



What is the mysterious X Factor that sets these innovative companies apart?

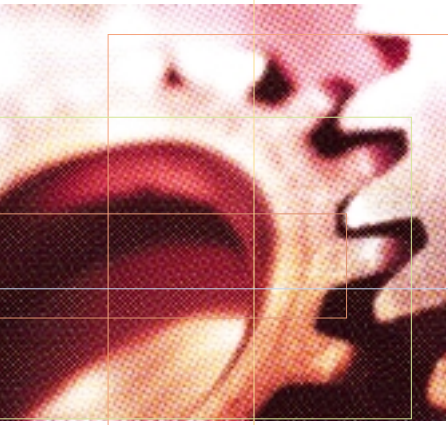
# LEARNING IN THE MANUFACTURING SECTOR

By Barbara Simpson, Judy McGregor, Rainer Seidel, Darl Kolb,  
John Henley-King and David Tweed

What does a company that exports nutritional supplements to around 30 countries have in common with a company that commands about 25 percent of the global market for high quality anchor winches or another company that is one of the largest consumers of specialised engineering plastics materials in the Southern Hemisphere?

They are all small, highly innovative manufacturing enterprises that have exploited new technologies to carve out a successful business niche for themselves. What is more, they are here in New Zealand. But their success goes beyond being just “kiwi ingenuity”. What is the mysterious X Factor that sets these innovative companies apart? This was the question that stimulated our research project.





In designing this study, there were two key factors we wanted to take into account. First, we recognised that there are characteristics of New Zealand manufacturing that are quite different from conditions in other countries, especially those in which much of the current research originates.

For instance, Statistics New Zealand defines small enterprises as those employing up to 49 people, while medium-sized enterprises employ 50 to 99 people. In other OECD countries, small and medium-sized enterprises (SMEs) might employ up to 499 people.

The New Zealand case is remarkable for its Lilliputian scale. Of the 20,000 manufacturing firms in New Zealand, a staggering 98 percent are classified as SMEs, compared with a mere 43 percent of manufacturers in the European Union that employ fewer than 100 people (OECD, 1997:18).

A further distinguishing feature is proximity to markets. If you take a map of the world and draw a circle with a 2000-kilometre radius around Auckland, the arc will just reach the east coast of Australia. If you take the same circle and centre it on London, it will enclose most of Europe and a potential pool of 370 million consumers.

New Zealand manufacturers have adapted to these market conditions by developing a great deal of agility in short-run production and this has become a real competitive strength in the global market.

The second factor that we took into consideration was that innovation is an

extraordinarily complex, often chaotic process. Although thousands of research articles have been written on the subject, no single, unified perspective has yet emerged that is capable of accounting for all the intricacies of the innovation process.

To accommodate this theoretical diversity, the research team was deliberately formed to exploit multiple views. We are a highly multi-disciplinary team with expertise in engineering and technology, innovation management, organisational change, managerial communications, strategic thinking and finance and accounting, plus a wealth of practical experience with small businesses. We all bring our own disciplinary assumptions and expectations to assist in the development of a rich understanding of innovation.

To explore the unique New Zealand context, while also making best use of our team research skills, we adopted an in-depth case study approach. The selection of companies was guided by a number of criteria. We wanted companies that are:

- Actively using new technologies. This was the most important criterion, but it is not easily measured. In the event, we made our selections by drawing on databases operated by government and other agencies that fund technology development, as well as recommendations from industry associations.
- Small but not too small. The scope of the project was strictly limited to SMEs, which employ fewer than 100 people. But we also imposed a lower limit of 20 employees to ensure a degree of organisational complexity in our cases.
- Wholly New Zealand-owned and autonomous. They are neither subsidiaries nor alliance partners of other, possibly larger, companies.
- Spread geographically around New Zealand, in both industrially intensive and community settings.

We targeted companies in three industries: food processing, light engineering and plastics. Each company was guaranteed complete confidentiality.

Initially we collected data from four companies in each of the industry sectors (12 in all). On site visits, we conducted in-depth interviews with the general manager, owner or other senior manager of each company, plus other managers, co-owners and technical staff. Interviews were designed to elicit details of company history, structure, management and operations, as well as some critical incident examples of technological innovation.

The findings from these case studies were then further elaborated in a nation-wide series of focus groups. In all, our results reflect interactions with 38 SMEs in the food processing, light engineering and plastics industries.

## WHAT WE DISCOVERED

The most pervasive theme that recurred in all of these interactions was learning. In a changing environment, the ability to learn is central to an SME's capacity for innovation, especially given the short-run production that characterises New Zealand industry.

Learning may take the form of continuous adaptation to changing or complex circumstances, or, at the opposite extreme, it may be a crisis response to unforeseen events. Indeed, many of the companies have had 'near death experiences' that brought them to the brink of business disaster.

These crises have generally been precipitated by financial issues, but ultimately the company's ability to learn has saved it from total failure. Survivors acknowledge that their crises have thrown them onto very steep learning curves,

which have required them to change rapidly. But the learning skills they developed actually make these companies more resilient to future changes.

Another important source of learning is external advice, although within our sample experiences with consultants have been by no means uniformly positive.

Our case companies also have internal procedures to support both product and process innovation through the deliberate development of people skills, incremental problem solving and learning from mistakes or failures that prompt new thinking. Some of the companies have a formal R&D mechanism that contributes new ideas to the business. For others, R&D is indistinguishable from product and process development.

By whatever means, technological learning or the conversion of technical information into applied knowledge, is essential for sustainable technological innovation (Hodgson, Howe, Saunders & Winsley, 1998).

It is undeniable learning skills are central to the success of our case companies as technological innovators. But learning alone is too generic a concept to provide useful insights to SME managers. Accordingly we set about refining the notion of learning by recognising that whenever learning occurs, new knowledge is created (von Krogh & Roos, 1995).

From our research data, we have differentiated four distinct types of knowledge that interact in the process of technological innovation. These knowledge types are:

## KNOW WHY

In every one of our case companies, the motivation for innovation was clearly articulated, but the reasons are not always the same. For some it is about making a profit and seeing positive returns for effort invested. For others, it is a matter of entrepreneurship and the desire to create something out of nothing (or not very much). For yet others, it is more to do with the desire for self-determination and a preference for self-employment. Regardless of the reasons,

“Many of the companies have had ‘near death experiences’.”

however, the driving force and purpose of the business were always strongly expressed.

Contrasting with these inspirational or motivational qualities, all of our case companies have some means of providing checks and balances to keep them on track with their purpose.

These controls can generally be linked to the nature of ownership and the role that shareholders, or their representative boards of directors, take in setting directions and defining the company mission. More than half of the cases in our sample are family-owned businesses, having their own special issues with respect to control. In these cases, family dynamics and tensions have to be accommodated within any control measures.

In addition, the environment plays a key role in shaping the choices available to a company. The companies in our sample are subject to the forces of globalisation, with different levels of domestic and overseas market access, depending on the particular industry.

New Zealand manufacturers experience varying levels of infrastructural support based on factors such as industry maturity and finance sector attitudes, while Government policy defines the regulatory environment within which they must operate.

The specific technologies employed, as well as distance from the suppliers of these technologies, also constitute an environmental factor over which individual companies have little control.

Geographic location is another environmental consideration. Companies in provincial towns,

although they may be distant from markets, have the advantage of community support and ready access to a willing pool of labour and raw materials. Companies in cities have the advantage of easy access to customers and export/import facilities.

In summary, the Know Why dimension is concerned with knowing the drivers and constraints, both internal and external, that define an organisation's activities.

## KNOW HOW

The resources that people bring to a company are fundamental to any successful enterprise. Much of the early competency literature addresses the individual expression of this form of knowledge (e.g. Boyatzis, 1982; Spencer & Spencer, 1993). Specific technical skills such as toolmaking, engineering design, or food technology form the basis upon which each of our case companies was originally built.

Development beyond this starting point has involved leadership plus communication and people skills. In addition, a wide variety of other skills are apparent in our cases, including financial, administrative, organisational, selling, planning and strategic thinking skills.

However, several of the companies commented on their difficulties in recruiting the right people, noting that it is often a matter of pure good luck when they succeed in this. Not only are people often multi-skilled, but also there are frequent skill overlaps that create a valuable, flexibility-enhancing redundancy.

But Know How is not limited to the individual level. It is also reflected at the organisational level, where processes and routines have become

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embedded as systems (e.g. Prahalad & Hamel, 1990). Organisational systems reduce complexity by establishing routines that decrease dependency upon the knowledge of individuals.

Varying degrees of sophistication are apparent in the systems of our case companies, depending on where complexity is located within the business. One company might focus its systems on gathering market intelligence, while another might be more concerned with new product or process development.

In some cases, companies have worked towards fully integrating their management, manufacturing and quality systems to provide a seamless mechanism for running the entire business. Some of these systems are fully automated and microprocessor controlled whilst others use more people-based systems such as scheduled meetings.

In addition to people, other essential resources include information and capital. Information resources provide a means of keeping up with developments and setting the stage for the development of new ideas. Customers, suppliers, trade magazines and industry fairs were all identified as useful sources of information.

Capital resources are also clearly essential, although several companies commented that getting the right people, more than acquiring capital, is the major constraint on their business development.

It is interesting to note that in terms of financial management, many of our case companies are quite risk-averse. A quarter of them operate without any debt, routinely making significant capital purchases from financial reserves. However, they will consider borrowing if there is a strong business case for this.

In summary, the Know How dimension deals with the specific skills, experience and job-related knowledge required for technological innovation. In addition, having access to the right resources at the right time is a matter of Know How.

## KNOW WHOM

At some level, all of our case companies operate on the basis of trust, which raises the issue of relationships. In this respect these small companies differ from many larger enterprises that prefer to operate on a more contractual basis.

The necessary levels of trust in our cases have been built through family links or long-term working relationships. Important relationships are by no means confined within a company, but also include customers, suppliers and other players in the industry and the wider community. Typically these small businesses rely on co-operation through networks, alliances and other affiliations that span an extraordinary breadth of personal experience.

The importance of relationships is reflected in the need to be responsive to customers and other environmental stimuli. All of our case companies are intensely focussed on the needs of their customers and they actively seek customer feedback. The companies emphasise the importance of being flexible, being able to seize opportunities, reducing the lead time before new products enter the market and developing a reputation for reliable and timely execution of orders. These qualities require a positive orientation towards change and action.

Being customer- or market-led is clearly very important for these small manufacturers, but some of them also acknowledge that from time to time they may lead the market by producing new items that have not been specifically requested by customers.

Communication is the essential lubricant in good relationships. Internally, our case companies show a definite preference for informal, face-to-face communications and 'management by walking around'. Meetings are used a lot to facilitate these internal communications.

Two of our companies have set up websites to support their external communications strategies and a number of the others are regular users of email for information transfer.

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Problem solving typically draws on ideas from throughout each company, but new initiatives are most often driven from the top. Personal charisma, persuasive abilities and negotiation skills are all factors in successful communication.

Conversely, our cases reveal several instances where miscommunication has ultimately presented the companies concerned with an opportunity to change and learn.

In summary, the Know Whom dimension recognises that learning is a socially situated activity (e.g. Brown & Duguid, 1991; Wenger, 1998) through which knowledge emerges as a result of the interactions between people. It addresses questions such as 'what relationships should be fostered, and how'?

## KNOW YOURSELF

Self-knowledge is essential for learning to occur. Without the ability to reflect on experiences (Schön, 1983), there is no possibility



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of the second order, or double loop, learning required for change (Argyris & Schön, 1978).

At the level of the individual, the Know Yourself dimension is about personal traits, confidence, self-awareness and acknowledgement of one's limitations (Bennis & Nanus, 1985).

Our cases suggest that a range of personal attributes is likely to be distributed within each company. The key to success is not just the existence of these attributes, however, but also how they complement each other. We observed optimism and a real passion for the business, especially in the leadership roles, and this was often expressed as enthusiasm throughout the company.

At the organisational level, this dimension relates to the beliefs and values that shape the culture and identity of the business. Culture is an elusive concept, but it is often revealed in the stories that are told about, for instance, how the company was founded, or heroic deeds that saved the company, or huge errors that caused the company to change direction. Our cases reveal tremendous commitment and pride in achievements, as well as a respect for integrity and fair play.

A sense of fun is also an essential component of the culture of our case companies, although they are generally cautious and conservative and take only carefully calculated risks. This is hardly surprising since, as small businesses, they have little latitude for error. 'Kiwi ingenuity' is a pervasive element of culture in our case companies, reflecting both an attitude of tenacity and self-sufficiency and an approach to problem solving through tangential thinking. Kiwi ingenuity is rooted in New Zealand's isolation from major markets, which demands independent solutions and inventiveness.

In summary, the Know Yourself dimension relates to insights that are gained through the reflective interaction among individuals, each of whom has his or her own personal characteristics, and the organisational culture, which guides choices and decisions.

## A MODEL FOR TECHNOLOGICAL LEARNING

These four dimensions of knowledge define the types of technological learning we observed in our sample of New Zealand manufacturing SMEs.

Clearly, the definitions of each dimension span across individual and organisational levels of analysis. This is appropriate given that learning occurs within the mind of the individual who is situated in a larger context (e.g. Kim, 1993; Cook & Yanow, 1993).

Figure 1 illustrates the interplay among the dimensions. It is this interplay that holds the potential for creativity. The model implies that regardless of where one might choose to start, each form of knowledge feeds into the others in a continuous process of development.

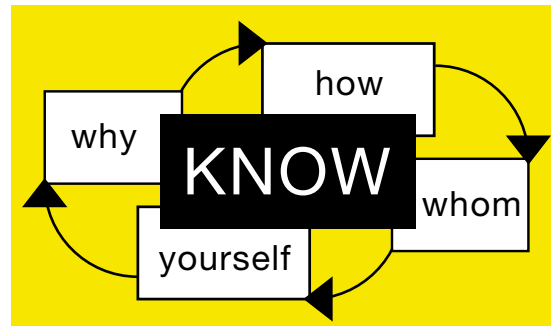


FIGURE 1: A PROCESS MODEL FOR TECHNOLOGICAL LEARNING

For instance, being motivated by Know Why defines the particular skills and experience, or Know How, that are needed for a task. Gaps in Know How may be addressed by seeking out relevant others (Know Whom) who can help to find solutions. But in interacting with others, it is critical that one's own values and expectations (Know Yourself) are clearly defined. In turn, increasing self-knowledge is likely to lead to a revision of one's purpose and motivations (Know Why) and so on. No single dimension is more important than the others. Together they create a balanced and holistic model for technological learning.

Similar multi-dimensional models have already appeared in the literature. Our model differs from the others in that it separates the

motivating forces (Know Why) from the issues of self-knowledge (Know Yourself). We see these as two quite distinct forms of knowledge that should be treated separately in order to fully inform the process of innovation.

Ultimately the real test of any model is its practical application. In the next section we illustrate the use of our technological learning model by superimposing it upon a generic new product development process model.

We have chosen new product development for this exercise first because it is closely associated with technological innovation, and second because all of our case companies have reported recent examples of new product development. We argue that the technological learning model brings new insights to this process of new product development.

**APPLYING THE MODEL - AN EXAMPLE**

Perhaps the first formalised process model for new product development was reported as early as 1957 (Booz-Allen & Hamilton, 1982). Since then models based on studies of successful and unsuccessful innovations have proliferated in the literature.

Figure 2 illustrates a New Zealand-specific example for new product development in the food processing industry (Earle, 1997). The model begins with the development of a business strategy, which some see as a prerequisite rather than part of the new product development process. It then goes on to emphasise co-ordination of product processing and market research, integration of consumer research and evaluation of the market, with critical decision gates by management between stages.

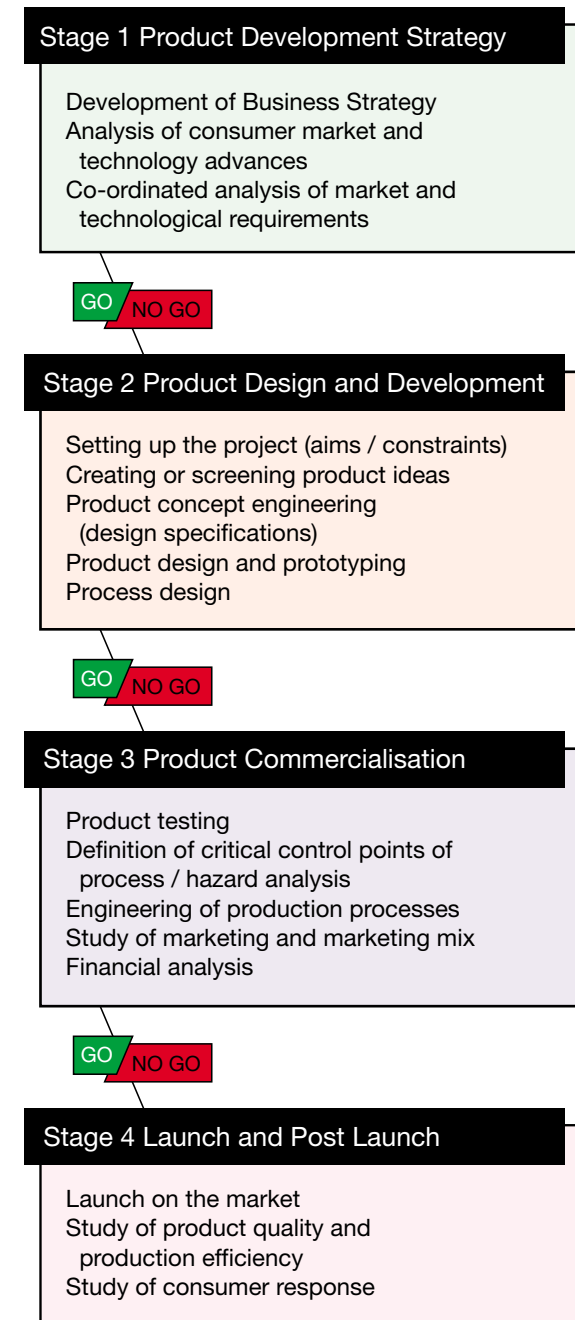
Consistent with many other new product development models, Earle uses a linear diagram to link the various stages of the process. However, innovation is widely acknowledged to be a non-linear process with the various activities overlapping or occurring concurrently (e.g. Crawford, 1994).

Furthermore, whereas new product development models usually define distinct technical and

instrumental stages of the process, they do not necessarily illuminate the accompanying knowledge flows and decision-making processes. Earle, for example, relegates this issue down to the simple level of 'Go/No Go' decision gates at each stage in the process.

We propose that by superimposing our technological learning model upon Earle's model for new product development, the result is a continuous learning process that, rather than following a linear path, spirals forward over time. At each stage, different types of knowledge are required to stimulate innovation.

FIGURE 2: NEW PRODUCT DEVELOPMENT PROCESS MODEL



		Technological Learning Model			
		Know Why	Know How	Know Whom	Know Yourself
New Product Development Model	Stage 1: Product Development Strategy	Shareholders' requirements; making money; personal drive; curiosity; desire to sustain competitiveness; company mission / goals; entrepreneurial spirit	Appropriate checks & balances; leadership; strategic planning; analysis of opportunities & threats; market analysis; understanding of technological developments	Customers; suppliers; competitors; other industry players	Strengths & weaknesses; awareness of risks; current position; creativity
	Stage 2: Product Design & Development	Driver/champion; to develop good ideas; technological advantage; to seize an opportunity; to make it happen	Technical skills; multiskilling; systems to capture ideas; slack resources; project management; design & testing prototypes; organisational skills	Technical specialists and external sources of technical advice; end-users, suppliers, personal networks; sources of ideas	Communication style; enthusiasm; awareness of technical capabilities & limitations; creativity
	Stage 3: Product Commercialisation	To make money; to realise an idea in the marketplace	Testing; manufacturing systems; financial skills; people skills; problem-solving skills	Customers; competitors; sources of capital	Optimism; tenacity; commitment; Kiwi ingenuity; company culture
	Stage 4: Launch & Post Launch	To get it out there; shareholders' return on investment	Production & quality systems; marketing skills; customer feedback	Market players	Confidence; determination; ability to persuade

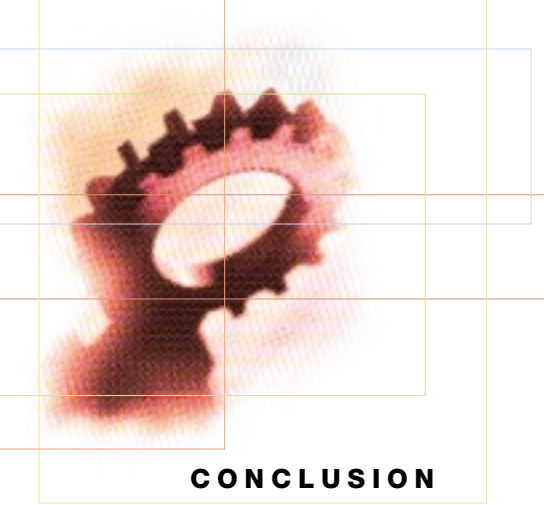
TABLE 1: THE GROWTH OF KNOWLEDGE IN THE PROCESS OF NEW PRODUCT DEVELOPMENT

Table 1 illustrates some of these knowledge forms with examples that we have identified in our case studies. Thus, for instance, in Stage 1 of the new product development process the emphasis is on strategic development, which is driven by concerns for survival, competitiveness and success (Know Why). The Know How required includes leadership and the ability to apply appropriate controls, while Know Whom demands detailed understanding of various players in the marketplace. The more one understands one's own strategic position (Know Yourself), the more effective one may be in driving the learning process forward.

At each successive stage in the new product development process there are specific and different knowledge requirements, as illustrated in Table 1.

Application of our technological learning model reveals the complexity and multi-faceted nature of knowledge growth throughout the process of new product development. The model provides a missing link by acknowledging the necessary human and managerial factors involved.

Table 1 is by no means intended as an exhaustive analysis and neither is it universal. Rather, it serves to highlight the unique learning requirements of manufacturing SMEs in New Zealand. However, the same analytical approach could equally be applied in any other organisational or industry setting. Similarly, the technological learning model could be superimposed on other innovation processes to elucidate the embedded knowledge requirements.



## CONCLUSION

This paper reports the results of a study to investigate the X Factor in manufacturing SMEs that succeed in technological innovation.

The work has been stimulated by the recognition that existing theory relating to technological innovation is limited, first because much of it assumes a linearity that is patently inappropriate, and second because of the difficulties in applying 'universal' theories in unique settings such as New Zealand industry.

Our approach has involved the explicit recognition of learning as an integral part of the innovation process. Specifically, we have proposed a technological learning model involving the four dimensions: Know Why, Know How, Know Whom and Know Yourself. By weaving this model into more conventional innovation process models, there is potential for a greater range of distinctions to be made regarding process requirements.

It also highlights an organisation's preferences for some forms of knowledge over others. In this sense, the model provides a useful diagnostic framework tool that points to knowledge deficiencies in an organisation or industry.



THE TECHNOLOGY FOR SUCCESS  
PROJECT TEAM

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## FURTHER READING

Readers who would like to know more about technological learning in New Zealand are referred to the 1998 FRST Report by Hodgson, Howe, Saunders and Winsley called 'Technological learning and the knowledge application review'. For comparative data on SMEs, the 1997 OECD report 'Globalisation and small and medium enterprises (SMEs)' provides a valuable resource.