
<td>Product complexity</td>
<td>42 (60.0%)</td>
<td>28 (40.0%)</td>
</tr>
<tr>
<td>Markets served</td>
<td>49 (70.0%)</td>
<td>21 (30.0%)</td>
</tr>
</tbody>
</table>

It can be concluded that projects A and B are in general more similar than they are different.

4.2 Measuring learning behaviour

4.2.1 Frequency and diffusion of learning behaviours

In the CIMA model two dimensions of learning behaviour were distinguished: frequency and diffusion. The first is a measure for how often the learning behaviour is exhibited by individuals and groups. The second is a measure for how widespread the learning behaviour is throughout the product innovation process. The CIMA model assumes that managerial activities and decisions aimed at (stimulating) learning behaviour can be directed at either increasing the frequency or the diffusion of the learning behaviour. This assumption on independency of the two dimensions was tested by means of correlation analysis (Pearsorm's) which offers insight into how independent (or correlated) the two dimensions are within each project.

The results show that the correlation between frequency and diffusion is significant at the 0.01 level for each behaviour. Also the correlations between frequency and diffusion of different behaviours are mostly statistically significant. In practice this means that the frequency and diffusion of all the learning behaviours are correlated to an extent that a change in one results in a change of the other.

The issue arising from this finding is whether there is a direction in the dependency between frequency and diffusion. To put it in another way: in reality when stimulating learning behaviour, should the organisation focus on frequency or diffusion? Within the context of this study for now this question cannot be answered confidently since the data do not allow for structural equation modelling.
4.4.2 Scale for measuring learning behaviour

Factor Analysis (FA) was applied to explore whether there is a structure in the data on learning behaviour. The results show that for both dimensions of learning behaviour, diffusion and frequency, two components are identified. However, all the behaviours load most to one component. The major component explains > 40% of the variance. In the FA for all behaviours of both projects A and B together, we see that four components are extracted. Again there is one dominant component explaining > 40% of the variance. So, the data actually indicate that there seem to consist a limited number of components, with one dominant component. The question then was asked whether there is one construct "hidden" in the data. For this a reliability analysis (Cronbach’s $\alpha$), was carried out of the results are shown in table 3. Cronbach’s $\alpha$ gives information on whether the inter-item-correlations for all the 16 items (8 learning behaviours x 2 dimensions) are sufficient enough to construct one reliable scale for learning behaviour.

Table 3: Reliability analysis for learning behaviour.

<table>
<thead>
<tr>
<th>Learning behaviours</th>
<th>Project A N=66</th>
<th>Project B N=47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency k=8</td>
<td>Cronbach’s $\alpha = .79$</td>
<td>Cronbach’s $\alpha = .86$</td>
</tr>
<tr>
<td>Diffusion k=8</td>
<td>Cronbach’s $\alpha = .81$</td>
<td>Cronbach’s $\alpha = .86$</td>
</tr>
<tr>
<td>Total k=16</td>
<td>Cronbach’s $\alpha = .90$</td>
<td>Cronbach’s $\alpha = .93$</td>
</tr>
</tbody>
</table>

Cronbach’s $\alpha$ can vary between 0 and 1: the higher the value of the measure, the more reliable the scale is. The question is what value the $\alpha$ is to have to be able to decide that using a scale is defensible. Generally accepted rules of thumb are used here according to de Heus et al. (1999). A scale is considered "good" if $\alpha \geq .80$, "reasonable" if $.60 \leq \alpha \geq .80$ and "bad" (thus should be removed) if $\alpha \leq .60$. Table 3 shows that the 16 items of learning together constitute a reliable scale for both projects, which we have called “learning behaviour”.

4.2.3 Less data for project B

Respondents experienced considerable difficulties in providing information on the project that was completed some time ago (project B), since N in the sample was considerably smaller for B (N=47) than for A (N=70). Several explanations may account for this. The respondents who filled in the questionnaire were from different positions and backgrounds, such as Managing Directors, Engineering/Technical Directors, Marketing Managers, Quality Managers, R&D Managers, Operations Managers and Financial Controllers. It is possible that some of the respondents were not involved in project B and do not have the knowledge to complete that section in the questionnaire. A second explanation lies in the difficulties with retrospective research. In general (especially in questionnaires) it is assumed that retrospective accounts of reports are reliable and valid. However, this is not necessarily the case. Huber & Power (1985) and Golden (1992) examine the methodological issues involved in using retrospective reports in research. Huber & Power (1985) refer to “data inaccuracy” which implies that the data are incomplete, biased or imprecise. They examined approaches to minimise the occurrence or magnitude of these inaccuracies and provide guidelines for improving the accuracy of retrospective reports of which several have been followed in the CIMA-research: identify
the person most knowledgeable about the issue of interest, have informants co-operate with the researcher (through the workshops), framing of questions and using pre-tested and structured questions.

The search for a structure or pattern in the data on learning behaviours resulted in the conclusion that the eight different learning behaviours (each with their two dimensions) can be regarded as items on one scale for measuring learning behaviour. This result is helpful in assessing the effectiveness of levers, which concerns answering the first research question: which managerial activities and decisions (levers) stimulate learning behaviour in product innovation processes.
5. The influence of levers on learning behaviour

The research model underlying for the data-analysis to find an answer to the first research question is depicted in figure 7.

![Figure 7: Research model for data-analysis.](image_url)
In the CIMA questionnaire the respondents were asked for each category of learning behaviour: “What encourages this behaviour? To facilitate their response to this question they were presented with a menu of eight categories of levers, that if appropriate could be extended with new categories. Each category was guided by specific examples, which were drawn from the in-depth case studies (see table 4).

Table 4: Lever categories.

<table>
<thead>
<tr>
<th>Lever</th>
<th>Specific examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lever 1</td>
<td>Product family plans, carry-over policies, standardisation policies</td>
</tr>
<tr>
<td>Lever 2</td>
<td>Stage-gate processes, company innovation procedures</td>
</tr>
<tr>
<td>Lever 3</td>
<td>Teamworking, matrix organisation, committees</td>
</tr>
<tr>
<td>Lever 4</td>
<td>Personnel rotation, departmental assessment and development plans, Reward systems, empowerment programmes</td>
</tr>
<tr>
<td>Lever 5</td>
<td>Project termination reports, design reviews</td>
</tr>
<tr>
<td>Lever 6</td>
<td>Comparison of measurements to previous results or with other subsidiaries or leading organisations</td>
</tr>
<tr>
<td>Lever 7</td>
<td>Standardised design methodologies and procedures, libraries of Standard Design solutions, integration procedures (e.g. Quality Function Deployment, Design for Manufacturability)</td>
</tr>
<tr>
<td>Lever 8</td>
<td>IT systems, computer-aided technologies, prototyping technologies</td>
</tr>
</tbody>
</table>

Figure 8 displays the percentage of companies in which levers are applied to stimulating learning behaviours in both projects A and B.
The similarity in application of the levers in both projects is striking. It is also apparent that project planning and control (L5) is most applied, whereas Human Resource Management policies are applied least frequently (L6).

Caffyn et al. (2000) analysed the extent to which levers were used to stimulate frequency and/or diffusion of learning behaviours. The results show that both frequency and diffusion of learning behaviour are stimulated by all levers and the majority of respondents report utilisation of three to four of the levers. It is only in rare instances that organisations identified seven or eight levers that were used to stimulate one of the identified learning behaviours. This might indicate that organisations (i.e. the managers) favour certain levers, either because of company policy (such as project management and control, process definition), personal preference (due to experience, familiarity) or explicit choices with regard to learning and continuous improvement. Also "fashion" in managerial concepts, methods, tools & techniques can play a role (Mintzberg, 1979).

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:

1. The first cluster (12 companies) consists of entrepreneurial firms with fewer than 30 employees and a low labour turnover. Their customers are located in a domestic market and provided with highly customised products. The operations and R&D activities are confined. The product life cycle is very long, although their development time is very short and complexity rather high. In these companies management is very much involved in technological and customer issues.

2. The second cluster (24 companies) concerns mainly companies with fewer 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.

3. The third cluster (20 companies) in general consists of large industrial groups (more than 250 employees, high labour turnover) with a geographical area as their market (Europe, Asia). 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.

4. 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 levers typically associated with each of these clusters and found that a certain emphasis on particular levers 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, customised products, good project management

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4 Mintzberg, 1979: 292: Hypothesis 16: Fashion favors the structure of the day (and of the culture), sometimes even when inappropriate.
procedures, resources allocation and scheduling are important means in affecting learning behaviour. The second cluster shows a similar preference: 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 levers, but for these companies relations with other companies and research centres seem to be important for their innovation activities.

These analyses provide “background” colour to the data, but do not provide an answer to the question of effectiveness of levers in stimulating learning behaviour. For this, we built on the finding of an aggregate scale for learning behaviour, which enables the testing and measurement of the contribution of each lever to (the aggregate scale of) learning behaviour. Our interest was firstly focused on the exploratory task of finding out which levers are related to learning behaviour. For this case we were interested in measures of the strength of the relationship, by means of correlation coefficients. Correlation analysis provided insight into which variables are correlated; regression analysis provided information on the strength of these correlations. Since the tables of both analyses are too large to include in this article we limit ourselves to presenting the highlights of the regression analyses in tables 5 and 6.

<table>
<thead>
<tr>
<th>Lever 1</th>
<th>The formulation and existence of a product family strategy.</th>
<th>No significant correlation with learning behaviour.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lever 2</td>
<td>Defining and standardisation of the innovation process are positively related to learning behaviour.</td>
<td>$r=.31 \ r^2=.10 \ (F1,66)=7.04 \ p&lt;.05^*$</td>
</tr>
<tr>
<td>Lever 3</td>
<td>Organisational integration mechanisms are positively related to learning behaviour.</td>
<td>$r=.30 \ r^2=.09 \ (F1,66)=6.74 \ p&lt;.05^*$</td>
</tr>
<tr>
<td>Lever 4</td>
<td>The development and execution of human resource management policies are positively related to learning behaviour.</td>
<td>$r=.44 \ r^2=.19 \ (F1,66)=15.48 \ p&lt;.001^{***}$</td>
</tr>
<tr>
<td>Lever 5</td>
<td>Planning and control of product innovation processes are positively related to learning behaviour.</td>
<td>$r=.48 \ r^2=.23 \ (F1,66)=19.82 \ p&lt;.001^{***}$</td>
</tr>
<tr>
<td>Lever 6</td>
<td>Performance measurement is positively related to learning behaviour.</td>
<td>$r=.30 \ r^2=.09 \ (F1,66)=6.28 \ p&lt;.05^*$</td>
</tr>
<tr>
<td>Lever 7</td>
<td>Standardisation of design tools and methods is positively related to learning behaviour.</td>
<td>$r=.34 \ r^2=.12 \ (F1,66)=8.75 \ p&lt;.01^{**}$</td>
</tr>
<tr>
<td>Lever 8</td>
<td>The implementation of computer-based technologies is positively related to learning behaviour.</td>
<td>No significant correlation with learning behaviour.</td>
</tr>
</tbody>
</table>

(* p < .05: correlation is significant at the 0.05 level)  
(** p < .01: correlation is significant at the 0.01 level)  
(*** p < .001: correlation is significant at the 0.001 level)

Table 5: Results of the regression analysis with levers as the predictor variable for learning behaviour in project A (N=66).
The formulation and existence of a product family strategy is positively related to learning behaviour.

Defining and standardisation of the innovation process are positively related to learning behaviour.

Organisational integration mechanisms are positively related to learning behaviour.

The development and execution of human resource management policies are positively related to learning behaviour.

Planning and control of product innovation processes are positively related to learning behaviour.

Performance measurement is positively related to learning behaviour.

Standardisation of design tools and methods is positively related to learning behaviour.

The implementation of computer-based technologies is positively related to learning behaviour.

<table>
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<td>Lever 3</td>
<td>Organisational integration mechanisms are positively related to learning behaviour.</td>
<td>No significant correlation with learning behaviour.</td>
</tr>
<tr>
<td>Lever 4</td>
<td>The development and execution of human resource management policies are positively related to learning behaviour.</td>
<td>$r=.36 \quad r^2=.13 \quad (F_{1,47})=6.86 \quad p&lt;.05^*$</td>
</tr>
<tr>
<td>Lever 5</td>
<td>Planning and control of product innovation processes are positively related to learning behaviour.</td>
<td>No significant correlation with learning behaviour.</td>
</tr>
<tr>
<td>Lever 6</td>
<td>Performance measurement is positively related to learning behaviour.</td>
<td>$r=.39 \quad r^2=.15 \quad (F_{1,47})=8.13 \quad p&lt;.001^{**}$</td>
</tr>
<tr>
<td>Lever 7</td>
<td>Standardisation of design tools and methods is positively related to learning behaviour.</td>
<td>No significant correlation with learning behaviour.</td>
</tr>
<tr>
<td>Lever 8</td>
<td>The implementation of computer-based technologies is positively related to learning behaviour.</td>
<td>No significant correlation with learning behaviour.</td>
</tr>
</tbody>
</table>

(* $p < .05$: correlation is significant at the 0.05 level)

(** $p < .01$: correlation is significant at the 0.01 level)

Table 6: Results of the regression analysis with levers as the predictor variable for learning behaviour in project B (N=47).

The larger response for project A enables different results in the regression analysis from Project B. Whereas in table 5 only two levers show statistically significant correlations, this number has increased to six out of eight for project B (table 6). The strong relationships between levers 2, 3, 5 and 7 and learning behaviour in project A and the lack of these relationships in project B cannot be explained on the basis of the information that is available.

Based on the results of the regression analysis for project A, three categories of levers can be distinguished according to their relationship with learning behaviour:

- Levers that have no significant impact on learning behaviour: L1 (product family strategy) and L8 (computer-based technologies) exhibit no statistical significance relative to learning behaviour.

The influence of levers on learning behaviour
- Levers with a moderate \((0.30 \leq r \leq 0.34)\) impact on learning behaviour: L2 (process definition), L3 (organisation integration mechanisms), L6 (performance measurement), L7 (design tools and methods).

- Levers with a stronger \((r \geq 0.44)\) impact on learning behaviour: L4 (Human Resource Management Policies), L5 (project planning and control).

The results are also depicted in figure 8. These results concern partial correlation and regression analysis, which means that each independent variable (= lever) has been researched separately for its correlation with the dependent variable (= learning behaviour). It is not possible to compute all the single \(r^2\) and then state that the sum for all eight levers \((\Sigma r^2)\) together explains x % of changes in learning behaviour, which leaves x % unaccounted for. In order to make such a statement, a multiple regression analysis was carried out. The result shows that the levers together explain 46% of the variance in learning behaviour. This is an interesting result from both a theoretical and a managerial point of view. Of all the means, tools, etc. that are available to try to influence (learning) behaviour exhibited by individuals and teams the limited number of levers in the CIMA model (six statistically significant levers) account for almost half of the impact, which actually is quite a good result. This indicates that the model represents reality rather good and for management this implies that the "managerial toolbox" in the model already supplies management with rather effective tools.

The results of the partial regressions analysis were discussed in order to establish whether they could be explained by means of reasoning and literature. It was concluded that the levers that have a moderate effect have an impact on the way the work is carried out. Design tools and methods prescribe how to carry out particular activities. Process definition determines which activities have to be carried out, when and by whom. Performance management indirectly influences the operations. By defining the goals and more specifically the output, a certain degree of standardisation is introduced and it is known that performance management does have an effect on people’s behaviour: people start acting/behaving “strategically” to realise the (rewarded) output. The last group of levers, organisational integration mechanisms, regulates to a certain extent the moments that information and experience are to be exchanged. It could be concluded that standardising the integration process facilitates learning.

Product family strategies do not necessarily impact on operational work. They merely function as a framework for decisions that refer to the context of operations without necessarily having an impact on the operational content of the operations. Computer-based technologies substitute manual labour for computerised activities, speed up activities through automation and can result in the decentralisation of activities to lower levels in the organisation by incorporating them in specific technologies and tools. The implementation of new computer-based technologies seldom "comes alone". Generally it is accompanied by changes in the organisation structure, working procedures, responsibilities and authorities, c.q. applying other levers at the same time. The operational work is changed but it is difficult to measure the impact of computer-based technologies sec.
The group of levers with a moderate impact on learning behaviour can be labelled as *punctuated levers*: levers that have an impact on learning behaviour, especially during their implementation. Examples are the implementation of a new performance management system, appraisal system, new working procedures and a new communication structure. These levers have a formalising effect on behaviour, regulating effect on operational activities in the product innovation process and facilitate the transfer of new individual knowledge to team and organisational knowledge. The levers also help individuals "adjust" their behaviour and fine-tune it (getting better in doing the same things).

The two levers with a strong impact can be labelled as *continuous levers*, i.e. levers that have a stronger impact on individual and team capabilities to learn and as such continuously affect learning behaviour. They have an effect in extending and refining the knowledge base in the organisation. These two levers definitely are formalising behaviour and thus regulating operational activities, but at the same time they leave enough room for individuals and teams to operationalise the levers according to their specific circumstances and thus they do not impede learning. Project management and control define the activities to be carried out, information to be gathered, transferred and stored, as well as where the responsibility and authority lies. Practice shows that the “amount” of project management and control increases with experience. At the same time, however, there appears to be an optimum level of project management and control before it becomes bureaucratic and has a negative impact on learning (Van Aken, 1996). Human Resource Management Policies are regulating in a different way. Through activities aimed at improving individual and team knowledge, experience and capabilities the methods that individuals employ to control and manage their activities become more aligned and, to a certain extent, standardised. This facilitates and stimulates learning.
Closing the research cycle
6. Disablers for stimulating learning behaviour

To be able to stimulate learning in product innovation processes, it is also necessary to gain insight into factors that hinder learning, in order to understand their nature and consequences so as to design effective intervention strategies that may help remove such barriers e.g. disablers to learning. In the CIMA questionnaire one single question on disablers was presented to the respondents: “what factors tend to discourage these behaviours?”
The respondents brought up a wide range of disablers, which were aggregated into a limited number of categories, see figure 9.

Lack of resources (such as time pressures to meet deadlines, lack of budgets and financial constraints, heavy workloads from the existing product range, short lead times, short-cutting processes, lack of knowledge and capabilities) is perceived to be the most frequent

Figure 9: Factors that discourage learning behaviour (70 respondents reported 218 disablers).
disabler (38%). Figure 10 breaks down this category and shows that lack of time has a major adverse effect on learning behaviours.

![Figure 10: Lack of resources for enabling learning behaviour.](image)

A culture that is not supportive of learning combined with a lack of commitment at both managerial level and operational level is reported to hinder learning (14%). Factors mentioned included resistance to change, fear of failures, politics and private agendas, a “knowledge is power” attitude, a “not invented here” syndrome. Organisational arrangements that hinder learning (14%) were phrased in terms such as functional versus project organisation, absence of procedures to transfer knowledge, rigid structures, many hierarchical levels and physical distance between workplaces. In a number of companies it was reported that the understanding and execution of a corporate strategy was confined to upper management, which deprives employees in the product innovation process of guidelines to develop and direct learning. Also mentioned (5%) were the lack of ability of non-technical management to define clear targets, insufficient linkages of new product R&D with the overall company capability and long-term planning, and the absence of strategy and clear goals. Poor communication (including lack of cross-functional interaction) was also perceived to hinder learning (12%), as was lack of feedback on performance (5%). Companies also report the absence of integrated information systems, poor accessibility and retrieval of knowledge that is stored somewhere in the organisation, knowledge being confined to people and not embedding it into vehicles such as information systems (6%) as inhibitors. The miscellaneous (4%) category includes comparability of the innovation project, product characteristics and differences in core technologies in innovation processes.

Time, knowledge, experience, and money are all essential ingredients in freeing up people for effective learning. However, it is not enough to simply put the resources in place and expect managers to ensure that their staff will learn in a way that benefits the organisation. As long as the product innovation process is not under control and a considerable effort of managerial activities is aimed at this control issue on an operational level, simply providing the resources will not be effective. Discussions with respondents indicated that several factors are of influence. The first is whether the organisation is committed to (improving) learning. This commitment should be “not just by talk, but also by walk”. It
should be visible to (employees in) the organisation that engaging in learning activities is valued, for instance through performance measurement linked to reward and recognition systems, education and training, etc. It was mentioned that the classical “terror of budget and time” in project management actually is one of the greatest barriers for learning processes. A second major factor appeared to be the background, experience and/or interest of the project manager him/herself. Managers from an engineering background have a different opinion on learning in product innovation processes, than managers with an administrative background, for instance. Analysis of the CIMA database on this aspect by Hyland et al. (2000) has shown that different occupational clusters (or managerial cultures according to Schein (1996) have distinct views of learning behaviours and thus probably on learning barriers.

The conclusion with regard to the second research question is that barriers are not the inverse of levers, they reduce their effectiveness. Many of the barriers adversely affect the preconditions for learning such as (managerial) commitment, motivation for learning, slack, communication, focus and information loops. Where these are in place the learning process can start and mature. It appears that there are several “no-go’s” (such as using resources for learning, the implementation of design tools and methods, innovation managers skilled in using HRM tools and methods), which in the majority of cases are beyond the scope of individuals and teams involved in product innovation.

It must be kept in mind that the sample for each cluster in the CIMA database is relatively small which calls for caution in generalising.
7. Investigating improvement performance

The third research question concerns the relationship between learning behaviour and (improvement) performance in product innovation processes.

There is not yet a generally accepted approach or method for measuring R&D performance, i.e. the effectiveness of R&D. A number of studies characterise performance measurement in R&D processes as hindering or, at most, being irrelevant in R&D settings whereas others come up with different results. There is also no publication that can act as a model for literature. Werner & Souder (1997) state that "R&D effectiveness measurement methods are so individually varied and uniquely designed for particular situations that they almost defy systematic classification".

If performance measurement within product innovation processes is already difficult, the situation gets even more difficult in the present research, since the performance here also refers to the improvement of learning performance. This issue is hardly debated in managerial literature, so we cannot build on readily available theory.

The CIMA model distinguished between three types of performance:

- The project performance: the (improvement) performance of the product innovation process itself.
- The improvement performance: the improvement of the improvement process.
- The people performance: changes in abilities of people to use improvement methods and tools and to communicate with each other.

The implicit assumption is that improved learning behaviour indeed positively affects performance, but this assumption is not unchallenged (Dodgson, 1993). Next to this, it is even possible that the same configuration of learning behaviours results in improved performance when the levers in this configuration are applied more focused or when their intensity is increased. This can be illustrated with L5 (project planning and control): it is likely that a company that recently has intensified (the already implemented) project planning and control throughout its company reports increased learning performance, while (as measured in/by the CIMA methodology) no increase in learning behaviour could be assessed.
The question also can be raised in what term the application of certain levers results in changed/improved learning behaviour, which then ultimately is to result in improved performance. Dodgson (1993) remarks that “the costs of learning are immediate and the benefits long-term”.

The assumption underlying the CIMA model can be denoted as follows: Performance = \( f(B; L; C; E) \), e.g. a function of behaviours, levers, capabilities and contingencies (E).

The performance is measured by investigating the changes in behaviours from project B to project A: \( \Delta \) Perf. B→ A.

The \( \Delta \) can have three values:
1. \( 0 \rightarrow \) there is no change: project A shows no learning improvement compared to project B.
2. \( + \rightarrow \) there is a positive change: project A show improved learning behaviour compared to project B.
3. \( - \rightarrow \) there is a negative change: project A shows deteriorated learning behaviour compared to project B.

Since the respondents were asked to indicate which levers were used in both project A and B to stimulate the learning behaviour, the obvious research question is what levers contribute to improved performance. The procedure then would be to investigate the relationship between differences in application of levers and changes in performance indicators and establish which levers appear to be effective in improving learning performance.

Apart from problems of a theoretical nature, we encountered the practical problem that the quality of the data on performance improvement in the CIMA database was far from sufficient for these data to be used confidently for this kind of analysis or even for hypothesis testing. Quite a few respondents were not able to provide information on changes in the project performance (\( \Delta \) in delivery time, cost and quality of the project output), improvement performance (\( \Delta \) in number of improvement suggestions put forward, diffusion and consolidation of improvement ideas and results) and people performance (\( \Delta \) in use of product innovation tools, project management tools, problem identification and analysis tools and communication within and across teams). A second problem in the data is that some of the questions concerning changes in certain performance indicators were answered both positively and negatively. For instance, on the question if the output of project A was delivered more quickly, in a shorter time than the output of project B, responses were for instance: Yes: + 75% and Yes: - 40%. It is not always unambiguously clear if both responses refer to an improved delivery time. For some of the cases it was possible to recover the right data, but not for all. It was felt not opportune to interpret the remaining responses.

All these considerations have led to the decision not to perform any statistical analysis for the purpose of hypothesis testing on the effectiveness of learning behaviours and/or levers on improved performance. Results from descriptive statistics can nevertheless be presented.
Project (= product innovation process) performance

A first observation is that in general the measurement of project performance is poorly developed. With regard to the product innovation process, approximately 25% of the companies have implemented time to market performance indicators, 50% use performance indicators to measure product performance, 60% measure design performance through performance metrics looking at manufacturability and manufacturing cost, whereas little over 25% of the companies measure the number of product redesigns and testability. With regard to measuring the impact of product innovation on competitiveness, market shares are measured by (approximately) 15% of the companies and sales by 35% of the respondents. The impact of product innovation on the product portfolio is measured by a third of the companies. Approximately 60% measure profits generated by the product innovation process.

Lead time, cost and quality are perceived to be the three most important performance indicators. From a learning point of view this is interesting since these indicators in general are related to the lever of project management and control.

The numbers illustrate that performance measurement on project performance is far from mature, which is interesting from the point of view that product innovation is regarded crucial for maintaining and increasing competitiveness. The question can be raised how companies assess their competitiveness and what information they use to monitor their development (improvement) on this aspect. The fact that only 24% of the companies routinely and systematically benchmark their performance against that of competitors does add to the relevance of the question.

Interesting outcome was that of the companies that report to measure performance, only a small percentage report better results for project A (the most recent project) compared to project B.

Improvement performance

Approximately 50% of the respondents report that in general individuals and teams are more engaged in improvement activities, the improvement results are more diffused and more embedded. The most often identified performance are individuals and groups suggesting improvements to the innovation process (56%), the least frequent individuals and groups suggesting improvements for the evaluation and/or diffusion of improvements (36%). Apparently the organisations in the database are much more involved in establishing a learning process than trying to spread and improve the learning process. Nevertheless, the data seemed to indicate that improvement in general has increased, c.q. that the learning process is improved. The immediate question is if this increased improvement performance results in an improved project performance over time.

People performance

Learning requires abilities by individuals and teams to use improvement methods and tools and communicate with each other. The data show that communication within project teams has improved most often in companies (70%), which indicates that use of project management and control (as the most often used lever) is effective in addressing the communication issue and that apparently quite often there is room for improvement in this area. The use of problem identification and analysis tools has increased in only
approximately 30% of the companies. This last category of improvement is imparted by the
level of underlying knowledge and capabilities. It is expected that high capabilities in
this area will make it difficult to increase/improve the capabilities (law of diminishing
returns). For building improvement capabilities in general, experience and training are
regarded major contributing factors. Organisational arrangements have a specific positive
impact.

The descriptive statistics lead to a number of questions and propositions with regard to
measuring performance improvement. The most important question is that of how
companies do measure improvement in the product innovation process in practice,
considering the lack of information on performance indicators as observed from the
CIMA database.

These results provide insight into what respondents report about the actual situation in
the companies with regard to performance measurement and performance improvement.
In addition, information is gathered on the extent to which the respondents were able to
answer the questions. This provides clues to the quality of the questions and the
information that can be expected from the respondents. The review of the data on
performance then, resulted in a number of recommendations to improve the section on
performances in the CIMA questionnaire.
8. Building propositions on the impact of levers on the levels of learning and the learning process

So far this article reported on finding answers to the three research questions, which involves verification of assumptions underlying the CIMA model. At this point it can be concluded that part of the underlying assumptions were tested, especially those related to the effectiveness of levers. Another assumed relationship, the one between learning behaviour and improvement performance could not be verified, due to lack of data of sufficient quality.

One important result was that there is some doubt as to the correctness of the assumptions with regard to the stimulating effect of two of the eight levers on learning behaviour. Another result was that all the levers together explain 46% of the changes in learning. The question is raised if indeed all the behaviours that are of impact have been identified or if there are more effective levers which have been "missed".

8.1 Additional levers

Relating the identified disablers to the effective levers and allows for finding levers that are not yet incorporated in the CIMA model, but which may prove to be effective.

Slack for learning

The most often mentioned barrier for learning is lack of resources (time, finances and knowledge). This implies that putting these resources in place can be characterised as a lever for stimulating learning. What often is required for engaging in learning is not only the resources, but slack, c.q. (psychological) space for individuals to engage in different activities than the obliged operational activities: step away, outside and reflect on day-to-day activities or look outside.

Absence of resources is a barrier, but presence of slack is not an enabler in itself: slack is a necessary condition, but not a sufficient one and for slack to be used for stimulating learning behaviour, managerial action is required. In addition, it can be argued that
although management can explicitly make resources (slack) available for learning, the "ownership" of the slack and the decision how to deploy it should be on a team and individual level, albeit that the team and individual are held accountable for the way the slack is put to use for learning. Measurement of some kind is to be put in place here.

**Individual learning styles**

One of the main assumptions in this research is that learning in organisations is about changing (individual and team) behaviour and cognition. Up to this point no attention has been paid to the potential relevance of personal preferences for learning, the so-called learning styles. Several researchers have concentrated on exploring different preferences for learning (Kolb, 1976 and 1984, Honey and Mumford 1986). Honey and Mumford (1986) have developed different learning styles:

1. **Activists**: people who involve themselves "fully and without bias in new experiences" (p. 10); people who learn best when they can use trial and error to discover something, people who thrive on the challenge of new experiences but are bored with implementation and long term consolidation.

2. **Reflectors**: people who "like to stand back to ponder experiences and observe them from many different perspectives" (p. 11). People who learn best when they are given adequate time to digest, consider and prepare; people who prefer to listen to others and who like to consider all possible angles and implications.

3. **Theorists**: people "who adapt and integrate observations into complex but logically sound theory" (p. 13); people who learn best when there is a sound structure and a pattern of purpose - they respond well to complex ideas or concepts that stretch or question current thinking.

4. **Pragmatists**: people "who are keen on trying out ideas, theories and techniques to see if they work in practice" (p. 14), people who learn best when they can be given real life practical issues to discuss and are supplied with practical tips and suggestions.

Individuals will have a preference for a particular learning style, and successful learning processes require the presence of a good mixture of the learning style(s). The criteria for what a good mixture is are determined by the goals of the innovation and learning process. Not all individuals will be able to display all the learning styles. Teams provide the opportunity to create the favourable mix of learning styles by appointing individuals with different learning styles to the team.

**Management involvement**

The second most important barrier (and the only barrier not discussed yet) for enabling learning behaviours is a culture that is not supportive of learning. Such a culture manifests itself mainly through lack of commitment to learning on all levels in the organisation, but especially on management level. This barrier is not addressed by one of the levers in the CIMA models as it is. The corporate culture on learning (Fiol & Lyles, 1985) is debated by several researchers under different headings such as involved leadership (Nevis, et al, 1995), a learning climate (Pedler et al 1989), senior management involvement in activities (Inkpen and Crossan, 1995). Senge (1990a) assumes the commitment and active involvement to be present to achieve learning.

The question is whether this culture and commitment to learning is linked as a lever to the learning process, or if the culture is the result of the application of different levers for
stimulating learning such as HRM policies, a process of strategy making, openness with regard to performance measurements, etc. Within the framework of this research it is not possible to answer this question, primarily because scholars in the field of Organisational Behaviour and Organisational Studies still heavily debate the issue whether culture follows structure or structure follows culture.

An important pre-requisite is that an open culture that is committed to learning should be part of the company vision/strategy and is assumed to have a similar function as the strategy. Culture, however, not only works passively, a culture can also be addressed through behaviour, especially managerial behaviour ("setting the example"). The required behaviour for showing commitment to learning and facilitating a supportive culture cannot be genuine without sincere involvement by management in learning processes. Involvement of management should reflect the importance that management attaches to learning (processes) as well as it provides the opportunity to set the example by demonstrating the ability to learn. Management commitment, as often put forward in publications, is related to intent, whereas involvement relates to the process that is to result in the intended outcome.

8.2 The impact of levers on the learning process

In the analysis so far the learning process (the process of acquisition/generation, distribution, storage and retrieval of knowledge) has not been taken into account. It can be argued that the eight, initially distinguished learning behaviours can be regarded as being linked to one or more subprocesses of the learning process, see figure 10.

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Acquisition/Generation</th>
<th>Distribution</th>
<th>Storage</th>
<th>Retrieval</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1: Focus improvement and learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B2: Develop knowledge</td>
<td></td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B3: Experiment with new solutions</td>
<td></td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B4: Integrate knowledge among product innovation phases</td>
<td></td>
<td>V</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>B5: Transfer knowledge between product innovation phases</td>
<td></td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B6: Abstract and generalise knowledge</td>
<td></td>
<td>V</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>B7: Embed knowledge into vehicles</td>
<td></td>
<td></td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>B8: Assimilate knowledge from external resources</td>
<td></td>
<td>V</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

Figure 10: The position of learning behaviours in the learning process.

The figure shows that it is possible to link each learning behaviour to one or more subprocesses of the learning process, except for B1 (individuals and teams use the organisation’s strategic goals and objectives to focus and prioritise their improvement and learning activities). This behaviour appears to be more of a conditioning nature for the
entire learning process, but it does not address one or more of the behaviours directly. B2 (individuals and groups use innovation processes as opportunities to develop knowledge) and B3 (individuals and groups use part of time/resources available to experiment new solutions) typically are related to the acquisition and generation of knowledge. Integration of knowledge (B4) deals with the distribution and storage of knowledge. The storage not only concerns the explicit knowledge in explicit form, but it also can involve tacit knowledge in tacit form (and the various combinations). Transfer of knowledge (B5) can be associated with the distribution of knowledge. B6 (individuals and groups abstract knowledge from experience and generalise it for application to new processes) can be linked to both the generation of knowledge and the storage of knowledge (by applying it to new processes a certain amount of storage can be expected to take place). B7 (individuals and groups embed knowledge into vehicles such as reports, guidelines and databases) in its nature is linked to the storage of knowledge. At the same time the storage allows for easier and structured retrieval of knowledge. The last behaviour, B8 (individuals and groups assimilate and internalise knowledge from external sources) on the one hand concerns the acquisition of knowledge (extracting it from external sources), on the other hand it can be argued that the assimilation (and internalisation) also concerns the storage of knowledge.

Not one single learning behaviour is able to address all four subprocesses of the learning process. Propositions are formulated that can be tested in future research:

**Proposition 1:**
Each phase of the learning process can be improved by focussing on one or more learning behaviours.

1. **Acquisition/generation of knowledge** can be improved by addressing learning behaviours related to developing knowledge (B2), experimenting with new solutions (B3), abstracting and generalising knowledge (B6) and assimilating knowledge from external resources (B8).

2. **Distribution of knowledge** can be improved by addressing learning behaviours related to integrating (B4) and transferring knowledge (B5) within and between phases of the product innovation process.

3. **Storage of knowledge** can be improved by addressing learning behaviours related to integrating knowledge within product innovation processes (B4), abstracting and generalising knowledge (B6), embedding knowledge into vehicles (B7) and assimilating knowledge from external resources (B8).

4. **Retrieval of knowledge** can be improved by addressing learning behaviours related to embedding knowledge into vehicles (B7).

**Proposition 2:**

1. There is not one single learning behaviour that is able to affect the entire learning process.

2. A configuration of learning behaviours is required to measure the entire learning process.

Next to the learning process, a second element can be introduced that is of relevance for the impact of the levers, namely different levels of learning: single-loop, double-loop and
Deutero learning. Single-loop learning involves the detection and correction of errors within a given set of governing variables. Because this level of learning occurs within a given (organisational) framework, it emphasises the type of association building that results from repetition and routine (Fiol and Lyles, 1985). Single-loop learning is often associated with incremental changes, where new methods and tactics are tried out in an attempt to get rapid feedback on the consequences in order to be able to make continuous adaptations. Double-loop learning involves changing the governing variables themselves. As a result of this type of learning "the way we do things around here" may be disrupted. Double-loop learning is linked to radical changes, such as product or process innovations, entering new markets, etc. Deutero learning is associated with learning capabilities, knowing how to learn and knowing what level of learning is appropriate in what situation, c.q. deciding on the right configuration of level(s) of learning.

In managerial discourse the levels of learning are often portrayed as being a hierarchy in which double-loop learning is superior to single-loop learning and deutero learning is even superior to double-loop learning. However, what is often lost in this discourse is what forms of (behavioural) changes are associated with each level of learning, and which are called for or appropriate in specific circumstances. The question following this question of which level of learning is desirable, is the one asking which managerial action/activity will stimulate (or at least address) the level of learning sought after. As McKee states (1992): "At each of these levels, learning must be managed; it is not automatic". Next to this "white spot", an issue that is hardly addressed in this discourse, is what level of learning is addressed by which managerial actions/activities.

The subprocesses of the learning process and the levels of learning can be regarded as two aspects that can be related, see figure 11. We can argue as to where in the learning process a lever impacts what level of learning.

<table>
<thead>
<tr>
<th>Deutero</th>
<th>Double-loop</th>
<th>Single-loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition/Generation</td>
<td>Distribution</td>
<td>Storage</td>
</tr>
</tbody>
</table>

Figure 11: The levels of learning and the learning process.

Building on the literature study it was concluded that, although a number of (effective) levers is put forward (the “what), it is not known, what the impact of these levers is, and how they have an impact.

A number of propositions have been formulated which indicate in more detail "where and how" in the learning process the levers are exercising their influence. It is argued that the impact of the levers on the learning process can be direct or indirect, through the product innovation process.
Proposition 3:
3.1 Characteristics of the innovation process affect the learning process.
3.2 The better the innovation process is structured and managed, the more effective the learning process will be.

Proposition 4:
The effects of innovation process definition (L2) on learning depend on the extent to which the lever is explicitly used to stimulate learning.

Proposition 5:
5.1 The effectiveness of organisational integration mechanisms (L3) in stimulating learning is driven by tools that (a) have an integrative function, (b) have a structuring function or (c) can fulfil both functions.
5.2 Organisational integration mechanisms are a necessary, but not sufficient condition for deutero learning.

Proposition 6:
Performance measurement (L6) can facilitate double-loop learning if the performance of the learning process is explicitly measured, analysed and fed back.

Proposition 7:
7.1 Design tools and methods effectively stimulate single-loop learning.
7.2 The effectiveness of design tools and methods (L7) in stimulating learning is facilitated by good communication within and between product innovation processes.
7.3 A high level of double-loop learning is associated with effective deployment of design tools and methods.

Proposition 8:
If properly applied, project management and control (L5) creates opportunities for learning, whereby a prerequisite is that individuals are motivated to learn and are "allowed" (i.e. given the resources and stimulated to use them) to learn.

Proposition 9:
9.1 The effectiveness of HRM policies (L4) for stimulating learning behaviour depends on the capabilities of operational managers to apply the lever in practice.
9.2 The effectiveness of HRM policies for stimulating learning behaviour over time requires stable and consistent application of HRM policies.

Proposition 10:
ICT (L8) applied to stimulate new ways of working will stimulate the learning process.

Proposition 11:
11.1 The learning process is not stimulated by the presence of a product family strategy (L1).
11.2 The learning process is stimulated by a process of strategy making involving individuals and teams that are concerned with the execution of the strategy.
There appears to be not one single lever that currently is able or has the potential to stimulate all the subprocesses of the learning process and at the same time address/include all levels of learning. In addition, the research indicates that some of the levers tend to be reinforcing one another or at least can be considered to be related. Stimulating learning behaviour through one particular lever can result in changes of the application of one or more other levers.

A consequence of the argument that the levers impact on different subprocesses of the learning process is that in order to effectively stimulate the entire learning process a configuration of different levers is required.

Miller and Friesen (1984) state that every organisation has an existing configuration at a given point of time. Their argument is that elements of a configuration make sense in terms of the whole: they form a cohesive system but not necessarily successful, functional or even perfect system. A configuration can be defined in terms of its overall characteristics (Burns and Stalker, 1961: organic versus mechanistic) or alignment among elements (Lawrence and Lorsch, 1967: alignment among levels of environmental uncertainty, structural integration and differentiation). Probably the best known configurations are Mintzberg's "ideal types" (1979).

Various researchers have studied organisational configurations focusing on structural characteristics in certain situations (Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Miles and Snow, 1978). The interdependencies between strategy and structure (Chandler, 1962) and structure and environment (Burns and Stalker, 1961; Lawrence and Lorsch, 1967) have been studied. It is emphasised that performance is influenced by the level of congruence of the elements. According to this so-called "contingency approach", organisational design should be based on situational characteristics and it can be studied which configurations appear to be effective in their context.

The line of reasoning that every organisation has an existing configuration at a given point of time can be extended to the existence of a configuration of levers that appear to be effective in a certain context, whereby the context also consists of a configuration in itself. To be more concrete: the product innovation process will have a certain configuration of levers that are effective in stimulating the process. In the previous discussions several levers were stated to impact direct on the product innovation process instead of directly on the learning process. This innovation process forms the context for the learning process. For effectively stimulating the learning process, also a configuration of levers is required. Both elements will have their own configuration of levers that are not necessarily the same.

It is possible for levers to stimulate the innovation process, at the same time hindering the learning process. An example can be found in "project management and control". If the lever is properly applied to the innovation process it is likely that resources become available (time, money). Management has the option to allow teams and individuals to use these resources to engage in learning. However, management can also decide to use these gains for efficiency improvement without stimulating the teams and individuals to learn.

A deployed strategy for innovation processes will have the function of a framework for decisions and activities and as a consequence will determine what levels of learning are called for. Although product family strategy does not have a statistically significant influence on learning behaviour, it might well be that there is an indirect effect of the
presence of a strategy, namely through a well defined (= presented by the strategy) configuration of levers. In addition innovation strategy involves the long term and can be expected not to be addressing only single-loop learning (in terms of realising the strategy), but also double-loop and deuter learning in terms of strategic flexibility (zie also De Weerd-Nederhof, 1997).

The findings and propositions found so far can be fed back to the CIMA model the research started with.
9. Conclusions, evaluation and directions for further research

The point of departure in this thesis was twofold. First, the CIMA project aimed at developing a methodology to stimulate learning behaviour in product innovation processes. Theory from different fields (innovation processes, CI, organisational learning and knowledge management) was used to develop the CIMA model that in the next phase was applied in companies to assess their situation with regard to learning in product innovation processes and arrive at recommendations for improvement.

Literature research and in-depth case studies resulted in:

- A categorisation of eight learning behaviours that together are assumed to represent the learning process.
- Eight (categories) of levers that are used to stimulate the learning behaviour.
- Three categories of performance improvement.
- Five different learning capabilities that can be built through exhibiting learning behaviour and applying levers.
- Eight contingency factors that were considered to impact the previous elements.
- The existence of disablers that hinder learning to take place, but that could not be categorised up front.

These elements together constitute the CIMA model and were operationalised into a questionnaire that was embedded in the so-called CIMA methodology: the entire system of methods used to research the company's situation with regard to learning in product innovation processes. A second point of departure were the data, gathered with the CIMA methodology.

The results of testing hypotheses underlying the CIMA model with regard to the relationship between levers and learning behaviour lead to a number of recommendations for improvement of the CIMA model. Within the framework of this summary these recommendations will not be dealt with in detail. The recommendations do not involve the section of capabilities and contingencies, since the research presented here did not cover these elements. Future research is to explicitly test some of the (new) relationships that are underlying the model.
"Working neatly" is the phrase that in daily research life is used to explain what a sound research methodology is all about: it concerns the formulation of research questions that can be answered and the defining of appropriate ways to arrive at answers (De Leeuw, 1990). The first two research questions could be answered through statistical analysis of the data in the CIMA database. It was not possible to answer the third question very detailed, because the available data were not of sufficient quantity and quality. The answer was limited to the results of descriptive statistics. The research question still is answerable in future research providing that sufficient data of sufficient quality are available. This leaves an evaluation of the second issue: have the questions been answered in an appropriate way? Working neatly in survey research requires the research meet particular quality standards that refer to the preparation phase of the research as well as the execution phase.

With regard to the preparation phase a few remarks can be made. The research represents in essence a quasi-experimental design. Data that were gathered in field research are statistically researched for assumed causal relationships. Within the CIMA-consortium it was discussed that large quantities of data would enable statistical research in the future (verifying the assumptions underlying the CIMA model), but the questionnaire itself was not designed and developed with the aim of statistical analysis for verification of theory. The fact that the data were not explicitly gathered for specific statistical analysis might be considered a weakness of the data and the current research, and compromising methodological rigour. Nevertheless, the analysis enabled a first step in improving the model and methodology.

The assessment with regard to the external validity was postponed. External validity refers to the reach and generalisability of the conclusions to populations and different circumstances such as time, place and environment. The conclusions are linked to the instrument with which the data were gathered. This is especially relevant for this research: the question is relevant whether the instrument, the CIMA methodology, can be applied as it is in other companies than the (larger) ones in the manufacturing industry in the sample. O'Mara et al. (2001) identified a number of semantic and procedural difficulties that they encountered in applying the original questionnaire in SME’s that led them to refine the questionnaire in a number of ways in order to improve its usefulness in smaller companies.

The last issue concerns the reliability of the research: can the research be repeated with the same results? It is argued that the repeatability of the research, both in terms of gathering the data for the database, as analysing the database, is considered to be satisfactory:

- The application of the CIMA methodology is accompanied by a workbook that guides the researcher through the process, explains the different steps to be taken and provides formats for the workshops and feedback report.
- The statistical analyses of the database was carried out explicitly and can be fully repeated.

The propositions in the previous sections call for further research.

Different types of research questions can be distinguished (see Yin, 1994). The propositions above typically involve "what" and "how" type questions.
1. The first question to investigate is "what configuration of levers is effective in managing the innovation process?" Since it has been proposed that the product innovation process provides the context for the learning process and the context of the learning process does have impact it is fairly obvious that the context is investigated first. The goal of this question is to reveal what levers are effective in affecting c.q. managing the learning process such that goals are realised. This type of "what" question can be investigated in different ways: through case-studies in revealing the factors that are of importance and through surveys in establishing effectiveness.

2. The second question to investigate is "What configuration of levers is effective in stimulating the required learning process?" This question has the aim to reveal the underlying dynamics of linking goals for the learning process with levers helping to realise these goals and in effect does include a number of the elements that have been put forward in Chapter Seven:
   - A strategy or goal with regard to the learning process.
   - A strategy or goal with regard to the product innovation process in which the learning process takes place.
   - Configurations of levers related to the learning strategy.
   - The effectiveness of levers.
These "what" questions call for conducting an exploratory or descriptive case study. Next to the "what" the "how" is important as well. In order to understand the effectiveness of configurations, knowledge must be developed as to how goals determine the choice of levers, how levers can help realise goals and how the levers impact on the learning process. The question as it is phrased deals with operational links that need to be traced over time and that even can be tested in a series of experiments.

3. The third research question then to investigate is a "how" question: How do configurations of levers for managing the innovation process differ from configurations of levers for stimulating the learning process? This question can be answered through different research strategies (see Yin, 1994:6): case study, history study, archival analysis and experiment. Considering however that so far no research into the relationship between the two configurations is carried out, it is advised to start with descriptive and explorative research (case study) to investigate how the configurations can be mapped and how the differences can be assessed. This almost inevitably involves looking into the question of how the configurations can be manipulated by management and where the differences are in managing the two configuration. In addition a logical next question is whether it is possible to design configurations that contribute to both processes. The effectiveness of these configurations can be established both through longitudinal (studying the implementation process and revealing critical success factors) and quantitative research (comparing different sets of configurations and comparing their effectiveness).

It was already mentioned that the CIMA model and methodology are not perfect, on the contrary. Yet they have enabled an international team of researchers to work together in order to try and understand a little more of practice. The data have helped to reflect on theory and refine it such that better models can be built in the future. In addition the
literature research, data analysis and reflection on both enabled linking fields of theory that so far have been dealt with separate.
10. Literature


Figure 1: The research model.

- Data on levers for stimulating learning in PI processes
- Data on learning behaviours in PI
- Data on barriers for learning in PI
- Data on improvement performance
- Analysis of effectiveness of levers in stimulating learning behaviour
- Analysis of impact of barriers on learning behaviour
- Analysis of effectiveness of learning behaviours in stimulating improvement performance

Discussion of findings in view of theories on:
- Organisational learning
- Knowledge management
- Continuous improvement
- Innovation Processes

Recommendations for improvement of CIMA model and methodology

Propositions on stimulating learning in product innovation processes