THE STRATEGIC ROLE OF DESIGN MANAGEMENT TO ENHANCE PERFORMANCE WITHIN SMALL MEXICAN TECHNOLOGY-BASED ENTERPRISES IN NEW TECHNOLOGICAL INDUSTRIES

by

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ABSTRACT

This thesis discusses how design management can play a relevant role to improve the performance of small Mexican technology-based enterprises (TBEs) in new technological industries. The research began exploring the general role of design in Mexican business context and a gap in the literature was revealed about the role of design management and its relevance on the development of technological innovations in Mexican TBEs. A multi-method design research was adopted to identify and further detail data about the benefits and effects of design management in small Mexican TBEs. Therefore, a QUAL⇒quan design approach was utilised to apply sequentially qualitative and quantitative methods to develop a model (theory) that later was subjected to testing. The first action was to explore the context of the study through qualitative methods in order to develop an instrument (diagnostic toolkit) that enabled the researcher to evaluate the condition of the case studies within their current business practices. Then, the researcher implemented the second strategy to know the condition of the principal case studies to provide an intervention treatment. This allowed the researcher to introduce and implement design management practices within the case studies for a period of seven months to later assess once again the case studies to prove whether the intervention had provoked a change. Findings suggested that the implementation of design management can help small Mexican TBEs in new technological industries to improve their performance. The primary contribution of this research was to produce a detailed account of the conditions in which small Mexican TBEs in new technological industries operate and how they were affected by the implementation of design management. This helped to provide a holistic perspective on the use of design management, design thinking and design leadership. Similarly, it assisted in the development of an empirically confirmed design toolkit to assess the condition and design abilities and capabilities of small Mexican TBEs. The design toolkit offered users the opportunity to obtain results and suggestions about their condition and to identify and apply a series of methods, tools and techniques that can be implemented in their three levels of business activities: strategic, tactical and operational engagement.

OUTCOMES ARISING FROM THIS RESEARCH

Articles:

2008 'El Diseño y su Contribución a la Ciencia y la Tecnología'. Paper within Memorias del Foro por una Política de Diseño en México (Forum for a Mexican Design Policy) 29th October. Mexico City, Mexico.

Presentation:

CRUZ MEGCHUN, B. (2010) 'The Contribution of Design Management as a Facilitator in Achieving Eco-Efficiency within Small Mexican Technology-Based Enterprises in new Technological Industries' Paper within Conference Proceedings of the 9th International Conference in EcoBalance. 9-12th of December. Tokyo, Japan.

CRUZ MEGCHUN, B. (2009) 'Is Design Management an Asset for Small and Medium Sized Enterprises in Developing Countries?' D2B2 Tsinghua International Design Management Symposium. Beijing, China.

CRUZ MEGCHUN, B. (2009) 'Do Mexican Designers have Empathy with Small and Medium Size Enterprises Strategies and Market Necessities?'. Paper within Conference Proceedings of the 8th European Academy of Design Conference. 1-3rd April. Aberdeen, Scotland.

CRUZ MEGCHUN, B. and HANDS, D. (2008) 'The importance of Strategic Design Management in Embedding Ecodesign Thinking within New Product Development Activities in Small and Medium Enterprises'. Paper within Conference Proceedings of the 8th International Conference in EcoBalance. The challenge of Creating Social and Technological Innovation Through System-Thinking. 10-12th of December. Tokyo, Japan.

CRUZ MEGCHUN, B. (2008) 'El Diseñador como Resultado de la Relación Intrinseca entre la Teoría del Diseño y su Práctica en el Reino Unido y sus Aportes de la Educación en

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ACRONYMS

AVANCE	Special programme of CONACYT for Mexican technology-based enterprises
BIS	Department for Business Innovation and Skills
BSI	British Standard Institute
CEPAL	*Comisión Económica para America Latina* - United Nations Economic Commission for Latin America and the Caribbean
CIA	Central Intelligence Agency
CONACYT	*Consejo Nacional de Ciencia y Tecnología* - National Council of Science and Technology
DOF	Diario Oficial de la Federación
DMI	Design Management Institute
EU	European Union
ICSID	International Council of Societies of Industrial Design
ILO	International Labour Organisation
INEGI	*Instituto Nacional de Estadística y Geografía* – National Institute of Statistics and Geography
IMD	International Institute for Management Development
IMF	International Monetary Fund
METI	Ministry of Economy, Trade and Industry of Japan
NAFIN	*Nacional Financiera* – National Finance
NAFTA	North American Free Trade Agreement
NIC	New Industrialised Countries
NPD	New Product Development
NP/SD	New Product or Service Development
OECD	Organisation for Economic Co-operation and Development
PDMA	Product Development and Management Association
SE	*Secretaría de Economía de México* - Ministry of Economy of Mexico
SECOFI	*Secretaria de Comercio y Fomento Industrial* – Secretary of Commerce and Industrial Development
SEP	*Secretaria de Educación Publica* - Ministry of Education of Mexico
SHCP	*Secretaria de Hacienda y Credito Publico* – Ministry of Finance and Public Credit

SMEs	Small and Medium-Sized Enterprises
TBEs	Technology-Based Enterprises
RENIECYT	Special programme of CONACYT for Mexican technology-based enterprises
UN	United Nations
WEF	World Economic Forum
WTO	World Trade Organisation

GLOSSARY

Competitiveness. The set of institutions, policies, and factors that determine the level of productivity of a country.

Design It represents a process that employs different resources in order to fulfil the requirements established by the company and external factors in order to satisfy and optimise the market expectations using outcomes (product/service) that can be tangible or intangibles.

Design generic strategies

1. ***Brand:*** It utilises extensively design and marketing. Design focuses in the corporative identity and brand, packing, delivering of experience to the end users through superior and augmented products/services;

2. ***Market:*** The firm use jointly marketing, management, engineering and design. It focuses in exploiting the market through the development of a product or service that meet the current needs and desires of the market;

3. ***Cost:*** It uses management and engineering in order to reduce costs in the new product or service development process. Therefore, the final product/service can be able to compete through low cost in the market.

Design management. The formal implementation of design activities within a business leading to adopt a design core competence that allow the business to have a sustainable growth through the most suitable application and coordination of long-term and day-to-day strategic activities with the aim to achieve the firm's final objective. This means that it is an approach whereby organisations make design-relevant decision to achieve the aims of the firm and fulfil the consumers and market requirements, as well as optimising design relevant (corporate) processes. Thus, it is a comprehensive activity used at all levels of a business and it affects all the functions that interface with it.

Innovation. It is the moment in which a new product, process or service is introduced in a specific market; that means, that innovation impacts the production and the markets of goods and service. Indeed, it requires from previous activities such as technical changes, invents and technological developments, as they are elements or factors of innovation Schumpeter (1934).

Latin America It covers common historical, social, political and development patterns. Latin American region, geographically speaking, comprehend the landmass extending from Rio Bravo border between Mexico and United States to the southern tip of South America, plus some Caribbean Islands. The vast majority of the population speak Spanish; although, many other languages are official such as Portuguese (Brazil), French, English and Dutch (the Caribbean), and extensive number of Indian languages (Chile, Mexico, Peru, Guatemala among others). Historically, the region had encountered different situations that radically transformed the customs and lives of its inhabitants. These events can be summarised with the conquest of European nations in Latin American territories, the struggle of Latin American people to obtain independence and the search for political and economic stability as independent nations. Economically, Latin America belongs to the so-called 'developing world', as historically governments have adopted policies that enable dependency in the national industry or industrialisation (Skidmore and Smith, 2001). Politically, the region has experienced different types of political systems such as agrarian feudalism, populist regimes, oligarchies, military dictatorship, electoral democracies and social regimes since its conquest.

Management style and organisational structure	1. ***Efficient bureaucratic firm:*** They are commonly found in placid environments in where the need to innovate cannot be perceived as high. Their structure aspires to provide order and uniformity in the organisation's activities. Their structures are made to facilitate the fulfilment of routines and predictable demands of conservative managers; 2. ***Unstructured unadventurous firm:*** They are frequently found in environments that change rapidly. Their markets are focused on compete through improvements in current technologies. Their structure allows them to respond quickly to the opportunities and challenges of their environment, therefore it is common that they define their operations in a day-to-day basis; 3. ***Pseudo entrepreneurial firm:*** They are commonly found in placid environments. They are devoted to entrepreneur activities, but their structure does not totally support these activities as their structure is stable. Their organisational structure is formal with clear roles and responsibilities, and the decision power is centred in the general manager; *4.* ***Effective entrepreneurial firm:*** They are commonly found in dynamic and hostile environments; therefore, they tend to transform the industry. Their organic structure allows them to respond to market and industry demands. Their internal activities depend on good communication and a reduced number of bureaucratic barriers to innovate.
New product development.	The overall process of strategy, organisation, concept generation, product and marketing plan creation and evaluation, and commercialisation of a new product/service (PDMA, 2009).
Performance of the business in the process and/or project	***Planning*** is the act or process to make, act or doing something developed in advance; ***Organising*** arranges or prepares to efficiently coordinate the activities of a person or a group of people; ***Implementation*** puts a decision, plan, agreement, etc., into effect. ***Monitoring*** observes an checks the progress and quality of something over a period of time; keep under systematic review; ***Evaluation*** forms an idea of the amount, number, or value of the actions undertook or considered by the firm during a certain period of time; ***Design*** assesses the abilities and capabilities of the designers under the process and project.
Product/service value delivered	***Superior level*** The emotional product, which integrates attributes such as emotional appeal, emotional response, appearance, and brand identity; ***Augmented level*** The global product, which integrates non-physical attributes. It usually consists on added value factors for which people may pay or may not a premium price. Therefore, it is important consider extra services such as free delivery, after-sale maintenance, installation, and warranty; ***Current level*** The market product that is tangible and display physical attributes. It entails packaging, instruction of use, quality, style and brand; ***Basic level*** The technical product that is described by its core physical characteristics.
Small-sized enterprises.	Businesses that employ between 0 to 50 workers depending in their economic activity (commerce, industry and service), and their business is financially independent, managed by the owner, with none or loose organisational managerial structure, and with a close relationship between employer and employee.

Taxonomy of technology-based enterprises	1. ***Firms based in science and technology:*** They have the highest level of innovation in product/service; thus, they invest a large quantity of financial resources and time to those activities. The owner/manager tends to have an inclination to innovative activities, they use as a sources of innovation universities and research institutes, as well as the target market; 2. ***Firms based in intensive resources:*** They have a relative high level in innovation, in both product/service and process. For this reason, they assign financial resources & time to innovative activities. However, they tend to limit the resources to the personnel, & use external material & technologies; 3. ***Firms based in being a specialised supplier:*** They focus on the innovation process. They use few sources of consultation because they emphasise customer' needs in their innovations. They use their specialised labour in the generation of innovation; although, they depend on time and financial resources; 4. ***Firms dominated by the supplier:*** Assign their effort to innovate within their processes. They aim is to generate innovations from suppliers' proposal. Their openness within other institutions is the form in which businesses solve their problems. Their participation is associated as they depend on other firms to innovate.
Technology-based enterprises.	Enterprises with highly-qualified personnel that produce radical or incremental new products, services or processes with high added value through the effective use of scientific and technological knowledge. Likewise, they invest resources into research and development, their organisation and managerial structure favour innovation, and they are technological experts in highly-specialised fields (Corona, 1997:32).
Types of generic strategy	1. ***Leadership in differentiation:*** They focused their product development in enhanced product quality, precision, quality control and response time. Therefore, the products and services that offer are unique, these products/services are related to design, brand, image, technology, suppliers, distribution and after sale service; 2. ***Focus on differentiation:*** They focus on niche markets, thus, their development process relies on precision, quality control and response time. They develop their products/services with the aim to create a loyalty among customers and produce major profits than the competency. 3. ***Leadership cost:*** Their product development it is based in the facility to manufacture, efficient logistic and reduced number of materials. Their process development relies on the learning curve of employees and scale economies to reduce their cost. They have to have sustained access to capital, close supervision of work with controls in the cost, incentives based on quantitative controls, designs that are easy to manufacture, and have considerable advantage in raw materials, components, employees expertise, etc.; 4. ***Focus on cost:*** They centre their product development in minimising the quality of the product or service, and its development aims to minimise costs. They need to have great efficiency, reduce cost to the minimum, and hire experts in engineering; therefore, this strategy is viable to large size enterprises;

TERMS

Auditing the company.	Explore the management style of the firm and its organisational structure, and innovation taxonomy.
Auditing the strategy.	Analyse the factors that lead the firm to adopt and implement certain type of strategy;

	Design is centred in the management of corporative activities and the alignment of inter-organisational decision-making.
Auditing the process.	Evaluates those visible, tangible and intangibles actions that direct to achieve the posed strategy; **Design** evaluates those actions that help to make the process efficient and effective through the coordination of tasks and information.
Auditing the project.	Reviews all the individual or collaborative enterprises that are carefully planned and designed to achieve a particular aim (tangible result) **Design** evaluates those actions that help to improve activities and to obtain better results when the outcomes are assessed against requisites such as satisfaction of market needs, costs, technological achievements, economical objectives, technical quality, among others.
Auditing the product/service.	**Design** evaluates the levels of value delivered in the outcome. This covers the add value offered to the final user and/or consumer in the product/service as a response to their needs and desires.
Auditing the culture.	Examines the form in which the firm configure and maintain its day-to-day activities; **Design** considers the work environment and attitudes of employees to design.
Condition of the company.	Refers to the prevailing situation influencing the performance or outcome of a process. This includes those factors that can influence different levels and areas of the firm.
Design abilities.	Allude to the capacity of the personnel to do design activities and tasks.
Design capabilities.	Refers to the extent someone has power or abilities to perform effectively and efficiently specific design activities and tasks.
Performance.	Concerns with how successful the action or process of carrying out or accomplishing an action, task, function or operation is performed.
Strategic level.	Concentrates on the management of the corporative level activities and the coordination of inter-organisational decision-making activities. It conceives the corporative level as a 'production line' that aims to achieve its goals and objectives (Best, 2006). This refers that its main concern is to understand the demand from the market in order to acquire the necessary requirements to assess better the translation of ideas into a product/service to achieve this state, managers need to deploy effectively the resources available within the business.
Tactical level.	Focuses on the product development process. Its aim is to make the process effective and efficient through the coordination of tasks and information. Employees have a wide range of tools and methods to precisely control, store, present and distribute the information generated among the team members of the process.
Operational level.	Considers all the procedures related on the management and control of routine functions and actions of a business. It is important to regard tangibles (physical) and intangible (human) resources.

CHAPTER 1.0 INTRODUCTION

1.1 Background of the research

Countries are constantly subjected to measurements concerning with the performance of their institutions, policies and factors that determine their levels of productivity from institutions such as the World Economic Forum (WEF) and the Institute of Management Development (IMD). These types of study provide governments with sufficient information to position their nations with respect to their local and global competitive performance, and thus, to understand the extent to which their national environment encourage enterprises to perform in an innovative, profitable and responsible manner. This implies that nations that perform with high standards offer to their inhabitants high levels of social welfare in their quality of life. On the contrary, those nations that perform poorly do not provide a social welfare to their citizens, as they suffer from many weaknesses in their basic requirements, such as: health, basic education, macroeconomic stability, and infrastructure. According to the World Economic Forum (2010), Mexico is ranked 60 from 138 places; nevertheless, a decade ago, it was positioned in 33rd place. This result enhances that its competitiveness has suffered a substantial decline on its position during the years.

Researchers of the World Economic Forum (2008) have developed a taxonomy in which the nations studied are positioned in one of the three stages of development that drive their economies: factor-driven economy, efficiency-driven economy, and innovation-driven economy. In the analysis of the Global Competitiveness Report (WEF, 2008), Mexico is positioned in the transition stage between the efficiency-driven economy and the innovation-driven economy. Mexican Governments, as other governmental organisations (BIS, 2010; METI, 2010; SE, 2009), strongly believe that in order to be competitive; firms need to pursue innovation in their products and the way they are produced. Therefore, they are investing in programs that promote businesses through financial support, especially those based on technology, as they represent the hub of innovation. Technology-based enterprises (TBEs) are the places where it is possible to join together knowledge, technological skills and expertise to conceive a new product, service, procedure or process to benefit the population and the organisation (Tidd, et al., 2005).

Since the 1980's, there has been a growing interest among governments, industry and academia (Beven, 2007; Camacho, 1998; Corona, 1997; Fariñas and Lopez, 2007; Merino and Villar, 2007; Olalde, 2001; Sarason and and Tegarden, 2001; Storey and Tether, 1998) on TBEs. For they represent those agencies that exploit and develop continuously technological innovation (Storey and Tether, 1998). These enterprises are created under the premise that they are engaged with the design, development and production of new products, services or processes using innovative and systematic applications of scientific and technological knowledge. They require highly-qualified personnel to produce goods, service or processes with high add-value. This means that they are an important source of new product or service development, and this constitutes the focus for this research.

Previous research on technology-based enterprises (Beaver and Prince, 2002; Buesa, 2003; Camacho, 1998; Corona, 1997; Oakey, 1984; Storey and Tether, 1998; Yap and Sounder, 1994) has covered three broad themes: taxonomy of TBEs (adoption of strategy), management practices, and innovation behaviour. Nevertheless, there is scant literature about how TBEs translate the technological and scientific knowledge into an innovative product, service or process that fulfil the necessities of the business practice, the market and the environment. Therefore, exploring new product development (NPD) becomes of key importance as it captures a range of different types of innovative activities leading to the production of new services or products from radical innovations to simple modifications or adaptations to existing ones (Bruce and Cooper, 1997). NPD plays a major role in a country's overall innovative capacity because there are technical adaptations and accumulation of knowledge that in turn are the major determinants of productivity and growth within an individual business (Mortimer Review, 1997). However, it also symbolises a high-risk activity for the largest number of firms, especially to small businesses, in the introduction of new products or services in the market. It has been proven that nearly 50% of product development costs are likely to result in failure (Cooper and Kleischmidt, 1995).

Many researchers (Cooper and Kleinschmidt, 1995; Ulrich and Eppinger, 2003; Ulrich and Pearson, 1998) have explored the factors that trigger success on NPD. There are two main proposals about how companies can achieve commercial success; undertake actions either at the macro or project level. Macro level activities are based on the premise that firms need to have a holistic and broad view of their proceedings. Therefore, NPD depends on the firms' processes, organization, strategy, culture and commitment to increase their own performance within a manageable framework. Contrary, project level activities are focused on the best implementation of actions within the NPD to provoke a successful performance. Thus, every company has to understand their own key activities in order to implement accurate methods and tools that enhance their operational performance. In both contexts, design becomes a key asset in the new product/service development performance within TBEs.

A large body of research has recognised that design activity within different industries can improve the performance of firms (Best, 2006; Borja de Mozota, 2003; Bruce and Bessant, 2002; Bruce, et al., 1999; Bruce and Cooper, 1997; Cooper and Press, 1999; Frias-Peña, 2005; Gorb, 1990; Jerrard, et al., 2002; Lockwood and Walton, 2009; Oakley, 1990, 1984, Veryzer and Borja de Mozota, 2005). Design can act strategically, tactically or operationally within a company to set long term goals or take daily decisions (Best, 2006). Often design is used at the operational level within businesses, as a function that comes into play in the development of new products. Academics and practitioners (Best, 2006; Bruce and Cooper, 1997; Cooper and Press, 1999) agree that design within the NPD process acts as a creative process that uses different sources of information to conceptualize an idea and lead it to develop an innovative product or service. It significantly contributes to establish the amount of innovation and its rate of flow within the NPD activities; to leverage the overall quality of the product and its development range; and to co-coordinate and to simplify the necessary resources in the NPD (Swink, 2000). The accomplishment of these actions can be translated on producing superior products; inject life in to mature markets; and diversify into more profitable markets (Cooper and Press, 1999). Therefore, it significantly contributes to a range of critical management issues that determine the nature and the profitability of the product to the firm (Gorb, 1990). To achieve this state, design has to be effectively managed within organizational activities.

Design management, as a professional activity has been studied within business operations for more than three decades (Blaich, 1993; Borja de Mozota, 2003; Bruce and Bessant, 2002; Corfield, 1979; Gorb, 1990; Oakley, 1990; Topalian, 1980; Walsh, et al., 1992). However, it is considered as a new area of investigation in Mexican academic research. Design management has been built through the praxis of researchers and practitioners from different backgrounds and scopes on the design or management area. Although, there is not a universal definition, academics and practitioners (Best, 2006; Bruce and Cooper, 1997; Cooper and Press, 1999; Jerrard et al., 2002; Sebastian, 2005; Topalian, 1980) agree that it consists of managing all the aspects concerning on design at two distinct levels within the enterprise, corporate level and project level. At the corporate level, design managers coordinate inter-organizational decision-making. The firm is seen as a 'product line' where the demand from the market is acquired, the requirement analyzed, the job assigned to qualified personnel, and the design ideas, drawings, prototypes and model developed. At the project level, design manages the 'process' and 'product'. Design management at the process level concentrates on support and makes the product process effective and efficient toward the coordination of tasks and information (BSI, 1999; Bruce and Bessant, 2002; Sebastian, 2005). Whereas, at the product level focuses on the production of physical objects that meet the aesthetics, functional, economical and technical requirements in production and the market (Boyle, 2003; Eder, 1998; Sebastian, 2005). Design management becomes responsible for defining the values that are going to be incorporated in the final product using a design brief. However, too little attention has been paid to the application and implementation of design management, as action, in small technology-based enterprises.

It is becoming increasingly difficult to ignore the fact that design management can play a key role in Mexican businesses, especially small TBEs, as it has done in developed nations. According to Candi (2007, 2005), design is an element of innovation in the development of technology-based products and services, as it affects the way in which design activities are implemented and managed to encourage innovation and meet the business and market needs. Thus, it is possible that the implementation of design management can provide a positive impact to the performance of small Mexican TBEs in new technological industries. Due to it is recognised that this type of business in Mexico lack of skill from entrepreneurs and staff to transform their scientific and technological development in a marketable product/service.

1.2 Theoretical framework for this research

This research addresses the following problem: ***does design management improve performance of small Mexican technology-based enterprises in new technological industries when implemented within their activities?***

In order to answer this research question, three main themes need to be investigated: the condition of small Mexican technology-based enterprises in new technological industries; the abilities and capabilities they have in design; and the role that design management can play in the activities of the firm. These issues successively are addressed as three individual research questions that complement the main investigation.

This research proposes that, small Mexican technology-based enterprises in new technological industries not just suffer similar challenges to their counterparts in developed countries, but they also face problematic issues specific to their context. These problems can be experienced at two levels, governmental level and management level. The first consists of the lack of efficient policies to improve their situation; lack of programs that let businesses have access to national subsidies; lack of national programme that offer a complete business support to introduce products in the market; and lack of risk programme that help general managers obtain loans from financial institutions. The second level faces challenges on limited financial resources; lack of experience and technology; outdated machinery; low awareness of technological requirements needed; low desire to be producer of goods and services; low commitment to design, to develop and to produce innovative products; and a poor level of employees' skills. Therefore, corporate strategy elements, NPD process features and organisational culture are crucial in the improvement of this type of businesses. In addition, the use and implementation of design (management) in this type of businesses can represent an asset in their aim to develop technological and scientific products and to introduce these technological developments into the market. Consequently, the relationship between corporate strategy elements, NPD process features, organisational culture and design management and their effects to the success of the organisation are addressed in this research.

In order to develop a theoretical framework, it was necessary to explore four background themes of small enterprises: technology-based enterprises, organization and management style, new product development and design (management) implemented within businesses. This preliminary framework was refined as a result of the exploratory research and its iterative process. Three research questions were drawn from the theoretical framework produced.

The first research question centred on obtaining an understanding of the use of design within the everyday activities of small Mexican technology-based enterprises, and specified as:

RQ 1: ***How do small Mexican technology-based enterprises in new technological industries use and embed design in their business activities?***

Most of the research developed on design management emphasise that it is more likely used and embedded in large corporations (Best, 2006; Blaich, 1993; Borja de Mozota, 2003; Borja de Mozota and Young-Kim, 2009; Bruce and Bessant, 2002; Bruce and Cooper, 1997; Chiva and Alegre, 2007) than small and medium-sized enterprises (Borja de Mozota, 2006; Bruce, at al., 1999; Frias-Peña; 2005; Filson and Lewis, 2000). Similarly, there is little evidence of research done concerning design in technology-based enterprises (Candi 2007, 2005). The studies that cover the use of design within the activities of small sized enterprises and technology-based enterprises enhance the fact that it is mostly implemented at the operational level. This is mainly due to researchers explored in the context of study the role played by design and then suggested different set of actions that can improve the efficiency on its implementation.

RQ 2: How can small Mexican technology-based enterprises in new technological industries use, implement and integrate design management within their activities?

During the last two decades, different organisations (BSI 1999, 1989; Design Council, 2007; Danish Design Centre, 2003) and academics (Borja de Mozota, 2003; Bruce, et al., 1999, Inns, 2002; Moultrie, et al., 2006) have developed a series of design audits or checklist such as the Design Atlas, Design Demand or BSI 7000 that aim to provide designers and owner of business with resources to evaluate and to implement efficient design action in businesses. Indeed, these studies cover different issues of design management at different levels. For example, the tool developed by Moultrie, et al. focuses on assess the design performance in the process and project level in small and medium sized enterprises (SMEs) in United Kingdom. Similarly, the BSI 7000 provides a checklist of the considerations that are required in the new product development process in United Kingdom industries. Finally, the Design Atlas is a tool for auditing the design capabilities that a firm possess. Its relevance is based on the framework provided as it let design specialists to know which actions can be taken to develop design capability in response to the findings from the Design Atlas audit. Consequently, it is important to explore the situation of design in small Mexican TBEs in order to know whether they share some of the patterns already explored in the literature.

RQ 3: Do small Mexican technology-based enterprises in new technological industries improve their performance using design management within their business activities?

There are few published case studies (Borja de Mozota, 2006; Bruce, et al., 1999; Danish Design Centre, 2003; Design Demand, 2007; Jerrard, et al., 2002; Tether, 2005) that focus on the implementation of design management in SME's and on the description of it impact on those cases. Likewise, these studies have emphasised the use of specific design activities with particular design specialisation, such as industrial design in projects or graphic design in the brand identity, that have lead to obtain diverse outcomes in the different levels and actions of the case studies. Nevertheless, there has not been presented a study in where it is considered at the same time and in the same case study, the different roles played by design management within an organisation. Similarly, there is little research (Candi, 2007, 2005) about design (management) implementation in TBEs and its effects. Additionally, there is any information, especially academic, concerning with the implementation of design management in developing nations, especially in Mexican TBEs in new technology industries. Thus, it is recognised the necessity to explore design management holistically at the different levels and actions of small Mexican TBEs in new technology industries to asses the impacts that it has in these types of business. Having outlined the research problem and the three associated research questions, the justifications and contributions of the research are now discussed.

1.3 Rationale and contributions of the research

The rationale of this research relies on a number of grounds. The relevance of conducting research on small Mexican technology-based enterprises will lead to: provide information in the development of national programmes; contribute to the area of design management, design thinking and design leadership; and produce findings on both theory and practice of design management in small Mexican TBEs in new technological industries.

Relevance to the national economy. Mexico is facing a challenging time in which it is required to take appropriate decisions to settle actions that lead the nation to transform the current condition in future opportunities. Therefore, TBEs have raised significant expectations about their capabilities to transform the current economy (efficiency driven) into an innovative economy that can remain steady over time.

During the last decade (2000-2009), Mexico has failed to keep the pace of its competitive growth position in the assessment performed by the International Institute of Management Development (2009) and World Economic Forum (2009). As discussed in section 1.1 the latest evaluation conducted by the WEF, Mexico occupied the 60th position, 27 places far from its evaluation of 2000. The same occurred on its evaluation from IMD as it is ranked 46th, 9 places below its position held in 2000. Both results enhance three important issues: firstly, new economies have been able to formalise their economics, politics and social developments in order to provide their inhabitants with basic infrastructure to increase their social welfare. Secondly, new industrialised countries (NIC) have been improving their performance leading them to transit to another stage of competition. Thirdly, Mexico has executed inefficient policies and produced poor strategic programme provoking with it a limited growth. Thus, more than ever it needs to invest on those areas that are strategic to compete with other economies. According to Gans and Stern (2003), the basis of future economic competitiveness will increasingly be driven by technological innovation.

According to Global Competitiveness Report (WEF 2008:23), the Mexican economy remains vulnerable to external down turns given its close association with the US business cycle and its heavy dependency on oil revenues. Consequently, it is understandable that the productive processes of Mexico are based, in general, in techniques and machinery coming from abroad (Corona, 1997). Another central problem faced regards with the large inequality and poverty that suffer the Mexican inhabitants, as 40% of its population live below the poverty line (INEGI, 2009). This condition in turn influences the function of the market provoking a low economic growth, and a reduction of the enrolment on secondary, tertiary and high education and the numbers of high-qualified labour. In what respects to business performance, Mexico confronts problems on its ambiguous and non-transparent policy making; inefficient legal framework; and scarce financial resources to invest in programs that help SMEs and TBEs. That means that Mexico continuous positioned in the ‘efficiency-driven’ economy, and is required to start making significant changes to prepare itself to become the developer of its own technological innovations.

Mexican Governments have been promoting technological innovations since 1970 when the production of goods from United States of America decreased after World War II. Mexican businesses suffered because, firstly, they required foreign investment to adapt technologies to cope with the standards needed to produce products; secondly, they required specialised workers that were skilled enough to manage the technologies. Since then, Mexican Governments adopted a substitute strategy to gradually industrialise the national industry. However, its rigid protectionist policy did not facilitate the efficient implementation of the strategies provoking an inefficient industrialisation in the employment of intensive technologies. Thus, it was suggested the necessity to modify the economical model. At that time, it implemented a neoliberal model to help to accelerate the liberalization of the economy; to create a flexible foreign investment policy; to resize the public sector; and to create a financial system that operates besides the nationalised banking. In opinion of Aspe (1993) and Lusting, et al. (1992), this structural reform lead the country to have the necessary tools to implement better strategies to face the international competition and market forces. Therefore, TBEs have become of vital importance to compete in the open and deregulated economy of Mexico as they promote vitality and modernisation of the product system using technology and scientific development on the productive process.

Technology-based enterprises use a systematic application of scientific and technical knowledge on NPD in order to design, develop and produce new products or services. The outcomes obtained from the activities of TBEs cannot be called innovation until the moment where the new products, services or processes are introduced to a specific market (Schumpeter, 1934). Indeed, innovation requires previous activities as technical changes, inventions and technological developments, which are factors of innovation. It can be deduced that the likely success of TBEs through improvements in their NPD activities can have an impact on the economic performance of the nation.

This research focused on understanding whether the use of design (management) can improve the performance of small Mexican TBEs in new technological industries. Hence, the research findings can offer insights that lead to national institutions such as the National Council of Science and Technology (CONACYT) and the Ministry of Economy (SE) to consider different options that lead to leverage their current programmes or to invest in new areas research. In addition, it aimed to contribute in the discussion and development of the first Mexican design policy, especially in the area of innovation and technology, as it is necessary to raise awareness among designers and the governmental institutions responsible for the project.

Contributions to the academy. This study has two aims, extend the research focusing on small Mexican TBEs in new technological industries, and to explore the use, implementation and impact of design management within small Mexican TBEs in new technological industries. Both endeavours are considered of main importance to increase the awareness of local issues (Mexico) that can help to provide new insights into the implications of the use of design management in TBEs.

Research about small TBEs is limited in Mexico, as few researchers (Corona, 1997; Olalde, 2001) have been explored this type of organisations. Most of the studies developed have centred on isolated themes such as taxonomies of TBEs' strategies, management practices, generation of innovation and employment, and exploration of successful case studies. Consequently, it is difficult as a researcher to have a complete understanding of all the issues that are part of TBEs. As part of the research, it was necessary to explore small Mexican TBEs in order to produce a diagnostic framework that let the researcher to generate an assessment and a sensible intervention. This led to insight into the inter-relationships between corporate strategy, NPD process actions and culture. There are researchers (Cooper and Kleinschmidt, 1995; Griffin and Page, 1996; Montoya-Weiss and Catalone, 1994; Ulrich and Eppinger, 1995) that consider each of these themes as separate parts and components of linear sequence of events, especially the linkages between strategy and NPD. However, in opinion of Beven (2007) there is much closer relationship between corporate strategy and NPD process in the context of start-ups base on technology. Thus, the contribution of this research concerns on the description of the condition of small Mexican TBEs and the detailed account of actions undertaken by these. It was found that this type of businesses adopts an informal NPD process and they are able to manage innovation, informally, through the adoption of tools that help to converge and diverge the cycles of innovation.

The first contribution on design management theory concerns on the use of design in small Mexican TBEs. It was found that design is used in a varied manner at the strategic, tactical and operational level. Likewise, it was observed that companies tend to use, at the same time, different design strategies in order to achieve their general strategy. Finally, it was documented that the use of design does not guarantee business to obtain the outcomes required or expected. The second major contribution regarded on the implementation and use of design management. It had been explored that it was possible to implement design management at the three levels of action of TBEs in order to support and to translate the scientific and technological knowledge in to marketable product/services. Indeed, it is possible due to two main reasons: first, corporate strategy development and NPD activities occur in a parallel and overlapping manner, and second, design management was part of a teamwork that was amalgamated from different areas of knowledge to produce the transition from scientific and technological knowledge to a final product or service. It was also documented that the effects of design management can be positive when it is integrated holistically along with other areas and directed by non-designers (with the intervention of a design manager).

The third contribution discussed the intrinsic relation between design management, design leadership and design thinking. It was reported an intrinsic need from design management actions to integrate design thinking in the day-to-day activities of employees and to assume a design leadership perspective from the general manager to effectively implement manoeuvres in small Mexican TBEs.

Contribution to practical application. This research used a pragmatic worldview for it was necessary to question and assess the relevance of previous knowledge generated on design management within the context explored. It has been argued that the impact that can have design management into a business depends on the awareness of the people that are in charge of implementing it and the abilities and capabilities of the designer. Consequently, it is necessary to understand the cultural perception of design developed in a country because its implementation and use can differ from other nations.

One of the most important contributions of the study is the development of a design toolkit that allows the firms to undertake three actions; to assess their condition and design abilities and capabilities; to obtain results and suggestions about their condition; and to suggest a series of tools, techniques and methods that they can use. It was elaborated in order to fit the cultural knowledge of design (management) in Mexican businesses and designers. This will allow to shape future lines of research in Mexico and to develop its own abilities and capabilities of design. Likewise, it can be used as a support for designers and managers to understand, to use and to implement design within their every day activities.

It also contributed in producing the first introduction of design management in Mexican businesses, and with it reveals new lines of research in the country, especially in design management, design thinking, and design leadership. Similarly, it produced a detailed description of small Mexican TBEs. The taxonomy developed can be useful for governmental organisations that have programs for this type of businesses, as they can provide ad-hoc support. As well as, it can help to redesign the national programmes in order to deal with the current condition of this type of organisation. Finally, the data obtained can encourage public institutions to produce further research that support the development of new polices in technology and science as it has been poorly recognised.

1.4 Methodology

The study used a multi-methods design strategy (QUAL⇒quan), as it explored the impact of design management on the performance of small Mexican TBEs in new technological industries. In order to achieve its objectives (section 1.2), it was necessary to use two stages of research: ‘development of the design tooolkit’ and ‘pre-experiment’. The overall research design was guided by a pragmatic worldview (Bruce, et al., 1999; Moultrie, et al., 2006), as the theory in this study still in its early stages. As it was of an early stage to introduce design management in small Mexican TBEs in new technological industries, it was necessary to use a pluralistic worldview that combined deductive and inductive thinking, as well as mix qualitative and quantitative data. In addition, pragmatism concerns with consequence of the research, as its epistemology is oriented toward realism and practicality. To answer the type of question established for this research, it was appropriate to use multi-methods research.

Justification for the use of a mixed methods strategy. This design was used to bring qualitative and quantitative methods sequentially within a theoretical thrust in order to develop a model or theory that later was subjected to test the theory (Morse, 2003). The first stage, in general, explored the context of study through qualitative methods to develop the design toolkit that enable the researcher to evaluate the condition of the case studies within their current business practices. Then, the second stage was used to understand the condition of the principal case studies in order to provide modifications. This allowed the researcher to introduce and implement design management practices within the businesses to assess once again (after 7 months period) the case studies to prove whether the intervention enabled change.

The first stage 'development of the design toolkit' considered three phases to explore the context of study in order to develop an instrument that is not available by the time of research. Thus, the first phase, exploratory study, reviewed the topic qualitatively to generate themes, variables, items and scales from the qualitative data. The second phase, instrument development, tested the design toolkit and its feasibility in three pilot case studies and with three Mexican academics to confirm its basic viability and to inform its structure and content. The third phase, validation, concerned with the refinement of the design toolkit on its viability, content and structure to validate it.

The second stage 'pre-experiment' regarded three phases to produce a modification and to follow-up the results of the pre-experiment. The fourth phase, pre-measurement, aimed to implement the design toolkit to produce a description of the case studies situation. This set of results defined the modifications that were introduced in each of the three case studies over a period of six-to-seven months (phase 5). Finally, the researcher implemented the design toolkit again in the three previous case studies to assess whether the evidence shows an improvement or not (phase 6). As a result, meaningful insights were obtained from the exploration of small Mexican TBEs in new technological industries, their utilisation of design and their integration of design management within their context of study.

1.5 Definitions

As part of the research, several key terms need to be defined to establish the position taken in this research. These definitions are of utmost importance as they are the source from where the research provides scope, establishes boundaries and gives meaning to the findings.

Design management. There is a complexity in the variety of definitions provided for this term. These definitions stress the gap between theory and practice, and the wide spectrum on design and its connotations and typologies (Best, 2006; Blaich, 1993; Borja de Mozota, 2003; Chiva and Alegre, 2007; Corfield, 1979; Design Council, 2008; Hollin, 1991; Oakley, 1990). For the purpose of this research, it was necessary to produce a definition based on previous literature in the academy and practice. Design management refers to 'the formal implementation of design activities within a business leading to adopt a design core competence that allow the business to have a sustainable growth through the most suitable application and coordination of long-term and day-to-day strategic activities with the aim to achieve the firm's final objective. This means that it is an approach whereby organisations make design-relevant decision to achieve the aims of the firm and fulfil the consumers and market requirements, as well as optimising design relevant (corporate) processes. Thus, it is a comprehensive activity used at all levels of a business and it affects all the functions that interface with it'.

Innovation. The literature identified an extensive and rich myriad of definitions concerning on innovation, from economical to technological. The definition used for this study has been adopted from Schumpeter (1934): *'innovation is the moment in which a new product, process or service is introduced in a specific market; that means, that innovation impacts the production and the markets of goods and service. Indeed, it requires from previous activities such as technical changes, invents and technological developments, as they are elements or factors of innovation'*.

New product development. The definition adopted for the purpose of this study was that proposed by Product Development and Management Association (PDMA, 2009), *'the overall process of strategy, organisation, concept generation, product and marketing plan creation and evaluation, and commercialisation of a new product/service'*.

Small sized enterprises. The literature provided a large number of definitions for what constitutes a small sized enterprise in developing nations. In Mexico, there are different official definitions for small sized enterprises (DOF, 1999; INEGI, 2009; NAFIN, 2004; SE, 2001). Thus, it was considered for the definition of this study to develop an interpretation that fit under the current context of study. Small sized enterprises are 'those businesses that employ between 0 to 50 workers depending in their economic activity (commerce, industry and service), and their business is financially independent, managed by the owner, with none or loose organisational managerial structure, and with a close relationship between employer and employee'.

Technology-based enterprises. For the purpose of this research, technology-based enterprises are those *'enterprises with highly qualified personnel that produce radical or incremental new products, services or processes with high add value through the effective use of scientific and technological knowledge. Likewise, they invest resources to research and* *development, their organisation and managerial structure favour innovation, and they are technological experts in high-specialised fields'* (Corona, 1997:32).

1.6 Limitations of scope

A number of important limitations were encountered during the research. These limitations can be clustered into three groups: selection of cases, unit of analysis and methodological impact.

The first limitation concerns the selection of the pilot and principal case studies due to the subjects of study being required to fulfil the following requirements (Table 1.1). Therefore, it was necessary to identify adequate firms for inclusion in the study, although, there was a potential limitation. There were an unknown number of small Mexican TBEs in new technological industries. Previous research documented a limited number of small Mexican TBEs, and even less that use design. Consequently, both issues were addressed by accessing the list of enterprises that are part of the program 'AVANCE' from CONACYT, as it has the most complete list of national TBEs. The researcher went personally to each firm, before any implementation was undertaken, to explain the research purpose and to assess whether the data provided from CONACYT was accurate. In most of the cases, the firm did not fulfil the requirements established in the design strategy because the list of CONACYT was not updated. As a result, an appropriate and representative sample of target firms for this study could not be identified. Additionally, it is important to raise another issue, the number of staff employed in the principle case studies fluctuated significantly during all the pre-experiment stage and this could affect outcomes.

Table 1.1 List of requirements

List of requirements	Sub-variables
Being a technology-based enterprise	Use scientific and technology activities; innovative activities; aim to introduce (technological) innovations within the market
Small sized enterprise	Number of employees from 0 to 50
Mexican enterprise	Owned by Mexicans; National Intellectual Property (IP); Mexican workforce in its majority
Private organisation	
Use design within its activities	At the strategic, tactical or operational level; industrial design, graphic design, engineering design etc;
Active in the development of new product/services	Product; service; process
Develop innovation continuously	Radical (new to the market or new to the world); and incremental
Established in the business for more than three years	
Establish in new technological industries	Biotechnology; ecology; electronic; energy; new materials; and telecommunications

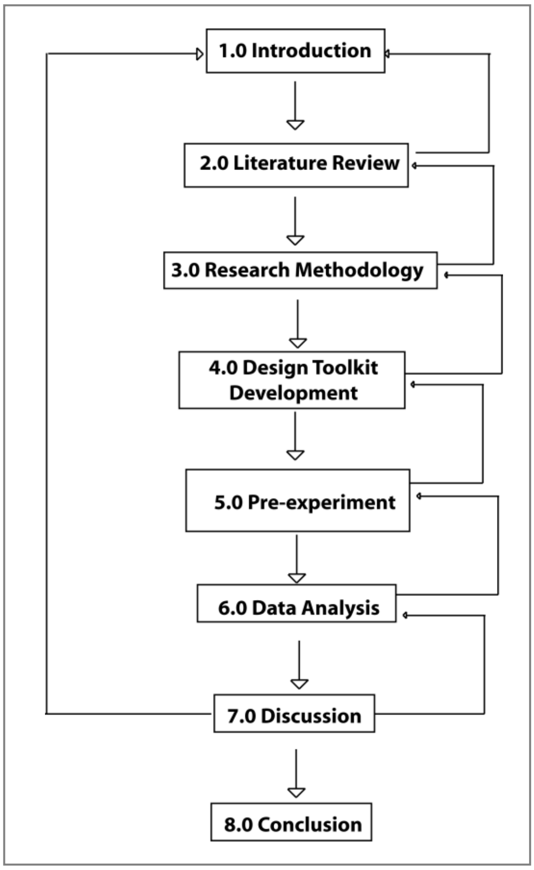
It was necessary to define the unit of analysis within the study in order to produce a pre-experiment. This is mainly due to being required to develop an instrument that enables the researcher shape the condition of the subject studied to later implement an intervention. It is important to emphasise that at the moment of the research there was not any instrument available to assess small Mexican TBEs in new technological industries. Thus, the researcher had to develop one. First, it was necessary to understand the condition of these firms to generate a taxonomy that positioned the firm according to their results. It was also important to understand how design was used and which abilities and capabilities were used within the organisations. Consequently, it was necessary to produce an instrument that evaluated the condition of the firm in any productive sector of new technological industries, and its abilities and capabilities of design. After obtaining this information, it was possible for the research to fulfil its aim, which was to introduce design management actions and to assess whether these actions affected the condition of the firm. Several limitations to this pre-experiment study need to be acknowledged. The sample size is reduced because the limited financial resources and personnel resources available to undertake a major sample of case studies. Likewise, the time of the pre-experiment was short (six-to-seven months) because it was required to finish on time the collection of the data to submit on time the PhD thesis.

Finally, three major methodological concerns were considered during the research: impact of the researcher, causality, and generalisability. The first pertains to in the influence of the researcher in the outcomes obtained due to their personal knowledge, skills or characteristics. Thus, feedback was fundamental to reduce the potential for research bias in interpreting the impact of the development of the design toolkit and pre-experiment. Causality was another aspect that relied strongly in the feedback of the usability and usefulness of the design toolkit. Therefore, data obtained from the design toolkit was triangulated with multiple data sources to address the issue of causality, as far as it was reasonably possible. Mainly due to the development of a new instrument, it is difficult to attribute any observed effect to the procedural intervention itself (Maslen and Lewis, 1994). The last issues relates to generalisation as this study had a limitation because it used action research and case study methodologies (Warmintong, 1980; Yin, 2003). Both methodologies focus on small number of companies and validate results through actions in the context studied. This instrument has been created to raise awareness of design issues in small Mexican TBEs in new technological industries. It is expected or desirable that all companies exhibit different performance within the different areas. Hence, different responses to questions would be achieved in different contexts, sectors of new technological industries, cultures, and sizes of businesses. Nevertheless, a potential limitation of this work is that it may face difficulties to demonstrate the external validity or generalisability of the procedure (Moultrie, et al., 2006; Yin, 2003). The inclusion of a final validation phase to wider industrial feedback goes some way towards addressing this concern, as this study aimed to find funding to keep researching the design toolkit.

1.7 Outline of the thesis

This thesis has eight chapters, as it was deemed the most suitable structure to introduce the themes considered in the research, to present the data collected and to explain its analysis (Fig. 1.1). Chapter 1 outlines the research problem and presented the importance of TBEs, especially small sized enterprises, to the national economic in Mexico. It discusses the relevance of TBEs in the continuous technological innovation development. Similarly, it discusses the problems that these organisations suffer during the technological development and the introduction of this into the market. It further argues that it is required to consider corporate strategic elements, organisational culture and NPD process features to improve the performance. Then, it describes the relevance of design activities within the business context, as it had documented its positive impact on the performance of the organisations (Best, 2006; Borja de Mozota, 2003; Bruce and Bessant, 2002; Lockwood and Walton 2009; Oakley, 1990; Veryzer, 2005; Veryzer and Borja de Mozota, 2005). Subsequently, it introduces design management issues related to its positive influence on the performance and competitiveness of enterprises. Therefore, it discusses that design management offers an opportunity to encounter the internal organisational problems suffered by small Mexican TBEs.

Figure 1.1 Outline of the thesis



In chapter 2, it reviews the literature relating to the research problem in order to develop a theoretical underpinning for the research. The chapter begins with a general description of the Latin America region and Mexico (section 2.2) to comprehend the context of the study. It also defines the terms of small Mexican technology-based enterprises (section 2.3.1) and its application of technology and innovation. Next, it explores the organisation and management style in small TBEs (section 2.4), as it represents the introduction to interrelate themes such as organisation within TBEs (section 2.4.1), taxonomy (section 2.4.2), management style (section 2.4.3), and culture style (section 2.4.4). Then, it introduces new product development (section 2.5) through its definition (section 2.5.1), different types of processes (section 2.5.2) and success factors (section 2.5.3). Finally, the last section explored design as a value asset within the business environment in its three level of implementation, strategic, tactical, and operational level (section 2.6). It is necessary to define two terms, design (section 2.6.1) and design management (section 2.6.2), as both allow to establish the views that consider design as a strategic asset within the business context (section 2.6.3). The last section concludes by examining design management levels, strategic, tactical and operational level, within the business context (section 2.6.4). It is important to highlight that the themes covered in the literature review were primarily based within the context of large and established firms in developed countries. Correspondingly there has been no research of design management in the context of small TBEs in new technological industries of developing nations available by the time of the research.

Chapter 3 outlines the research design utilised to address the three research questions that frame this investigation (Table 1.2). First, it was explained the research design (section 3.2) to decide then the philosophical foundation, pragmatism, under which is based this study (section 3.3). Subsequently, it is discussed multi-method design (section 3.4), along with the criteria employed for judging its quality. The multi-method design chosen, QUAL⇒quan (section 3.5), was explained in order to present the methods and techniques used to collect and analyze the data of the development of the design toolkit (section 3.5.1) and pre-experiment (section 3.5.2). Finally, this section concludes with a discussion of the ethical considerations (section 3.6) relevant to this research.

Table 1.2 Research questions

Research Question 1 (RQ1): How do small Mexican technology-based enterprises in new technological industries use and embed design in their business activities?
Research Question 2 (RQ2): How can small Mexican technology-based enterprises in new technological industries use, implement and integrate design management within their activities?
Research Question 3 (RQ3)/main: Do small Mexican technology-based enterprises in new technological industries improve their performance using design management within their business activities?

Chapter 4 provides an account of the procedures adopted to develop the design toolkit that was used to evaluate the condition of the firm and its abilities and capabilities of design. Thus, it first mentions the objectives and premises considered in the study (section 4.2), to later define the terms utilised for describing the condition of small Mexican TBEs and design abilities and capabilities (section 4.3). Next, the research phases of the study are explained, exploratory study, instrument development and validation. The first phase (section 4.4.1) explores the context of study and sense-checked the content and structure of the design toolkit. Then, it tests its feasibility to confirm the basic viability of the approach and the content and structure (section 4.4.2). Finally, it refines the design toolkit to implement it into the case studies, to later validate it with further assessments (section 4.4.3). The follow section detailed the methodological developments for each phase (section 4.5), and to later explain the results obtained from the design toolkit to assess the reliability of the scale (section 4.6).

Chapter 5 explores the implementation of the design toolkit to assess whether the three case studies reported changes in their condition and design abilities and capabilities. Therefore, it details the three research phases carried out in the pre-experiment, pre-measurement, modification and post-measurement. The pre-measurement phase (section 5.2.1) appraises two actions, the implementation of the design toolkit and the description of the firm's condition within the context of the study. The modification phase (section 5.2.2) analyses the evidence produced to develop specific modifications that were implemented and followed up during a period of seven months in each case study. The post-measurement study (section 5.2.3) concerns the second implementation of the design toolkit within the three previous case studies. The same order is used to describe the methodological development for each phase (section 5.3).

Chapter 6 analyses the data collected from the three case studies in order to yield answers for each research question posed. The first section reviews the design toolkit as it represents the main instrument to assess the three case studies condition and design abilities and capabilities (section 6.2). Subsequently, it presents the terms used throughout the research (section 6.3) to later describe the data displayed in the chapter (section 6.4) and a summary of the case studies (section 6.5). The next three sections are aimed to answer each of the research questions of the study (section 6.6, 6.7 and 6.8). This section finishes summarizing the key findings of the data analysis section (section 6.9).

Chapter 7 begins with a synopsis of the three research questions and respective findings (section 7.2). Afterwards, it analyses each of the research questions findings to contrast and compare with current theories in order to present the implications for theory and practice (section 7.3, 7.4, and 7.5 respectively). Section 7.6 details the conclusions of the section.

Chapter 8 presents the conclusions of the research questions and research problem (section 8.2). These are followed by a presentation of the contributions for theory and practice (section 8.3) and the limitations of this research (section 8.4). Finally, it provides opportunities for further research (section 8.5). Figure 8.1 shows a summary of this chapter.

1.8 Conclusion

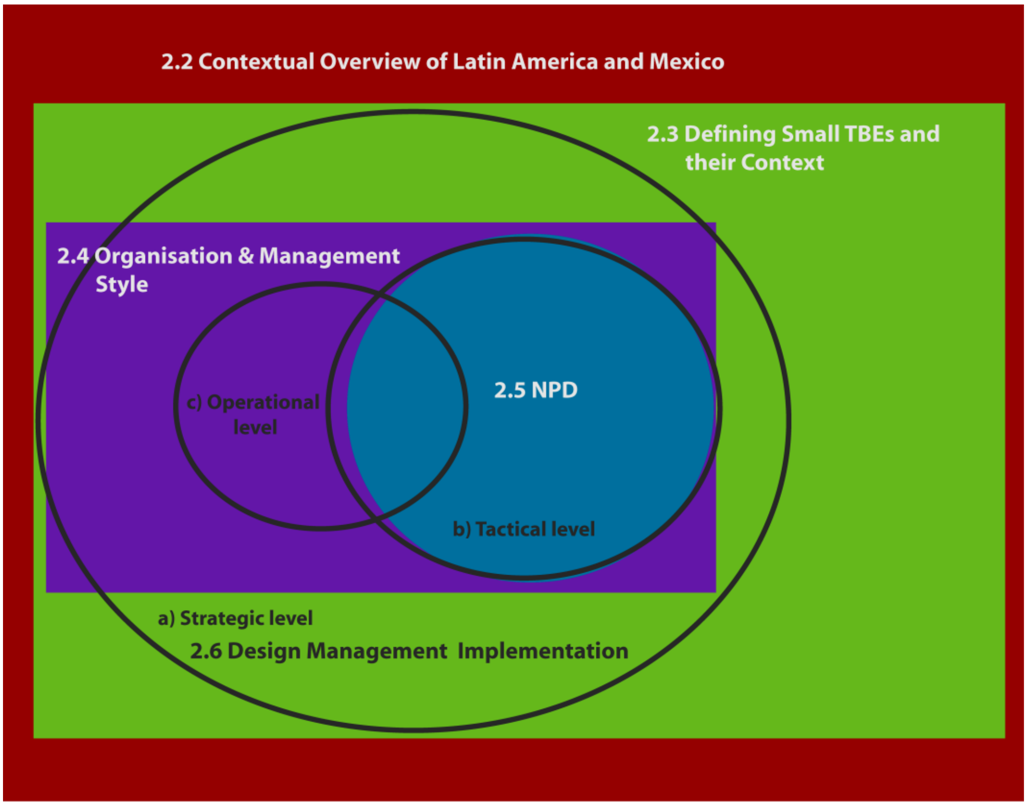
This chapter had provided a detailed and comprehensive summary of the actions considered and undertaken in the development of this research. Thus, it presented the background to the research and introduced the research problem and research questions together with outlining the contributions this research has made. Subsequently, it justified the research and its design strategy to later define the key terms and delimitations of scope to finally outline the chapters that comprehend the thesis. Once introduced the research, it is possible to present the theoretical framework that provide the background information needed to understand the research project and to establish the relevance of this research.

CHAPTER 2.0 LITERATURE REVIEW

2.1 Introduction

The focus of this chapter is to review existent literature in order to have a clear understanding of studies encompassed to this research. To establish a comprehensive theoretical framework, it is proposed to layer the different topics, moving from general to specific themes. The introductory theme provides a contextual overview of Latin America and Mexico (section 2.2) to later define small technology-based enterprises under the context of study (section 2.3). Then, it is possible to explore organisation and management style of this type of businesses (section 2.4), and the different actions that comprehend the NPD process (section 2.5). Subsequently, a complete analysis about design management and its use within the business context is explored (section 2.6). Finally, the chapter concludes by summarising the key findings from this chapter (section 2.7). Figure 2.1 summarises the relationship between the different themes that comprise the theoretical framework.

Figure 2.1 Relationships between the topics covered in the literature review

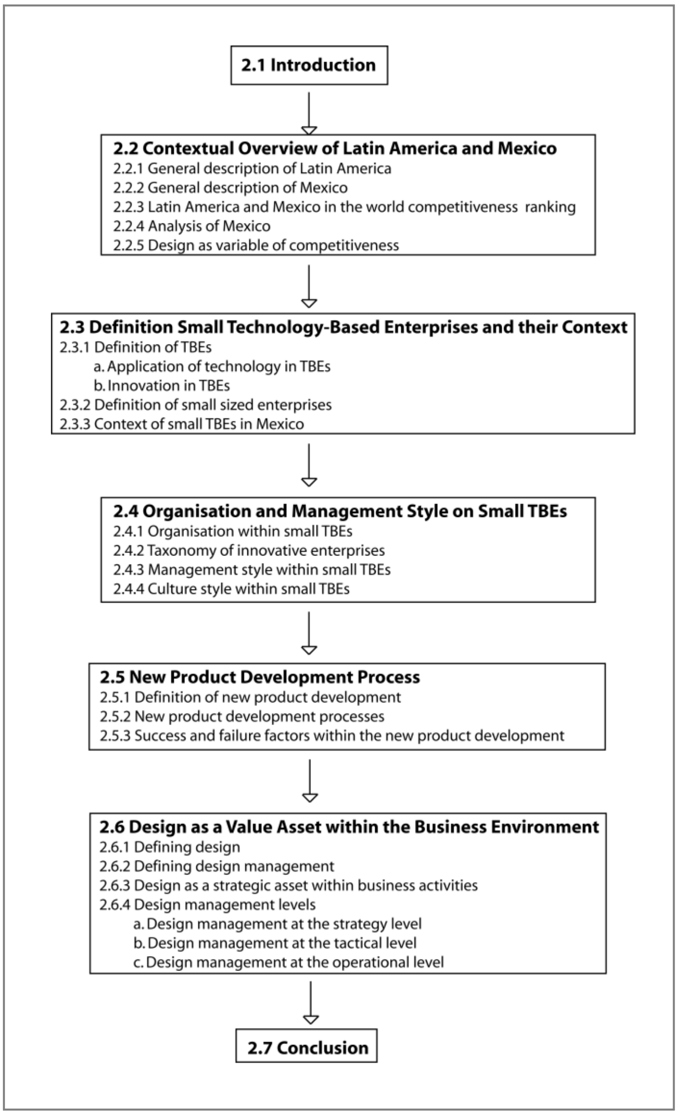


Based on the background discussion in section 1.1, the research problem for this research is: *does design management improve performance of small Mexican technology-based enterprises in new technological industries when implemented within their activities?*. This study addressed this research problem by proposing that when Mexican small TBEs in new technological industries are undertaking activities to launch an innovative product, service or process it is required to comprise two core components: 1) elements that are external to the business activities (Corona, 1997; Courseault-Trumbach, et al., 2006; Olalde, 2001; Mintzberg, 1983; Porter, 1983; Soderquist, et al., 1997; Weick and Quinn, 1999); and 2) activities that are internal to the business (Cosh and Hughes, 2003; Porter, 1983; Rousseau, 1997; Yap and Soudner, 1994). Through the understanding of both components, it is possible to explore the interplay between design management and small Mexican TBEs. This is due to design management concerns with the implementation of design activities within a business leading to adopt a design core competence. This allows organizations to have a sustainable growth through the most suitable application and coordination of long-term and day-to-day activities with the aim to achieve the firm's strategic objectives. This will provide a set of options in which design management can be used, implemented and integrated effectively within the business in order to obtain certain type of outcomes. Then, it is possible to examine the existence of causal relationships between design management and the improvements on the performance of small Mexican TBEs in new technological industries.

First, a review of literature regarding the definition of Latin American region and Mexican context is presented (section 2.2). Starting with a general description of Latin America (section 2.2.1) and then, Mexico (section 2.2.2) allowed the researcher to provide the necessary background to understand its competitiveness ranking (section 2.2.3). Indeed, it helped to comprehend further competitiveness position of Mexico (section 2.2.4), its policies, programmes and plans, especially concerning design (section 2.2.5) as a key driver to leverage its competitiveness. Subsequently, it was examined the different determinants and parameters used by academics and governmental organisations to define small technology-based enterprises (section 2.3.1). Next, two key themes are explored, as they are an intrinsic part of TBEs: application of technology (section a) and innovation (section b). Likewise, it defines small-sized enterprises (section 2.3.2) and the context of small TBEs in Mexico (section 2.3.3) in order to define the parameter of the study.

After setting the description of the object of study, it reviews literature regarding the organisation and management style of small TBEs (section 2.4). Hence, it explores the type of organisation within small TBEs (section 2.4.1) and later explains their taxonomy (section 2.4.2), management style (section 2.4.3) and their culture style (section 2.4.4). Then, it examines the NPD process (section 2.5), through its definition (section 2.5.1), different types of process (section 2.5.2), and success and failures factors (section 2.5.3). The last section sets out design as a value asset within the business environment (section 2.6). Consequently, it was necessary to define two terms, design (section 2.6.1) and design management (section 2.6.2), as both definitions establish views that consider design as a strategic asset within the business context (section 2.6.3). It concludes by examining the levels of design management within the business context (section 2.6.4): strategic level (section a), tactical level (section b), and operational level (section c). Figure 2.2 summarises the structure of this chapter.

Figure 2.2 Outline of the literature review



2.2 Contextual overview of Latin America and Mexico

During the last decade, numerous nations have been subjected to some of the effects of economic depressions, broken international relationships, natural disasters, and health and security issues. However, there are geopolitical regions that have been more affected than others such as the Latin American region. Consequently, the aim of this section is to describe Latin America to understand further the contextual condition of Mexico and its relationship with this region.

2.2.1 General description of Latina America

A considerable amount of literature has been published on relation to Latin American studies. Researchers (Black, 1998; Hilman, 2001; Kirby, 2003; Larrain; 2000; Oxford Analytica, 1991; Skidmore and Smith, 2001) have agreed that it is a complex task to define Latin America, as it comprehends a myriad of factors that affect its approach and understanding. The analysis tends to covers historical and cultural data to thoroughly study its different stages of development and current situation through the perspectives of different multidisciplinary areas of study. Then, it is going to be possible to reduce the bias and incomprehension about the great diversity, unique amalgamation and global importance of the region (Hilman, 2001); as it is common that stereotypes and myths offer a distorted partial truth.

There are different viewpoints on the definition of Latin America, the most common references are: region, culture, identity or geopolitical. For the purpose of this study, the definition of Latin America covers common historical, social, political and development patterns. Latin American region, geographically speaking, comprehend the landmass extending from Rio Bravo border between Mexico and United States to the southern tip of South America, plus some Caribbean Islands. The vast majority of the population speak Spanish; although, many other languages are official such as Portuguese (Brazil), French, English and Dutch (the Caribbean), and extensive number of Indian languages (Chile, Mexico, Peru, Guatemala among others). By 2001, its total population rose to more than 500 million people representing approximately 10% of the world’s population (Hilman, 2001).

Historically, the region had encountered different situations that radically transformed the customs and lives of its inhabitants. These events can be summarised with the conquest of European nations in Latin American territories, the struggle of Latin American people to obtain independence and the search for political and economic stability as independent nations. Economically, Latin America belongs to the so-called 'developing world', as historically governments have adopted policies that enable dependency in the national industry or industrialisation (Skidmore and Smith, 2001). Politically, the region has experienced different types of political systems such as agrarian feudalism, populist regimes, oligarchies, military dictatorship, electoral democracies and social regimes since its formation.

In order to understand further the context of Latin America, it is important to disclose the six stages of transition that its culture, politics and economics encountered. The first stage, colonial foundation (1492-1880s), had its origin when European nations discovered America as part of their remarkable expansions. This conquest had dramatic changes for the American civilizations due to the population was drastically reduce, the traditional social order was weakened and distorted; the religious beliefs completely transformed; and the lands were totally seized (Hilman, 2001; Skidmore and Smith, 2001). During the period 1800 to 1900s, it took place the next transformative phase, oligarchic modernity, which was represented for the social movements headed by Latin Americans to obtain independence from Spanish and Portuguese rule. Those nations that attained their independence had to undergo a deep conversion in their politics, culture and economy, as unfortunately the social order remained untouched (Larrain, 2000). Thus, governments faced many encounters such as revolts, regional conflicts and public debts to establish national and economic structure. This provoked that some governments imposed dictatorial regimes, military officers, to assert law order, stability and social control. Nevertheless, the oligarchic power did not last long, 50 years, as it was substituted with populist regimes that encourage the process of import-substituting. This transition represented a turning point in the social structure of the nations, as it registered two fundamental changes. The appearance and growth of middle social strata and major changes in the working class, and the transformation of the urban sector of society as an effect of the import of labour and migration from the countryside (Black, 1998; Larrain, 2000; Skidmore and Smith, 2001).

The third stage was prompted by World War II and the Great Depression, as Latin American countries were dependent on advanced nations due to their lacked of stable socio-political environments and efficient economic structures. This stage represented the transition to industrial expansion, 1951 to 1970, in which it was stressed the process of modernisation and the economic basis of Latin America. In order to overcome the global economic crisis, governments adopted two strategies: to forge even closer commercial linkages to the industrialised nations and to embark on industrialisation (Skidmore and Smith, 2001). Both manoeuvres were considered essential to become less dependent of Europe and United States and less vulnerable to their economic shocks. Nevertheless, the process of industrialization and development lost its dynamism and social and labour agitations became widespread in the Latin America region. The failure in the adoption of industrialisation stimulated the next stage, dictatorship and stagnation 1961 to 1990, in which the exhaustion of political experiments precipitated a wave of military dictatorship. The major causes that halted the introduction of industrialisation were: the pseudo industrialisation of economic policies, the lack of a domestic demand and the scarce technological involvement in the national industry. The last stage, neoliberal modernization, has been adopted since 1990 to onwards in most of Latin American countries. This stage is represented by the eradication of dictatorship and the acceleration of the economic and political modernisation. New economical concepts such as 'free market' and 'open economy' policies were adopted in Latin America. Although, it is important to recognise that these nations are still facing challenges to embrace the new economical paradigm, as they have economical, political and social structures that inhibit full integration.

2.2.2 General description of Mexico

Mexico is geographically located in North America, as it shares boundaries in the north with United States of America, and in the south with Belize and Guatemala (INEGI, 2010). Its coastlines apportion limits in the east with the Caribbean Sea and Gulf of Mexico and in the west with the (North) Pacific Ocean. Its official language is Spanish, although 63 other such as Mayan, Nahuatl, and Mixtec, among others has been recognised and protected. Mexico has a population of over 11 million inhabitants and its median age is 26 years (CIA-The World Factbook, 2010). This nation is constituted by 31 states and a Federal District that are regulated through a Federal Republic government. Its legal system has borrowed a mix from

United State constitutional theory and civil law system. It has an executive branch that is directed for a president; a legislative branch formed by a bicameral National congress constituted for the senate and deputies; and a judicial branch composed by the supreme court of justice appointed for the president with consent of the senate. Table 2.1 shows an overall list of basic facts about Mexico.

Table 2.1 Basic facts of Mexico

Basic Facts	Data
Full name	United Mexican States (Mexico)
Capital	Mexico City
States	31 states and a Federal District
Land area	1,943,945 sq Km
Exchange rate ($)	13.64 (2009)
Population (millions)	111,211,786 (July 2009)
Official language	Spanish and other 63 languages
National currency	Mexican pesos (MXN)
Natural resources	Petroleum, silver, cooper, gold, lead, zinc, natural gas, and timber
Free trade agreements	12 agreement with over 40 nations

Source: CIA-The World Factbook (2010); and INEGI (2010)

The territory where Mexico is now established was occupied during the 15th century by Amerindian civilisations such as Aztecs, Mayans, and Olmecs. However, Spaniards arrived to the area and conquered it, leading to three centuries of exploitation (Hilman, 2001). Mexican inhabitants achieved its independency after dozen insurrections against Spain between 1808 and 1821. After obtaining independency, many problems arose as governments adopted a geriatric dictatorship that could not satisfy the needs of the population provoking a Revolution in the first decade of the 20th century (Ross, 2002). Then, the nation embraced an import-substituting industrialisation along with a western-style democracy and free-market capitalist that have prevailed until now (Skidmore and Smith, 2001). Its economy is based on a mixture of modern and outmoded industry and agriculture, increasingly dominated by the private sector (CIA-The World Factbook, 2010). It is considered a rich country in natural resources, as it has petroleum, silver, copper, gold, lead, zinc, natural gas and timber.

According to the World Economic Forum (2009), Mexico has been positioned as ‘efficiently driven economy’ because it has achieved the trillion-dollar class. This was possible due to the economic policies undertaken, but also for the 12 free trade agreements with over 40 nations. Its most important agreement is the North American Free Trade (NAFTA) signed in 1994. Nevertheless, it increased its dependency on United States and provoked stagnation on its development because it has not the infrastructure to obtain tangible benefits from this agreement, as the country is still facing basic economic problems. Hence, it needs to upgrade its infrastructure, modernize labour laws, reduce poverty and generate employment.

2.2.3 Latin America and Mexico in the world competitiveness ranking

Competitiveness is a concept that is extensive and multidimensional. Several attempts have been made to define competitiveness, as there is a controversy about the drivers to measure it at the micro level (firms and industries) and macro level (countries) (European Commission, 2009; Hamel and Prahalad, 1994; IMD, 2010; Porter, 1990; WEF, 2010). Therefore, it is important to define which level is going to be adopted in this research. Consequently, this section aims to define competitiveness at the macro level in order to understand the pattern of economic development of Mexico.

A large number of studies have been published on competitiveness at the macro level (European Commission; 2010; IMD, 2010; Porter, 1990; WEF, 2010), as each study has used different methodologies and conceptual outcomes to measure competitiveness. This has led to raise many questions about how to assess competitiveness properly; how to discriminate indexes that do not reflect competitiveness as an outcome; whether the micro level concept can be extended to the national level; and whether it is compatible or complementary to it. Thus, international organisations, institutes and academics have defined a set of measures to assess the competitiveness and growth of nations. The most advanced organisations in the study of competitiveness are the International Institute of Management Development (IMD) and the World Economic Forum (WEF), as they have been able to produce an instrument with standard units and theoretical underpinning. Their approaches to measure competitiveness are different, but their outcomes rather than oppose complement each other to produce a comprehensive view of the competitiveness of a nation.

On one side, the World Economic Forum (2008:3) refers to competitiveness '*as the set of institutions, policies, and factors that determine the level of productivity of a country*'. This definition has been adopted since 2005, as it is considered, so far, the most complete and comprehensive definition to determine competitiveness. This is due to the previous definition considered two assessments, one focused on global competitiveness as '*the set of institutions and economic policies supportive of high rates of economic growth in the medium term'* (Porter, et al., 2002:16). The other approach to competitiveness used microeconomic indicators to measure the '*set of institutions, market structures, and economic policies supportive of high current levels of prosperity'* (Porter, et al., 2002:16). The Growth Competitive Index used by Sachs considers three indexes: public institution, macroeconomic environment and technology index (Table 2.2). Whereas, the Institute of Management Development (IMD, 2009:1) defines competitiveness as '*how nations and business are managing the totally of their competencies to achieve a greater prosperity*'. It emphasises that competitiveness is not just about growth or economic performance but should take in consideration the 'soft factors' of competitiveness, such as environment, quality of life, technology, knowledge, etc. Hence, its approach comprehends four determinants to measure competitiveness, economic performance, government efficiency, business efficiency and infrastructure (Table 2.2).

Table 2.2 Determinants of competitiveness

IMD	WEF
Economic performance	Public institution performance
Government efficiency	Macroeconomic environment
Business efficiency	Technology
Infrastructure	

Source: IMD (2004), and WEF (2004)

The 21st century has been represented by a continual transformation in the way businesses and nations face challenges, as they have to be able to: respond to globalisation; keep pace to the rapid technological change; maintain an instant information flow; reduce the economic distance between nations; and open liberalisation of economies. This provoked that international organisations committed to measure competitiveness increased the number of variables that might affect the assessment. On one side, WEF employed its Global Competitiveness Index (GCI), with 12 competitiveness pillars to determine the wealth of nations. On the other side, IMD used over 300 competitive variables distributed in four competitiveness factors that were subsequently subdivided in to five sub-factors within each variable (Table 2.3).

Table 2.3 Sub-factors to measure competitiveness

<table>
<tr><th colspan="2">IMD</th><th>WEF</th></tr>
<tr><td>Economic performance</td><td>Domestic economy
International trade
International investment
Employment
Prices</td><td rowspan="4">Institutions
Infrastructure
Macroeconomic stability
Health and primary education
Higher education and training
Goods market efficiency
Labour market efficiency
Financial market sophistication
Technological readiness
Market size
Business sophistication
Innovation</td></tr>
<tr><td>Government efficiency</td><td>Public finance
Fiscal policy
Institutional framework
Business legislation
Societal framework</td></tr>
<tr><td>Business efficiency</td><td>Productivity
Labour market
Finance
Management practices
Attitude and values</td></tr>
<tr><td>Infrastructure</td><td>Basic infrastructure
Technological infrastructure
Health and environment
Education</td></tr>
</table>

Source: IMD, World Competitiveness Yearbook (2009) and WEF, Global Competitiveness Report (2009)

Once mentioned the factors that are considered in the assessment of national competitiveness, it is possible to introduce the condition of some Latin American countries. As previously discussed in section 2.2.1 that Latin American nations had suffered turbulent economic and politic scenarios. Nevertheless, the majority of nations have been reflecting a good integration of macroeconomic fundamentals to endure the current global economic crisis and lower commodity prices (WEF, 2010). According to the Global Competitiveness Index (WEF, 2010), Chile (30th place) appears among the top performers. It is closely followed by two small Caribbean economies, Puerto Rico (42nd) and Barbados (44th). Subsequently, a large group of Latin American economies that have lingered behind the best performers, these are Costa Rica (55th), Brazil (56th), Panama (59th), Mexico (60th) and Uruguay (65th). These results show that Chile is located in the transition stage between efficiency-driven and innovation-driven economy, whereas the rest of Latin American nations are positioned in the efficiency-driven stage (Table 2.4). The World Competitiveness Scoreboard (IMD, 2009) ranked Chile among the top 25 performers, contrary to Brazil (40th), Mexico (46th), Colombia (51st), Argentina (55th) and Venezuela (57th). Both results enhance the improvements of Latin

American countries in the use of their competencies, as they have been decisive to face a free-fall economy and its adversities, and to show resilience to weather the crisis (IMD, 2009).

2.4 Stages of development

Pillars of Competitiveness	Stages of Development	GDP per Capita ($)
Basic requirements Institutions Infrastructure Macroeconomic stability Health and primary education	Key for FACTOR-DRIVEN economies	**Stage 1** $ 0< 2,000 **Transition** $ 2,000-3,000
Efficiency enhancers Higher education and training Good market efficiency Labour market efficiency Financial market sophistication Technological readiness Market size	Key for EFFICIENCY-DRIVEN economies	**Stage 2** $ 3,000-9,000 **Transition** $ 9,000-17,000
Innovation and sophistication factors Business sophistication Innovation	Key for INNOVATION-DRIVEN economies	**Stage 3** > $ 17,000

Source: Modified from the Global Competitiveness Report (WEF, 2009)

Mexico has been ranked on the 60th place by the WEF and 46th by IMD in 2009. In 2000, it was positioned by WEF (2000) in 33rd rank, this means that it had suffered a decline of 27 places. In the assessment of the IMD in 2000, Mexico was set on the 33rd rank, this represents that it has fallen 13 positions. Both evaluations show that Mexico has been performing poorly, demonstrating a passive condition in the development of policies and encouragement of its business environment. This situation enhances three important issues: firstly, new economies have been able to formalise their economics, politics and social developments in order to provide their inhabitants with basic infrastructure to increase their social welfare. Secondly, new industrialised countries (NIC) have been improving their performance leading them to transit to another stage of competition. Thirdly, Mexico has executed inefficient policies and produced poor strategic programme provoking with it a limited growth. Thus, more than ever it needs to invest on those areas that are strategic to compete with other economies. As well as, it requires to produce programmes and policies that ensure the nation achieve the variables that influence the competitiveness and the growth of Mexico in the short, medium and long-term.

2.2.4 Analysis of Mexico

Macroeconomics concerns the study of the economic behaviour of a nation as a whole. Its nature is complicated because it copes with those factors that influence the performance of a country. Its analysis focuses broadly on three variables; national output (Gross Domestic Product-GDP); inflation and unemployment. The WEF (2010) argue that Mexico has been introducing sound macroeconomic fundamentals through more responsible fiscal policies; as well as, has been opening, liberalising and diversifying its economy. These actions have enabled the country to address the recession more effectively; although, the performance of the country has been affected by the crisis, the inefficiency of public institutions and high insecurity. In 2009, Mexico has a GDP per capita of $13,200 with a slashed inflation of 5.3% and an unemployment rate of 6.2%. Its primary source of income came from the service sector with 69.9%, followed for the industry sector with 26.3% and then, lingered behind the agriculture industry with 3.9% (Table 2.5).

Table 2.5 Macroeconomic determinants

Determinant	Figure
Gross Domestic Product	$13,200
Inflation	5.3%
Unemployment rate	6.2%
Composition of sectors: Agriculture Industry Service	 4.1% 34.5% 61.3%

Source: INEGI (2009)

Mexico has been able to use its strategic network of preferential trade agreements to invite foreign investor to bring their businesses and investments to the national market. This encouragement of foreign investment into the national has aimed to boost the economy through the creation of employment. This is due to its industry sector relies mainly on the processes, or transformation, or manufacture of food, beverages, tobacco; chemicals, iron and steel; petroleum; mining; textiles, clothing; motor vehicles; consumer durables; and tourism. Meanwhile, its industry sector is based in corn, wheat, soybeans, rice, beans, cotton, coffee, fruit, tomatoes, beef, poultry, dairy products and wood products. This means that most of the businesses compete on prices, and sell basic products and commodities. Therefore, it is understandable that its export commodities represented $223.6 billions of the national GDP, against the imports commodities that constituted $234.6 billions in 2009.

Table 2.6 Exportations and importations of commodities

<table>
<tr><th></th><th>Countries</th><th>Percentage</th><th>Product Commodities</th></tr>
<tr><td rowspan="3">Exports</td><td>United States of America</td><td>80.2%</td><td rowspan="3">Oil and oil products
Silver
Fruits, vegetable, and coffee
Cotton</td></tr>
<tr><td>Canada</td><td>2.4%</td></tr>
<tr><td>Spain</td><td>1.7%</td></tr>
<tr><td rowspan="5">Imports</td><td>United States of America</td><td>49%</td><td rowspan="5">Metalworking machines
Steel mill products, and agricultural machinery
Electrical equipment
Car parts for assembly, and repair parts for motor vehicles
Aircrafts, and aircrafts parts</td></tr>
<tr><td>China</td><td>11.2%</td></tr>
<tr><td>Japan</td><td>5.3%</td></tr>
<tr><td>South Korea</td><td>4.4%</td></tr>
<tr><td>Germany</td><td>4.1%</td></tr>
</table>

Source: CIA-The World Factbook (2009)

Table 2.6 illustrates the undoubted fact that Mexico depends on the United States macroeconomic performance, as it is the major partner in exporting and importing commodities. This implies that the economy remains vulnerable to external down turns, given its close association with United States' business cycle and its heavy dependence on oil revenues. Thus, Mexico has taken measures to address economic challenges through investing on the development of clusters, the improvement on quality of local suppliers and the establishment of a comprehensive value chain. However, it has to improve the rigid labour market characterised by strict labour regulations, high payroll taxes, high social contribution, and inefficient markets.

The Mexican government needs to invest in higher education and training systems, as it is currently inefficient in the number of skilled workforce, particularly high-specialised workforce, to source the economy. It has invested less than 1% (.36%) of its GDP on programmes to boost the number of high-qualified scientists and technologists. Despite, its relative high expenditure (compared with previous years) in high, secondary and tertiary education, enrolment rates remains low. In 2007, National Council of Science and Technology (CONACYT) presented the results of its research in which demonstrated an increment on the number of scientist and engineers with specialisation, as there were 17, 792 more specialised people than in 2001 (Table 2.7). According to Organisation for Economic Cooperation and Development (OECD, 2008), the educational system of Mexico is poor marked for its quality and its low level in maths and science. Consequently, Mexico cannot create an environment that conduces to adopting new technologies and generating new ones.

Table 2.7 Number of students with higher degree level in Mexico

Academic Level	Number of Student	
	2001	2007
Specialisation level	10,314	12,890
Master degree	23,632	37,832
Doctoral degree	1,085	2,101
Total	**35,031**	**52,823**

Source: CONACYT (2007)

Therefore, the Mexican government has to consider the application of strict competition policies combined with improvements in the basic infrastructure of the country and education curricula. Likewise, it has to consider adopting a more transparent policy making, reducing the level of corruption in public organisations and above all, controlling the insecure environment that affect inhabitants and causes the fleeing of foreign direct investment.

2.2.5 Design as a variable of competitiveness

Businesses are facing new conditions and challenges that lead them to take decision far beyond the protocols established to improve the global quality of their products and services. Consequently, firms require that governments encourage national economic environments that provide them with all the resources to develop cutting-edge processes, products and services to maintain a competitive edge. Therefore, governments have to implement programmes and policies that help national enterprises to leverage their performance in comparison with foreign firms. During more than 66 years, governments have been promoting design to improve the competitiveness and well-being of their nations. Countries such as United Kingdom, Sweden, Germany, United States, Japan, India, Finland, Korea, Portugal, China and Brazil among others have invested on creating design policies, plans and programmes. These cases have provided evidence that show the benefits of design on the social and economic development (Raulik-Murphy, 2008). In opinion of WEF (2002), there is an intrinsic relationship between design and the performance of the business environment of a nation (Fig. 2.3).

Figure 2.3 Global competitiveness report: design context

Country	Current competitive-ness index ranking	Extent of Branding	Capacity for Innovat-ion	Unique-ness of Product Designs	Production Process Sophisticat-ion	Extent of Marketing	Design average	Design ranking
Finland	1	6.3	6.4	6.3	6.7	5.9	6.3	1
United States	2	6.2	5.9	5.9	6.4	6.7	6.2	2
Netherlands	3	5.9	5.5	5.6	6.4	6.6	6.0	7
Germany	4	6.3	5.7	6.0	6.5	6.2	6.1	3
Switzerland	5	6.4	5.7	5.7	6.3	6.0	6.0	6
Sweden	6	6.0	5.8	6.0	6.1	6.1	6.0	8
United Kingdom	7	6.2	5.1	5.3	5.8	6.4	5.8	10
Denmark	8	5.9	5.5	6.0	5.9	5.8	5.8	9
Australia	9	4.0	4.4	4.4	5.3	6.0	4.8	21
Singapore	10	4.5	4.2	4.0	6.0	5.3	4.8	22
Canada	11	4.7	4.7	4.9	5.8	6.0	5.2	15
France	12	6.1	5.9	5.9	6.3	6.5	6.1	4
Austria	13	5.4	5.1	5.4	6.1	5.8	5.6	12
Belgium	14	4.8	4.8	5.1	5.8	5.5	5.2	16
Japan	15	6.4	5.9	5.9	6.3	5.8	6.1	5
Iceland	16	5.4	4.7	4.8	6.2	5.6	5.3	14
Israel	17	5.1	5.7	5.3	5.7	5.4	5.4	13
Hong Kong SAR	18	4.2	3.7	4.0	5.4	6.0	4.7	24
Norway	19	4.9	4.7	5.2	5.6	5.3	5.1	18
New Zealand	20	5.1	4.7	4.8	5.3	5.6	5.1	20

Notes: (1) The indexes have potential minimum values of 1, and potential maximum values of 7.

Source: World Economic Forum (2002)

Source: World Economic Forum (2002)

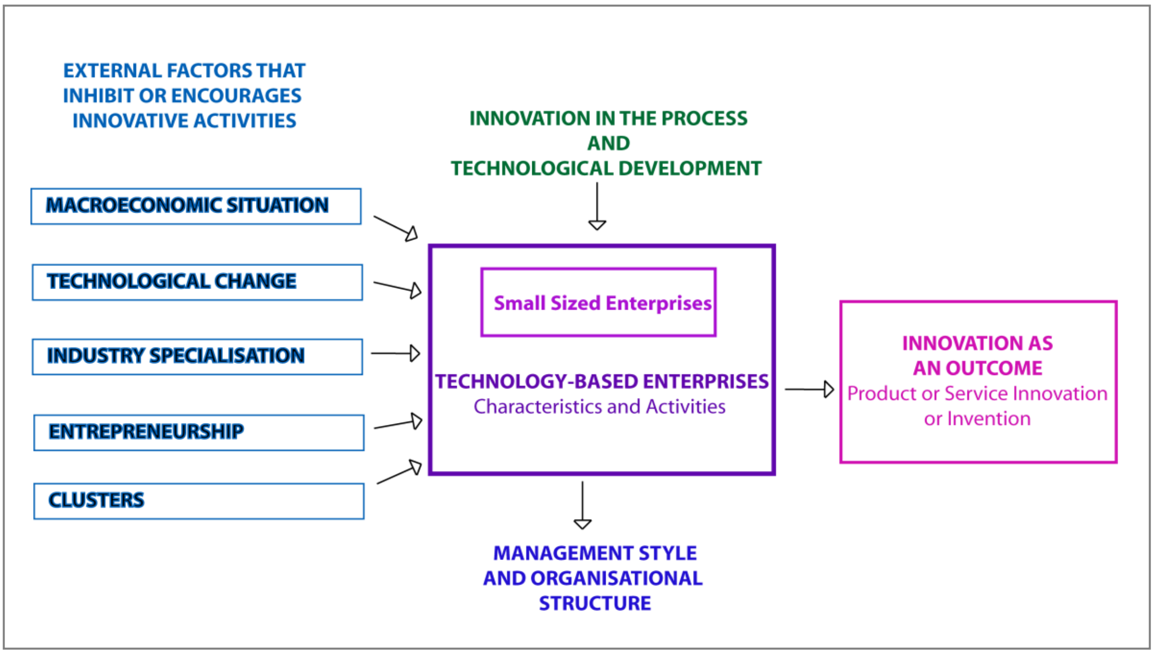
Figure 2.3 illustrates that countries that invest in design tend to be positioned in the top places of the competitive index ranking. Thus, it can be argued that design is one of the variables that can help to improve the growth, performance and competitiveness of nations. Consequently, it has became common that nations promote, support and create policies, plans or programmes to encourage the effective use of design within their nations. It has been demonstrated that the use of design programmes, plans or policies lead nations to encourage economic development, to support businesses, to reduce market failure, to improve the number of exports, to create a national identity and to improve the well-being of inhabitants (Danish Design Centre, 2003; Design Council, 2005, 2002). Hence, Latin American nations have been supporting in the last two decades design as an asset within their economies, such as Argentina, Brazil, Chile, Cuba and Mexico.

Unfortunately, design in Mexico is still at an early stage, as it is an area exported from European schools. This provoked confusion on its implementation within the national context, as the reality and effects are different. However, interesting actions have been implemented during the last two decades. For example, in 1994 Governments created the Mexican Design Promotion Centre, which aimed to promote the use of design as a core competence in local small and medium sized enterprises. Another important case is the movement formed by Mexican designers to create a Mexican Design Policy. It still in its preliminary stages, as it is necessary to create awareness in the design community, industry and governments and to set actions to face national relevant issues.

2.3 Definition of small technology-based enterprises and their context

This section discusses the core subject of this research, that is, defining the small technology-based enterprises (TBEs). It aims to provide the technical characteristics that define these types of businesses, as well as to those activities that are intrinsic in their operation and development (Fig. 2.4). Then, it contextualises the description developed within the context of study, Mexico. In the opinion of Oakey, et al., (1988), there is little disagreement on the critical important growth role that small TBEs play in ensuring the future prosperity of natural industrial nations. Much national effort at promoting high-technology industrial expansion in many countries has been, almost by default, focused on high-technology small firms' formation and growth. Therefore, it is of particular importance to explore this type of businesses, as they represent a vital factor for any country in its economic development and performance, and social stability (BIS, 2010; ILO, 2010; European Commission, 2010; METI, 2010, WTO, 2010; OECD, 2004; Zevallos, 2003). According to Zevallos (2003), small and medium sized enterprises (SMEs) contribute to the industrial development and market penetration of a country based on the rate of innovation that they introduce into the market. Likewise, they encourage the creation of jobs, the massive distribution of products and services, and the distribution of services to large enterprises. If these benefits are taken in conjunction with the one offered by TBEs, it can lead to: leverage the boundaries of technology as they boost regional economy; improve relations among institutions to produce research and development; and promote technological transference to improve competitiveness and social welfare (Contreras, 2008; Fernández-Dobaldo; 2008; Merino and Villar, 2007).

Figure 2.4 Relevant themes on understanding small technology-based enterprises



2.3.1 Definition of technology-based enterprises

Technology-based enterprises are considered as agencies that deal with the development and exploitation of technological innovations within the market and their developments involve high uncertainty (Storey and Tether, 1998). These organisations require experts in high-specialised fields in order to translate knowledge into an invention and innovation by using advance technological applications. This implies that the technological and scientific knowledge is a critical asset and valuable resource that need to be adequately governed. Therefore, to produce a comprehensive definition of TBEs, it is important to deal with their management characteristics and their technological activities.

During the last 30 years, much more information has become available about the administrative definition of TBEs (Camacho, 1998; Fariñas and Lopez, 2007; Little, 1977; Perez and Marquez., 2006; Olalde, 2001; Shearman and Burell, 1989; Storey and Tether, 1998). One of the first definitions was developed by Little (1977) who found that TBEs based their development around substantial technological risk; tended to be autonomous with not more than 25 years on operation; and relied on the exploitation of inventions or technological innovations. Shearman and Burell (1989) stated that TBEs were mainly new and independent businesses whose activities are related to the development of new industries. Subsequently, research on this area started to explore empirical investigations within TBEs in order to refine previous definitions. In a large exploratory study, Storey and Tether (1998) investigated TBEs from 16 different countries to uncover those characteristics that define them. They observed that these firms were enterprises of self-governing property, operating in high technology sectors. However, Fariñas and Lopez (2007) argued that Storey and Tether's research has to be considered carefully, as it excludes information that can infer that the nature of TBEs becomes restricted or boundless. Thus, they undertook a study in Spain exploring the specific attributes of TBEs. The results contributed to produce three definitions using five variables that can be interchangeable between them (Table 2.8). They appraised that two characteristics are basic, employment of 200 or less workers and work on high-medium technology sectors.

Table 2.8 Administrative characteristics of TBEs

Authors	Determinants
Little (1977)	- Autonomous firms of not more than 25 years old; - Exploitation of inventions or technological innovations; - Development implies a substantial technological risk
Shearman & Burell (1989)	- New & independent businesses; - Activities concern on the development of new industries
Storey & Tether (1998)	- Small enterprises of self governing property; - Recent creation; - Operate in high technology sectors
Fariñas & Lopez (2007)	- Employ between 200 or less workers; - Work on high or medium technology sectors; - Investment on in-house research & development teams; - Base productivity & commercial actions on technological innovation exploitation; - Use 25% or superior percentage of sales volume to produce innovation
Camacho (1998)	- Small sized organisations; - Strong influence on research & development activities; - Developers of goods/services with high add value; - High degree of risk for being on emergent markets; - The most important asset is knowledge; - Engaged with a high innovation character; - Transform scientific/technological knowledge in products/services; - Exploitation of intellectual right properties; - Close collaboration among qualified personnel
Perez & Marquez (2006)	- Operate process, products & services where technology is new; - Generate their own technology; - Offer products with high value due to their technological content

The previous definitions had been originated on developed nations, which are divergent from developing nations. Hence, it is necessary to explore studies developed on the Latin American or Mexico to understand their specific context. According to Camacho (1998), nine variables are intrinsically linked to the condition of businesses on Latin American region. He suggested that nine variables are important to understand as a whole, the management characteristics and technological activities within TBEs (Table 2.8). In 2006, Perez and Marquez contributed to the definition using three main characteristics that define TBEs in Mexico (Table 2.8). The characteristics discussed in Table 2.8 shows that internal technological activities are key in the nature of this type of businesses. Therefore, there is another line of research, which aims to study the exploration of technological activities to define TBEs.

The Office of Technology Assessment (1992) regarded TBEs as those firms that engaged with the design, development and production of new products or services using innovative manufacture and the systematic application of scientific and technological knowledge. Similarly, Bollinger, et al., (1983) asserted that these firms use completely new or innovative technology to operate their process and to manufacture their products and services. In addition, these firms are producers of their own technology, giving as a result products and services with high added value due to technological content developed. In 2007, Merino and Villar extended their previous definitions through the incorporation of both works. They defined TBEs as those organisations producers of goods and services that are based in new or innovative technologies and committed with the design, development and production of new services, products and/or processes of innovative manufacture through the systematic application of technical and scientific knowledge. Furthermore, they considered that TBEs were like business projects, as their principal characteristic is research and development.

There were two prominent studies conducted on developing nations. The first systematic study of TBEs in Mexico was presented by Corona in 1997. He identified TBEs as *'businesses that engage on the design, development and production of new products and services. To achieve this stage, they need to base their competitiveness in the domain of a determinate technology or group of technologies to maintain high rates of innovation. Hence, they are characterised for their proximity to science through the systematic application of scientific and technical knowledge on the new product development (NPD) lead by researchers and scientist'* (Corona, 1997:14). Furthermore, these enterprises have organisational structures that favour technological innovation. Olalde (2001) developed a more detailed set of core characteristics that define these firms such as generation of new products or services using innovation and incremental efficiency of processes and products on outmoded processes allowing for enterprises positioning in new market niches (Table 2.9).

Table 2.9 Technological activities of TBEs

Authors	Determinants
Office of Technology Assessment (1992)	- Design, develop, and produce new products or services using innovative manufacture - Systematic application of scientific and technological knowledge
Bollinger, et al. (1983)	- Operate process, products, services where technology is new or innovative - Generate their own technology - Offer products with high value due to their technological content
Merino and Villar (2007)	- Produce goods/services based in new or innovative technology; - Committed with the design, development and production of new services, products and/or processes of innovative manufacture; - Systematic application of technical and scientific knowledge; - Its principal characteristic is research and development
Corona (1997)	- Engage on design, develop, and produce new products/services; - Base their competitiveness in a determinate technology; - Maintain high rates of innovation; - Application of scientific and technical knowledge on the NPD
Olalde (2001)	- Generation of new products or services using innovation; - Increment on the efficiency of processes and products on outmoded process allowing to position in new market niche

Most of the characteristics presented to define TBEs in Table 2.9 are by nature qualitative rather than quantitative because this area remains limited in its study. Nevertheless, the identification of management and technological variables, especially generation of inventions, innovation, or technological innovation, shapes the parameter required to ascertain a precise definition. Thus, for the purpose of this research, technology-based enterprises are those *'enterprises with highly qualified personnel that produce radical or incremental new products, services or processes with high added value through the effective use of scientific and technological knowledge. Likewise, they invest resources into research and development, their organisation and managerial structure favour innovation, and they are technological experts in highly-specialised fields' (Corona, 1997:32).*

a) Application of technology in technology-based enterprises

Fariñas and Lopez (2006) discussed the necessity to analyse the application of technology at the firm level to understand the profile of TBEs in their respective sector of specialisation. The application of technology has three lines of enquiry: the intensiveness of research and development (Corona, 1997; OECD, 2007), low technology versus high technology (Tidd, et al., 2005), and technology-use (Sarason and Tegarden, 2001). These lines of research are not divergent, but intrinsic as each technological adoption provokes a determined set of reactions. According to Corona (1997), TBEs can be set in two large groups, 'new' and 'traditional' technologies, with respect to their chain of innovation[1]. The new technological industries are based on high competitive markets that lead businesses to invest large amount of resources (financial and human) in their process in order to produce products that are new to the market or new to the world (radical, innovations, or inventions). The areas clustered in this group are computer science, electronics, biotechnology, telecommunications, spatial technology, new materials and technologies for energy and ecology. Contrary, traditional technological industries concentrated in stable markets in where the investment on research and development is not critical to compete in the market. Research and development is used in low ranges within the process and thus the outcome has slight changes (incremental innovations). The areas clustered in this group are chemistry, pharmaceutical, instruments, equipment and agriculture.

Studies concerning the use of low technology versus high technology consider the industry area in which the firms are established. Enterprises that are based on new industries tend to use advance technology in their process and produce new products/services with high levels of technology. Whereas, those industries that are established on traditional areas are inclined to invest and use low levels of technology within their process as their markets require products with low degree of technology. Finally, technology-use can be considered in terms of whether the firm is technology-intensive or technology-based (Beven, 2007; Sarason and Tegarden, 2001). Technology-intensive firms use technology as a basis for producing a product/service that its nature relies on incremental improvements. Contrary, technology-

[1] **Chain of innovation** it refers to the technological relations between knowledge areas and their diffusion in the productive branch. The chain of innovation is set over a similar production cut to the input-output matrix, but differs from it as it covers areas of knowledge. Therefore, the chains include the follow levels: case of innovations, enterprises, branches and areas of new technologies. This implies that it is necessary to find the innovation cases, the branches in which they are placed, and the new areas that source their technological development, for example: electronic-information technology, bio-technology, eco-technology, and so on.

based firms use high technology as a fundamental element of product/service producing with radical technologies either for the market or the world. Hence, for the purpose of this research, it incorporates the requirement that TBEs need to be established in new technological industries.

b) Innovation in technology-based enterprises

Technology-based enterprises continuously embrace innovation to favour the utilisation of knowledge, technological skills and expertise to create new products, process and services (Tidd, et al., 2005). TBEs are agents that support the productivity of a country using knowledge to produce goods and services. Thus, it is necessary to explore innovation as a key driver within the context of these businesses. The scope of innovation is multi-dimensional, because it has been approached by diverse areas of study and under different contexts. Innovation can be explored under different perspectives; therefore, this research is going to review two of its approaches, the development process, and outcome. Innovation in the development process refers to the 'change' or 'modification' in products/services that an organisation offers and in the organisation's procedures to create and deliver those products/services. According to Tidd, et al. (2005:10), these two forms are traditionally termed as 'product' and 'process' innovation. For instance, these terms can be confusing and consequently it is necessary to explore both terms.

Tidd, et al. (2005:10) define innovation at the process level as '*the implementation or adoption of new or significantly new methods of production*'. This involves changes in the machinery, human resources, work methods, or the combination of all these elements. Damanpour (1987:12) contextualised his term of technological innovation at the process level, referred to it as '*those actions that bring change to the organisation. They occur as a result of the use of a new tool, technique, device, or system, and produce changes in products or services, or in the way products or services are produced*'. Romo and Hill (2006:6) argue that innovation is '*any kind of incorporation of new technology, process or product, through which the capacity of production of a company increases'*. Kimberly and Evanisko (1981) proposed a distinct perspective in the use of innovation at the process level, as they focused on the management of activities. They suggest that innovation is the one *'that produces changes in the organisation's structure or in its administrative process. They are only directly* *related to the basic work activity of the organisation and are more immediately related to its management'* (Kimberly and Evanisko, 1981:15). Similarly, Harvard Review (1991:14) mentioned that innovation comes from *'the embodiment, combination, or synthesis of knowledge in original, relevant, valued new products, process, or services'*. Finally, innovation from the perspective of marketing offers a more holistic view in the development process. According to Manjaro (in Zhuang, 1995:14), innovation is *'a dynamic process, which requires the input of creativity to develop new ideas or assimilate existing ones in a new way with an emphasis to make something better. This something represents a physical product, or a service, or a process that is generated or managed within the organisation's activities. The dynamics of innovation may be described as a cycle that evolves around creativity, innovation and change, which is usually not a linear process'*. Nevertheless, to produce innovation the company must possess two attributes; firstly, it has to have the necessary technological, financial and physical resources to employ them through the development process; and secondly, it needs human resources that have knowledge, skills, attitudes and abilities to produce innovative activities and outcomes. Hence, innovation at the process level refers to *'any change, technological or managerial, that affects the behaviour of employees and its outcomes in the development of new products, services and processes'*.

When innovation is examined from the perspective of product outcome, it is possible to find a diverse range of definitions from different areas. From the outlook of technology, innovation is '*the implementation or commercialization of a product with improved functional characteristics that offers a complete new or improved service'* (Tidd, et al., 2005:10). Similarly, the business perspective exemplified by Birchall, et al., (in Soderquist, et al., 1997:260) defines it as *'the creation, development, and introduction of new products, or services, or components, or a new procedure or process for doings things to benefit one or more of the stakeholders into an organisation'.* Contrary, the concept of innovation coined by Schumpeter (in Corona, 1997:11) refers to *'the moment in which a new product, process or service is introduced in an specific market; that means, that innovations impact the production and the market of goods and services. Innovation requires of previous activities such as technological changes, inventions and technological development, which are elements or factors of innovation'*. This concept led to produce definitions that comprehend a more holistic view on what concerns the introduction of innovation into the market and its effects. Zaltman, et al., (in Verhees and Meulemberg, 2004:136) argued that innovation is *'the process of developing a new item, the new item in itself, and the process of adopting the new* *item'*. This definition refers to innovation, as the process of development of a product, service or process that it is going to have an impact in the market and the way it is adopted within it.

In conclusion, '*innovation is not solely an activity that is spontaneous, because it derives from the adoption of technology acquired from other agents or from the internal development of activities of knowledge generation. It is an integral part of the organisation because the organisation employs it at different levels. Innovation is part of a constituted process that uses diverse elements to source the employees that work in an integral manner'*. Therefore, for the intentions of this research, innovation is going to consider both terms of innovation, *as a process and outcome to provide a more holistic view in the understanding of TBEs*.

2.3.2 Definition of small and medium-sized enterprises

National economic departments (BIS, METI, SE), regional economic centres (CEPAL, EU), economical organisations (IMD, OECD, WEF) and international organisations (ILO, UN, WTO) agree on the relevance of small and medium sized enterprises (SMEs) in the industrial development of nations. There is a consistent emphasis on the importance of these businesses as they constitute an important source of employment; a solution for the dynamic environment that countries are experiencing; a help to promote innovation; a tool to foster partnership; and another way to achieve and to retain a competitive advantage (Hibbert, 2000). Even though, there is consent about the impact of SMEs in the economy of a country, researchers have not been able to produce a general definition that describes them. This is due to definitions varying depending on their regional and economic context. Although, it is important to highlight that most of the definitions developed use the same quantitative (number of employees, turnover or annual balance sheet) and qualitative determinants (small market share and owner management). Ergo, this section aims to explore the different characteristics that comprise these organisations.

Quantitative determinants are commonly used to define small enterprises, as they offer a legal or authorised definition of the parameters that comprehend the universe of these businesses. According to the Bolton Report (Bolton, 1971), small sized enterprises employ from 0 to 200 employees depending on the type of industry and have a turnover between £50,000 and £200,000. The Department for Business Innovation and Skills (BIS, 2010) describes small enterprises, as those firms that employ no more than 50 employees and have a turnover lower than £5.6 m or a balance sheet under £2.8 m. The European Commission (2007) used similar parameters to BIS; however, they differed on the number of staff, turnover and total annual balance sheet. Similarly, the Ministry of Economy, Trade and Industry (METI, 2007) of Japan regard as criterion the number of staff and capital. The definition of the Organisation for Economic Co-operation and Development (OECD, 2007) diverge from the other definitions as it addresses the number of employees and financial dependency (Table 2.10).

Table 2.10 Definitions of small-sized enterprises in developed countries

Size	Bolton Report	BIS	European Commission	OECD	METI
Micro	**Number of employees** Manufacturing 200>1, Construction, and Mining 25>0, **Turnover of** Retailing, Miscellaneous, Service £50,000>, Motor trades £100,000>; Wholesale trades £200,000>; Road transport five vehicles>; Catering all including multiples & brewery managed houses	0-49 employees with a turnover lower than £5.6 m, or a balance sheet lower than £2.8 m	Less than 10 employees with a turnover lower than € 2 m or the same amount on the total annual balance sheet	Less than 19 employees, and financially independent-no more than 25% externally owned	It has to meet one of the following requisites: have a capital size between ¥ 300 to ¥ 50 m, have between 5-to-20 employees depending on the industry
Small			11-50 employees, annual turnover lower than €10 m or the same amount on the total annual balance sheet	20-99 employees, and financially independent-no more than 25% externally owned	

Source: Bolton Report (1971); BIS (2010); European Commission (2007); OECD (2007); METI (2007)

Latin American nations adopted the same quantitative characteristics considered by developed nations. The definitions considered address economic parameters, as their objective is to facilitate the trade among nations. Indeed, it is important to emphasise that the countries reviewed used similar criteria, but with different measures. The data contained in Table 2.11 mostly correspond to the manufacturing sector, and few cases to the service or commerce sector. The results show two important factors; first, Latin American nations rely on their definitions in one variable or two; secondly, they do not consider qualitative factors. This suggests that a large number of enterprises do not fit in the universe of those parameters.

Table 2.11 Definitions of small-sized enterprises in Latin America

Countries	Criteria	Micro	Small
Argentina	Sales	Up to 5 millions pesos	Up to 3 million pesos
Bolivia	Employment	Up to 10 employees	11 to 19 employees
Chile	Sales	Up to $57 600 USD	Up to $600 000 USD
Colombia	Employment	Up to 10 employees	11 to 50 employees
Costa Rica	Employment	Up to 10 employees	11 to 30 employees
Guatemala	Employment	Up to 10 employees	11 to 25 employees
Panama	Turnover	Up to $150 000 USD	Up to $1 million USD
Salvador	Employment	Up to 4 employees	5 to 49 employees
Venezuela	Employment	Up to 10 employees	11 to 50 employees

Source: Zevallos (2003)

In the case of Mexico, there are a diverse number of definitions developed by governmental organisations. The early definitions concentrated on the business economic aspect, such as number of employees, turnover, the value of money invested, energy consumption, levels of employees' specialisation, etc. Nevertheless, these interpretations were refined by the National Institute of Statics, Geography and Informatics (INEGI) to comprehend economic units like number of employees, turnover, gross production, and gross fixed capital information (Table 2.12). Then, the General Direction of the Micro, Small, and Medium sized Enterprises and Regional Industrial Development (SECOFI) elaborated an interpretation of small enterprise in which it is used just one criterion, number of employees (Table 2.12).

Table 2.12 Definitions of small-sized enterprises from INEGI and SECOFI

Size	INEGI	SECOFI
Micro	Economic Units 1-20 employees Turnover gross production or gross fixed capital information	1-15 employees
Small	Economic Units 11-20 employees Turnover gross production or gross fixed capital information	16-100 employees

Source: INEGI (2009); SECOFI (2009)

By 1999, after five years in NAFTA, public organisations (SECOFI, SHCP, SEP, NAFIN, and BANCOMEXT) in charge of the Mexican economy published in the Federal Official Diary (DOF) an agreed definition for small and medium sized enterprises. They agreed that two variables were necessary to define small sized enterprises, the number of employees and the economic sector (Table 2.13). In 2001, the Ministry of Economy promoted a definition according to the Mexican business activity in three main sectors, industrial, service and commerce, using as parameter the number of employees. National Finance (NAFIN) launched in 2004 an on-line resource for entrepreneurs in which it covered issues such as business fundaments and businesses classifications. Its definition had two interesting contributions; the first concerned the reduction on the criterion of employees; and secondly, it used qualitative variables (Table 2.13). This implies that it took into account the evolution of Mexican businesses and fine-tuned the variables in order to better assess a definition. After exploring a diverse range of definitions, it is possible to assert that three main quantitative measures are consistent: number of staff, turnover and annual balance sheet.

Table 2.13 Description of micro, small and medium-sized enterprises in Mexico

Size	DOF			NAFIN			Ministry of economy		
	Industry	Commerce	Service	Industry	Commerce	Service	Industry	Commerce	Service
Micro	1 to 30	1 to 5	1 to 20	1 to 10	1 to 10	1 to 10	1 to 30	1 to 5	1 to 20
Small	31-100	6-20	21-50	11-50	11-30	11-50	31-100	6-20	21-50
Medium	51-250	21-100	51-100	51-250	3-100	5-100	101-500	21-100	51-100
Large	> than 251	> than 101	> than 101	> than 251	> than 101	> than 101	> than 500	> than 100	> than 100

Source: DOF (1999); NAFIN (2004); and SE (2001)

Qualitative measures have been used since 1980's, as another approach to understand further the characteristics and conditions of enterprises. The Bolton Report (1971) discussed that small enterprises tend to be financially independent, to be managed by the owner or partially and to have a small market share. Another interesting definition is the one created by the Committee for Economic Development in the US. It discussed that small enterprises have as a minimum two characteristics from the following features: independent management as the manager usually owns the business; capital supplied and ownership by an individual or few individuals; operations are primarily local, although the market is not necessarily local; and the business is small in comparison with the larger competitors in the industry. Hauser (2000) extended the previous factors and introduced the personal relation encountered by employees during the firm activities. He argued that the follow factors are commonly experienced: identity of ownership and personal responsibility for the activities; identity of ownership and personal liability for the entrepreneurs' and the enterprises' financial situation; personal relationship for the success or failure of the firm; and personal relationship between employer and employees. In what respect to qualitative factor in developing nations, NAFIN (2010) consider that: the owner is the manager, the owner is largely involved in the business activities, the organisation is based on family members and the firm is customer oriented. As it can be seen from Table 2.14, there is consistency in the qualitative measures that describe these businesses such as the role of the owner as manager, the ownership of the business and the relationship between employer and employees.

Table 2.14 Summary of the intangible factors in small-sized enterprises

Bolton Report	Committee for Economic Development	Hauser	NAFIN
Owner managed; Financially independent; Small market share	Owner managed; Capital supplied; Ownership held by an individual or few individuals; Operations are primarily local; Business is small	Identity of ownership; Personal liability for activities; Personal liability for the entrepreneurs' and enterprises' financial situation; Personal relationship to success or failure; Personal relationship between employer and employees;	Owner managed; Owner involved largely in business activities; Organisations based on family members; Business are customer oriented

Source: INEGI (2009); SECOFI (1999)

In essence, the exploration of small sized enterprises pointed out the lack of an agreement on the variables that define them. There were emphasised two kinds of variables, quantitative and qualitative. For instance, governmental organisations used more quantitative measures to define small sized enterprises, and the most common variables were number of employees, turnover and activity sector. Whereas, qualitative factors were mostly used for public organisations, which highlights the fact that these factors are crucial to define small sized enterprises. Therefore, qualitative factors consider two lines of study, the one that refers to characteristics of the owner/enterprise, and the other that concerns on the interaction owner/employees. In the case of Mexico, the definition of small sized enterprises concerns the sector and number of employees. Consequently, for the purpose of the study, *'small enterprises are those businesess that employ between 0 to 50 employees depending on their economic activity, are financially independent, manage by the owner, with none or loose organisational managerial structure and with close relationship between employer and employees'.*

2.3.3 Context of small technology-based enterprises in Mexico

Technology-based enterprises need consideration in a number of key factors since their origins to their growth in order to succeed. According to Merino and Villar (2007), there are three key elements during the creation of TBEs: a) technological availability, b) resources availability, and c) degree of assimilation of entrepreneurship culture. These three elements lead to reflect about the quality of systems of research and development and relations between, say, University-enterprises or clusters. Undoubtedly, the entrepreneurship attitude is the most relevant element, as it triggers a group of variables that formalise an idea into a business. Consequently, it is common in TBEs that entrepreneurs posses a high education level, have professional experience in high technology firms or research centres, and their age range between 30 and 50 years old (Storey and Tether, 1998). In the study by Merino and Villar (2007), it produced a checklist of the tangible and intangible factors that are required in the organisation and externally to succeed (Table 2.15). Ergo, it is of main importance to explore within the context whether these factors are fulfilled or not.

Table 2.15 Tangibles and intangibles factors of TBEs

<table>
<tr><td rowspan="4">Intangible factors</td><td rowspan="3">Internal</td><td>Human Capital</td><td>Attitude
Aptitude
Capacities</td></tr>
<tr><td>Structural Capital</td><td>Strategic direction
Business plan
Environment vigilance
Organisation
R&D effort
Protection to the results of R&D</td></tr>
<tr><td>Relational Capital</td><td>Regional framework of business
Web participation</td></tr>
<tr><td>External</td><td>Close
General</td><td>External offer of available service
Entrepreneurship culture</td></tr>
<tr><td rowspan="2">Tangible factors</td><td>Internal</td><td colspan="2">Availability of owned resources (economics, installations, etc)
External support of financing, equipment and physical spaces</td></tr>
<tr><td>External</td><td colspan="2">Context and legal framework
Public programmes of support</td></tr>
</table>

Source: Merino and Villar (2007)

TBEs in Mexico became relevant in the 1970's, when the production of goods from United States of America decreased after World War II. During that period, Mexico focused on the production of light industries to satisfy the increasing necessities of its market and to export the surplus to the American market. However, national companies' required foreign investment to adapt technologies to cope with the standards needed to produce goods and specialised workers to use the new technologies. Therefore, Mexican governments adopted a substitutive strategy to gradually industrialise the national industry in a two-stage strategy.

The first stage was implemented from 1940 to 1960 in order to improve the domestic production of none durable consumer goods and some intermediate goods of simple technology. The second stage was established on the late 1970's to strength the domestic production of durable consumer goods and some intermediate goods that used relatively more complex technology. The results obtained were positive because they promoted the growth of the economy during more than two decades. However, the economical growth was a result of the rigid protectionist policy imposed by governments in the 1940's (Bueno, 1971; Wallace, et al., 1979). In addition, the concentration of capital in few large private groups emphasised the evident exhaustion of the substitution process and the incapacity of governments to create a real, coherent and integrate productive system. This situation caused an inefficient economic industrialisation in the employment of intensive technologies.

The international change experienced years later contributed to intensify the infrastructure and macroeconomic problems of Mexico (Harper and Cuzán in Hilman, 2001). Governments established a neoliberal model in which structural changes focused on: a unilateral and accelerated liberalization of the economy; create flexibility on foreign investment policy; resize the public sector and semi public sector; and create a financial system that operates along with the nationalised banking. During the 1990's, Mexico produced a wide agenda of structural reforms using instruments of stabilization on the economic policies in combination with structural adjusts of politics prescribed by the World Bank and the International Monetary Fund. Aspe (1993) and Lusting, et al. (1992) suggest these structural reforms lead the country to have the necessary tools to implement better strategies to face the international competence and market forces. Its current condition is not particularly favourable, as there is lack of efficient policies to improve the context of TBEs.

In Mexico, as in many other countries, there is no detailed information about the number of TBEs established nationally. There are few studies in Mexico about TBEs and indeed, most of them are recent. In 1997, Corona published the results obtained from his research exploring 100 Mexican innovative enterprises. He used incubators oriented to technology as a source to identify TBEs, leading with it to describe the context of firms and their environment. This study provided Mexican governments, institutions and researchers with rich data to have a comprehensive view of the condition of Mexican TBEs. Another contribution was to make available the quantity of workers within each size of TBEs and the sector in which they are established (Table 2.16).

Table 2.16 Employment by TBEs size

		Employment by sector	
Size	**Personnel Occupied**	**Manufacture**	**Service**
Micro	3.26	1.92	1.67
Mini	9.58	8.91	8.65
Small	46.13	38.40	33.95
Medium	165.78	156.35	150.59
Large	2,876.94	622.51	596.67

Source: Corona (1997)

Another contribution relates to the information of the number of TBEs divided by sector. Table 2.17 shows the results collected from 93 (seven did not fulfil the requirements) Mexican enterprises by size and technological area. The outcomes show that Mexican enterprises focused on eight technological areas considered as new and traditional industries. The area that has more businesses established is traditional technology with 32 firms, and opposite with just one firm was new materials. The second sizable area was service with 28 firms and it was followed by electronic with 14 firms. Another important issue concerns the number of enterprises involved in technological activities. Micro TBEs have the largest number of enterprises developing technological activities with more than 50% of the total figure and the second largest group are small enterprises with 16 companies.

Table 2.17 Technology-based enterprises by size and area

Technological Areas		Number of Technology-Based Enterprises				
		Micro	Small	Medium	Large	Total
New Technologies	Electronic	8	5	1	0	**14**
	Telecommunication	4	1	0	0	**5**
	Biotechnology	3	0	1	0	**4**
	New materials	1	0	0	0	**1**
	Energy	6	1	0	0	**7**
	Ecology	2	0	0	0	**2**
Traditional	Service	27	1	0	0	**28**
	Traditional technologies	8	8	7	9	**32**
	Total	**59**	**16**	**9**	**9**	**93**

Source: Corona (1997)

The most relevant contribution was the development of an innovation index (Índice Indico) that estimates the innovative performance of firms, as it measures the capacity, effort and innovative results to provide a profile of innovation between economic industries. Thus, the assessment about whether a product or service is innovative or not is relative to the technological knowledge of the productive branch, and generally, it pertains to improvements in the characteristics with respect to other products or services. Table 2.18 exhibits the number of innovations per TBEs and industry. The data shows that media is two innovations per EBT. It presents biotechnology as the industry that produces more innovation; contrary, telecommunication is the one that produces less number of innovations.

Table 2.18 Innovation per TBE and industry

Industry	Number of TBE	Number of Innovations	Innovation per EBT
Electronic	16	36	2.2
Telecommunication	5	8	1.6
Biotechnology	5	6	4
New materials	2	4	2
Energy	7	14	2
Ecology	2	5	2.5
Service	33	63	1.9
Traditional technologies	45	96	2.1
Total	**115**	**232**	**2**

Source: Corona (1997)

Finally, Corona (1997) argues that TBEs in Mexico suffer at management level from lack of appropriate technology at accessible costs; low degree of technology adoption; little qualification of their employees or entrepreneurs; management fragility and low productivity; and precarious environment conditions.

In essence, this section examined a general overview of the different definitions used to describe TBEs and small sized enterprises. Therefore, the quantitative and qualitative measures that provide sustenance for a holistic view were considered. This led to review other characteristics that are relevant to the study of TBEs such as innovation and technological implementation. Indeed, these are going to be further explored in the next section, organisational structure and management style. Furthermore, it was contextualised within the condition where small Mexican TBEs operate. Hence, this helps to introduce the next theme, and extend the description and definition of TBEs.

2.4 Organisation and management style in small technology-based enterprises

According to Johansson and Woodilla (2008), the management area basis on a multidisciplinary platform of applied social sciences for studying organisation. It combines practical activities and academic subjects and consequently traditional disciplines question its ‘pseudo-academic’ and not rigorous approach (O’Connor, 1994). Organisational and management paradigms aim to understand the organisation, its members, its management and how they relate with the environment and organise the processes. Researchers (Hick, 1972; Kast and Rosenzweig, 1985; Mintzberg, 1983; Mintzberg, et al., 1998; Morgan, 2006) have emphasised three main factors, technology change, innovation, and economic process, which have affected the production-market. The combinations of these three factors transform the patterns and ways in which firms organise, structure and manage activities. Therefore, enterprises need to adapt in order to cope with the increasingly uncertain environment produced by the change in the environment, the emergence of new global competitors, the convergence of new technology industries and the increasing speed and cost of technological development (Lloréns, et al., 2005).

The objective of this section was to identify themes related to organisational structure and management style in small TBEs. Thus, the following section seeks to explore the main factors in which small TBEs organise, manage and evolve. However, the literature was not restricted to identifying themes that are specific to the technology firms' environment exclusively. This is due to the limited research developed in this specific type of business and consequently, it is considered that some of the experiences reported on more generic studies can be transferable to this context.

2.4.1 Organisation within small technology-based enterprises

According to Rosseau (1997), the definition of organisation has three denotations: a body of persons organised for some end or work; the administrative personnel or apparatus of a business; and the act or process of organising. This refers that an enterprise is composed by tangible and intangible assets that are structured in certain way to communicate the different inputs and outputs to deliver an outcome. For Kast and Rosenzweig (1985:5), organisations *'consist of goal-oriented arrangements, people with a purpose; psychosocial systems, people interacting in groups; technological systems, people using knowledge and techniques; and integration of structured activities, people working in patterned relationships'*. This implies that it is important to structure and integrate activities, as this helps to work and cooperate in interdependent relationships among employees. To coordinate physical and human resources, their interrelation, their transformation and their evolution, are key to understand the organisation. Jones (1995) suggests that it is necessary to explore organisational theory in order to understand how organisations function and how they affect and are affected by people and the society in which they operate. Thus, organisational theory covers three large areas of study, organisational structure, organisational design and organisational culture.

Studies on organisational structure concern the formal system of rule and task and the authority relationships that control how people are going to cooperate and to use resources to achieve the organisations goal. Thus, it is necessary to control the coordination and motivation that shapes the behaviour of people and the organisation, as it can be managed and changed through the process of organisational design. Organisational design covers the process used for managers to select and to manage various dimensions and components related to organisational structure and culture. Therefore, an organisation can be able to control the necessary activities to achieve its goals. Indeed, it is needed a balance in the organisation to manage external and internal processes in order to survive in the long run. Finally, organisational culture investigates the set of shared values that control the organisational interactions of members with each other and with people outside the organisation. This implies that organisation culture is shaped by people and the organisational structure and it can be changed through the process of organisational design (Jones, 1995). As it was explored, these three broad areas rather than be isolated, nurture each other as they are intrinsically related.

Mintzberg (1983) argued that the structure of an organisation can be defined simply, as the total sum of the different ways in which its labour is divided into distinct tasks, and then, its coordination is achieved among these tasks. Thus, there are two fundamental and opposing requirements; the division of labour into various tasks to be performed and the coordination of these tasks to accomplish the activities (Mintzberg, 1983). Consequently, Van de Ven and Astley (1981) developed a diagram that defines the structural form and personnel actions of an organisation at macro and micro level (Fig. 2.5).

Figure 2.5 Structural forms and personnel actions within the organisation

Macro Level (Whole, Collective Orientation)	Industry/community structure Organisation design	Industry/inter-organisational collective action Board of directors executive committee
Micro Level (Part, Self Orientation)	Department/divisions Roles and positions	Task force management committee Individual
	Structural Forms	**Personnel Actions**

Source: Van de Ven and Astley (1981)

Figure 2.5 illustrates that an organisation is a work structure in where personnel are sourced with activities that have to be undertaken at different levels of actions. This signifies that the organisation is a flux of information that goes from top to bottom and vice versa, and from structural forms to actions and vice versa. Under this perspective, an enterprise is a network based on roles and people that produce knowledge that later modify the network itself (short, medium and long-term). Mintzberg (1983) considers that there are elements of structure that help to achieve an internal consistency or harmony, and this basic consistency relates with the organisation's situation (size, age), the kind of environment in which it functions, the technical system it uses, and so on. These situational factors are often chosen and with them the structure of the organisation. Both design parameters and the situational factors should be clustered to create different configurations. In order to explain the fundamental ways in which organisations coordinate tasks and the different divisions of labour it is necessary to use five coordinating mechanisms: mutual adjustment, direct supervision, standardisation of work processes, standardisation of work outputs and standardisation of worker skills (Mintzberg, 1983). Coordination of activities and its mechanisms are the most basic elements of structure because they represent the glue that holds the organisation together. Consequently, there is a wide range of possibilities in the use of these mechanisms and these options will depend on the needs of the firm.

Scholars (Mintzberg, 1983; Mintzberg, et al., 1998; Morgan, 2006) have classified organisations according to their school of thought. The early literature of management focused on formal structures and on the relationship among members of the organisation. Terms such as 'unity of command, scale chain and span of control' were popularised. The second school emphasised the standardisation of work throughout the organisation. Studies explored the programming of the contents for operating work, and the formalisation of roles, job description and training. Hence, it was vital to standardise work relationships around a tight system of formal authority. The third school of thought proposed the use empirical research to explore the internal condition of employees and to understand with it human relations (Table 2.19). In the last few decades, there has been a tendency to look for a more comprehensive structure and use tangible and intangible concepts for this end.

Table 2.19 Schools of thought

Schools	Proposition	Movements
First school of thought	Formal structure; Formal authority: Unity of command; Scale chain; Span of control	Principles of management-Henry Fayol
Second school of thought	Standardisation; Programming of the contents for operating cost; Activities were formalised by roles, job description and training	Scientific management-Frederick Taylor Bureaucratic structure-Max Webber
Third school of thought	Look at the structure more inclusively; Understanding organisational needs and environmental relations; Understanding information processing, learning and intelligence; Focus on values, beliefs and other patterns of shared meaning that guide organisational life; Focus on logics of change shaping social life	Human relation Organisation as a learning agencies Organisation as culture Organisation as flux and transformation

Source: adapted from Mintzberg (1983); and Morgan (2006)

According to Hick (1972), a popular scheme for classifying organisations is to label them as formal or informal depending upon the degree in which they are structured. Indeed, these designations represent only extremes, as it would be probably impossible to find a completely formal or informal organisation. A formal organisation has a well-defined structure that may describe its authority, power, accountability and responsibility relationships. Status, prestige, pay, rank, and other aspects are well ordered and controlled. Membership in formal organisations tends to be gained either consciously or unconsciously, and it is often difficult to determine the exact time when a person became a member. Contrary, informal organisations are loosely organised, flexible, ill-defined and spontaneous. Kast and Rosenzweig (1985) have named these two opposite types of organisations, stable-mechanistic and adaptive-organic forms. Table 2.20 summarises the characteristics that firms adopts when embrace any of these two types of organisation.

Table 2.20 Organisational characteristics of mechanistic and organic structure

Organisational Characteristics	Types of Structure	
	Stable-Mechanistic	**Adaptive-Organic**
Openness to environmental influences	Relatively closed. Attempts to select & minimise environmental influences & reduce uncertainty	Relatively open. Designed to adapt to environmental influences & cope with uncertainty
Formalisation of activities	More formality based on structure	Less formality based on structure
Differentiation & specialisation of activities	Specific, mutually exclusive functions & departments	General, sometimes overlapping activities
Coordination	Primarily through hierarchy & well-defined administrative procedures	Multiple means & interpersonal interaction
Authority structure	Concentrated, hierarchic	Dispersed, multiple
Source of Authority	Position	Knowledge &/or expertise
Responsibility	Attached to specific positions &/or roles	Shared by many participants
Tasks, roles, and functions	Clearly defined & specified in organisations charts, position description, &so on	Loosely defined and determined by circumstances, mutual expectations, & so on
Interaction-influence patterns	Superior ⇒subordinate, hierarchical	Superior⇔subordinate, horizontal and diagonal
Procedures and Rules	Many and specific, usually written & formal	Few and general, often unwritten & informal
Stratification	More difference between levels	Less differences between levels
Decision Making	Centralised, concentrated toward the top	Decentralised, shared throughout the organisation
Permanency of Structural Form	Tends to be relative fixed	Continually adapting to new situations

Source: Kast and Rosenzweig (1985)

Overall, the adaptive-organic system is less structured allowing for more frequent changes of position and roles, and provoking more dynamic interaction among the various functions. This structure needs more time and effort toward the integration of diverse activities. Whereas, stable-mechanistic form provides permanent and structured positions that are managed hierarchically. Enterprises that are in dynamic environments, such as electronic, telecommunications, biotechnology and new material industries, tend to adopt an organic structure. Contrary, those based on secure environments, such as mining, instruments, equipment and agriculture industries, champion stable-mechanistic form as it aims to compete through efficiency.

In respect of organisation culture, there is a widespread disagreement on its definition and scope (Denison, 1996; Jones 1995; Kottler and Heskett, 1992; Ogbonna, 1993; Ogbonna and Harris, 1998). Ogbonna and Harris (1998) argue that it is pertinent to note three main issues. First, many researchers note the treating culture, as a unitary concept in which it reduces its value as an analytical tool. Second, culture cannot be equated to power and politics or climate (Denison, 1996). Third, there is a disagreement on whether organisational culture can be easily changed (Ogbonna, 1993). One of the major reasons for its popularity stems from the argument (or assumption) that certain organisational cultures lead to superior organisational financial performance. Jones (1995) argues that organisation culture is of utmost importance as it represents a set of shared values that control the organisational interactions of members with each other and with people outside the organisation. Furthermore, it controls coordination and motivation, shapes behaviour of people and the organisation. Many academics and practitioners argue that the performance of an organisation is dependent on the degree to which the values of the culture are widely shared (Kottler and Heskett, 1992; Ogbonna and Harris, 1998).

According to Kets de Vries and Miller (1986) there are two organisational styles, authoritarian or participative and thus, enterprises should define in which style and at what level they are going to use it within their organisations. Authoritarian enterprises are those firms in which authority centres at the top, and they delegate authority to the next person down. Orders passes down as a chain of command for instance can lead to mistake resulting in critical appraisal and dismissal. Therefore, senior managers tend to overwork and workers carry with all the activities provoking a conflictive environment, as employees consider each other as competency in their work place. This organisational style is effective in cases of emergency; although, it does not mean that firms should stay in emergency, chaos and crisis all the times to be effective. Contrary, participative enterprises are those businesses in which authority emanates from employees as they acquire it by consent. The organisation relies on consent because people accept their responsibilities and they are accountable for the quality of their job. The job of managers is to remove obstacles from subordinates and coordinate the work of the group. Thus, employees experience a cooperative environment in which they facilitate the work of others.

TBEs are established in hypercompetitive environments and in fast-paced industries that are characterised by rapid technological change, shortened product life cycles, intensive competitive rivalry and global competition (Upton, 1994; Yip, 2003). Consequently, this hypercompetitive environment provokes a shift on the organisation's structure in which hierarchy levels are reduced, interest on strategic and environmental factors is increased, personnel practices are decentralised and workers and teamwork are motivated. Nevertheless, in the words of Huber and Van de Ven (1995:216) to change an organisation, *'it is necessary to know how the organisation functions, who their members and leaders are, what form will take, and how it will allocate its resources'*. Weick and Quinn (1999) suggest there is no a single best organisational structure for innovation. However, researchers and empirical research (Braglia and Petroni, 2000; Courseault-Trumbach, et al., 2006; Lloréns, et al., 2005; Soderquist, et al., 1997) emphasise that organisations tend to modify their rigid and complex hierarchy structure to new organisational forms based on high level of internal flexibility, lack of bureaucracy, entrepreneurial spirit, aligned corporate culture and a well defined top management. Mintzberg, et al. (1998) claimed that young and innovative enterprises that work in dynamic environments and in unsuitable conditions are prone to have an adhocracy businesses structure. As these entrepreneurial organisations require fast decision-making and simple tasks. Entrepreneurial organisation is referred to those firms where the chief executive is often the founder or the entrepreneur who may have a group of support employees along with a group of operators who do the basic work. As a result, the organisation structure is very informal and flexible, and although, it runs in a highly centralised way by the chief executive, it is ideal for achieving quick changes and manoeuvres.

Weick and Quinn (1999) assert that in order to achieve success, enterprises need well-defined managerial responsibilities and clear project priorities that allow the process to be highly flexible, improvisational and adaptable. These businesses demand a richly connected communication systems across project communications. Thus, TBEs should find a balance between purely mechanistic and organic structures in order to promote a corporate culture, develop co-operations and partnerships and allow flexibility to speed response (Braglia and Petroni, 2000). In the case of small sized enterprises, the organisational structure is mainly informal and associated with the relative absence of a wide range of efficiency in management techniques (Cosh and Hughes, 2003). This provoked the adoption of non-authoritative and participative approaches (Yap and Sounder, 1994), aiming to eradicate bureaucracy within the organisation. It tends to have weaker hierarchy and an evident decentralisation of personnel practices (Rousseau, 1997) leading to benefit the development of high technology products (Yap and Sounder, 1994).

2.4.2 Taxonomy of innovative enterprises

Researchers on the economic area (Archibugi, 2001; Athaide and Stump, 1999; Dosi, 1982; Jong and Marsilu, 2006; Nelson and Winter, 1977; Pavitt, 1984; Sum, et al., 2004; Schumpeter, 1942) produced sophisticated methods to group innovative enterprises. They classified these organisations using taxonomies, as they offer a way to organize and understand the diversity of innovative patterns in firms and sectors (Archibugi, 2001; Pavitt, 1984).

Schumpeter (1942, 1934) produced the first taxonomy where it proposed two patterns of innovation across industrial sectors. The first pattern of innovation, Schumpeter mark 1, considered entrepreneurial activity and creativity of small and new firms. The second pattern, Schumpeter mark 2, contemplated the formal research and development activity of large and established firms. Years later, Pavitt (1984) argued that taxonomies should focus on the organisational characteristics of innovative firms such as distinct sources, nature and directions of technological change across sectors. These variables help to produce four categories of firms: (1) science-base, (2) specialised-suppliers, (3) supplier-domain and (4) scale intensive firms. Through the years, researchers generated new taxonomies using as guideline Pavitt's work and these actions contributed to extend the state of knowledge.

For example, Dosi (1988) contributed through the identification of four dimensions that capture the technology regime of any enterprise. These are: (1) the level and sources of technological opportunity; (2) the conditions for appropriating the economic outcomes from innovation; (3) the extent to which new solutions build cumulative upon past ones; and (4) the nature of the knowledge basis relevant for innovation. In addition, Jong and Marsilu (2006) found out that the behaviour of enterprises is important to innovation. Consequently, six variables were underlined: (1) innovative output; (2) innovative input; (3) sources of innovation; (4) managerial attitude; (5) innovation planning; and (6) external orientation. Four dimensions were found using these variables:

(1) Supplier dominated firms: allocate innovation on the process as they respond to suppliers' proposal. Their openness with other institutions relates to the way in which they solve business problems, rather than participate in formal partnerships.

(2) Specialised suppliers firms: focus innovation in the process. These firms are customer driven, as they centre innovation on their necessities. They are not open on the number of sources that they consult; although, they frequently engage in formal collaborations.

(3) Science based firms: have the highest level of innovation in products and processes as they employ financial and time resources. They use knowledge from universities and research institutes as a source of innovation, but they also draw heavily on customers' needs. Managers have a strongly positive attitude towards innovation, frequently accompanied by a written plan.

(4) Resource intensive firms: have a relative higher level of innovativeness than the other type of firms. The role of suppliers as a source of innovation is less pronounced. Innovation is similar in process and product. They limit the use of employees in innovation and on external networks.

In 2003, Buesa explored Spanish enterprises, and he regarded that there are six patterns of innovation: one for large enterprise, three for medium sized enterprises, and two regard to small high technology enterprises (Table 2.21). These patterns were developed according to the level of investment and the type of procedures undertaken to produce innovation in businesses. Therefore, small enterprises that are oriented to radical product innovation do not have large quantity of resources. Nevertheless, they become inspired with the limited resources, so they come up with different forms to undertake innovative activities. They focus particularly on research and development and design as they pursue the development of products and the assimilation of external technologies in trying to launch a novel product within the market. Thus, they register procedures and patents to keep their industrial secrets. Contrary, small enterprises that are less innovative deploy resources and develop activities incipiently in order to generate knowledge. They produce improved products and processes with little cooperation with other agents of innovation, except from suppliers. They emphasise the adoption of technology through the registration of models and designs.

Table 2.21 Taxonomy of innovation

Size of Enterprises	Characteristics of innovation
Large enterprises	They invest large amount of resources to support all kind of innovative activities. There is especial emphasis to R&D and engineering activities. They are prone to develop products/processes and focus on the procedures to acquire knowledge.
Medium enterprises 1	They focus on radical innovation using high intensity activities directed to R&D, design and engineering. Although, the assignation of financial resources is reduced. Their objectives are to develop novel technological products/processes within the market in which they operate.
Medium enterprises 2	They concentrate on incremental innovation using relatively intensive activities in R&D. They do not use design or engineering activities. They introduce incremental improvements on product/process based on known technologies.
Medium enterprises 3	Enterprises with low commitment to innovation. They allocate few resources to innovation, and to their principal activities into their innovation process. They seldom concentrate in the improvement of process or products.
Small enterprises 1	They focus on radical innovation of products using few resources intensively on different innovative activities, especially in R&D, and design. Their objectives rely upon the development of products and the assimilation of external technologies in order to launch an innovative offer to the market.
Small enterprises 2	Enterprises with low commitment to innovation. Consequently, their activities to create knowledge are poor. They seldom tend to improve products or process.

Source: Buesa, (2003)

2.4.3 Management style within small technology-based enterprises

Kast and Rosenzweig (1985:5) argued management involves the coordination and material resources toward the accomplishment of objectives. Therefore, to manage effectively physical and mental activities, managers required four elements: objectives, people, techniques and an organisation. This implies that a process is required in order to relate the four components throughout the planning, organising and controlling of activities.

According to Rousseau (1997), the management style of an organisation depends on two factors, 1) size and 2) industry. Considering that Mexican technology-based enterprises tend to be small and compete on turbulent environments (Burns and Stalker, 2000; Corona, 1997; Morgan, 2006), an entrepreneurial management style correlates positively. Therefore, they need to have internal flexibility with a lack of bureaucracy to make swift decisions. Knowledge becomes the major value because it allows relate tangibles and intangible factors (Cosh, et al., 2004). A main constraint for TBEs concerns on remaining flexible in their structure and processes during their growth, as they need to respond to changing environments. These enterprises need to have the ability to identify and to develop new technologies with great potentialities and the necessary skills to take them to the market. Employees need to capitalise on the transformation of intensive capital knowledge generated by scientists and technologists. Indeed, managers play a crucial role in assisting the commercialisation process of intensive knowledge (Cosh, et al., 2005). Furthermore, TBEs base their efforts on the operation management and its improvements. They are able to hold mass customisation as a result of smarter production technology that is tailored by costumers and their specific designs. Firms concentrate on customers' requirements, competition, customers' technological change and socioeconomic issues. It is important that they consider the internal factors that can hamper the coordination between departments, interactions and collaborations (Miller and Toulouse, 1986; Hiroko and Wiseman, 1987).

Morris, et al. (2008) argued that entrepreneurship flourishes when there are few layers or levels in the structure of the firm. This style tends to orientate towards more horizontal and less vertical design provoking a decentralisation and empowerment during operations. Cross-functional interaction and cooperation are priorities that allow the clash of ideas from inter-functional interaction. Hence, there is less formalisation of roles and positions within the structure. Slevin and Covin (1990) proposed additional elements, but above all enhanced the patterns that companies can adopt over time. They highlighted that there must be a fit between management style and organisation structure (Fig. 2.6). An organic or mechanistic structure with emphasises on entrepreneurial or conservative management produces an effective entrepreneurial or efficient bureaucratic firm (Cell 1 and 3). However, the problem is when organisation structure and style are inconsistent (Cell 2 and 4).

Figure 2.6 Entrepreneurial leadership, structure and the concept of cycling

	Mechanistic	Organic
Entrepreneurial	Pseudo-Entrepreneurial Firm 2	1 Effective Entrepreneurial Firms
Conservative	3 Efficient Bureaucratic Firms	4 Unstructured Unadventurous Firms

Source: Slevin and Covin (1990)

A critical elusive ingredient, therefore, is alignment. This refers to having the entire organisation aligned on the same objectives, tactics and ultimately commitment. Organisational alignment requires employees who understand the value of working together and having the skills and temperament to do so. As a result, the company can have an integration that commonly acts as unification of diverse interest of people to achieve an established purpose via interactions, information sharing and coordination of activities. Kahn (1974) argued that businesses also needed to subsume ‘interaction’ and ‘collaboration’. He claimed that interaction between areas has to be formal through transactional communication links and collaboration has to be informal through cooperative relationships. These can build a shared vision and mutual understanding among participants in the new product development process. Hence, the communication along the company tends to be horizontal instead of vertical. Another important characteristic is the capability of the firm to deal with external and internal linkages. External linkages are an important source of knowledge that directly strengthens the technological competences of small TBEs and thus their competitive advantage (Cosh et al. 2005). Internal linkages focus on networks forming around knowledge. They depend more on personal resources, and ruled-centred work structures by people doing their jobs (Drazin and Sandelands, 1992; Manz, 1992).

This kind of management style has disadvantages that have been highlighted by different researchers. According to Romijn and Albu (2002), TBEs’ main problem concerns the assistance to direct the businesses’ technological capabilities to better meet market needs, rather than solve engineering problems. Another substantial problem concerns entrepreneurial managers, because they perceive greater internal capabilities, fewer weaknesses, more opportunities to new businesses and more optimism about the future of the hypothetical firm. In addition, Stinchcombe (1965) claimed that the relative lack of structure that characterises new firms is a liability not a benefit, as it is associated with the relative informality and absence of a wide range of efficiency (Cosh and Hughes, 2003). This provokes informal management structures that are not able to adopt cost leadership strategies that require sophisticated cost, budget and profit controls. As well as, it is unlikely that such a simple structure could adequately support a broad product market scope or extensive diversification (Miller and Toulouse, 1986).

In conclusion, *every enterprise uses a different model and original productive process that define their way of using resources and adopt a culture. However, some characteristics are key within enterprises to face the environment changes. These display flexibility of the organisation; informal structure, but with well-defined managerial responsibilities; clear project priorities and a richly connected communication systems within an entrepreneurial spirit.*

2.4.4 Culture style within small technology-based enterprises

According to Malhotra (2008), organisations are a powerful social institution with a life of their own. In line with Malhotra, theoretical researchers (Denison, 1990; Jones, 1995; Ogbonna, 1993) on organisation and management emphasised that it represents the social reality of the context in which they interact. Culture, in an anthropological view, *'refers to the collective mental programming of people in a society who develop common values, beliefs and preferred means of behaving'* (Kast and Rosenzweig, 1985:663). From a societal view, organisations are *'a culture-producing phenomena; therefore, they are seen as social instruments that produce goods and services, and as by-product, they also produce distinctive cultural artefacts such as rituals, legends and ceremonies'* (Sathe, 1983:6). Culture for the purpose of this research refers to the development of patterns reflected in a society system of knowledge, ideology, values, laws and day-to-day ritual. This alludes to the fact that every organisation has its own culture, which is influenced by external and internal variables. Organisation culture *'shapes the behaviour of employees through conveying a sense of identity among organisation members; facilitating commitment to something larger than self;*

enhancing social system stability; and providing recognised and accepted premises for decision-making' (Kast and Rosenzweig, 1985:663).

Morris, et al. (2008), underline in their work the cultural components that foster an entrepreneurial culture style (Table 2.22). They used the work of Cornwall and Perlman (1990), Peters (1997) and Timmons (1999) to synthesise these perspectives in order to find out a commonality within entrepreneurial culture. The previous shared views emphasised the following components: people and empowerment; value creation through innovation and change; attention to the basis, hands-on management; doing the right thing, freedom to grow and fail; commitment and personal responsibility; emphasis on the future; and a sense of urgency. These core values are richly embedded in the DNA of entrepreneurial companies. Indeed, it is complex to manage the culture because the internal environment is full with competing demands, a multiplicity of tasks and commitments and people operating under different horizons.

Table 2.22 Components of an entrepreneurial culture: three perspectives

Cornwall and Perlman (1990)	Peters (1997)	Timmons (1999)
Risk Earned respect Ethics of integrity, trust and credibility People Emotional commitment Work is fun Empowered leadership throughout firm Value win Relentless attention to detail, people, structure and process Effectiveness and efficiency	Listening Embracing change Customer focus Total integrity Excellence Involve everyone in everything Experimentation Fast-paced innovation Small starts and fast failure Visible management Measurement/accountability	Clarity, being well-organised High standards and pressure for excellence Commitment Responsibility Recognition Espirit de corps

Source: Morris, et al., 2008

Huber and Van de Ven (1995) and Weick and Quinn (1999) suggest that TBEs are flexible organisations that transform their firms' values, techniques and strategies on the work setting through increasing the participation of people from science and engineering disciplines. In opinion of Rousseau (1997), this leads to an effective coordination of multidisciplinary teams with a weak hierarchy and an evident decentralisation of personnel activities. Therefore, Yap and Sounder (1994) enhanced that culture relies on a non-authoritative approach that provokes high participation from employees. In addition, Morgan (2006) highlighted that employees are constantly motivated because they engage on different activities that give meaning to their jobs, autonomy, new responsibilities and enrichment. This implies that employees are enthusiastic about the risk that involves their jobs, but also by the participative and democratic environment and employee-centred style of leadership. Research in culture emphasises that goal settings are essential to motive and improve the performance of organisation at different levels such as individual, group and organisational. Locke and Latham (1990) highlight those enterprises that set moderately difficult goals motivate employees to achieve a high performance. Indeed, it is also recognised that successful companies reward and empower employees.

2.5 New product development process

Intense global competition, rapid technology change and shifting patterns within the world market force companies to continually invest in the development of new products (Owens and Cooper, 2001). During the last few years, a large number of literature (Cooper and Edgett, 2003; Cooper and Kleinschmidt, 1995; Crawford and Di Benedetto, 2000; SAT, 2006; Ulrich and Eppinger, 2003) have emphasised the importance of new product development (NPD), as the most important process executed within the organisation. It represents the lifeblood of firms because it is responsible for introducing new products or services to inject life to organisations (Cooper and Edgett, 2003; Cooper and Kleinschmidt, 1995; Crawford and Di Benedetto; 2000; Owens and Cooper, 2001; Ulrich and Eppinger, 2003). Its study has been traditionally associated with large firms (Crick and Jones, 1999; Millward and Lewis, 2005; Siu, et al., 2006). Thus, it is important to be cautious about generalising literature that may not suit the circumstances of small sized firms and TBEs. There is a general agreement about the lack of NPD process models and tools that adequately represent small sized firms and TBEs (Ledwith, 2000; Lindman, et al., 2008; Millward and Lewis, 2005; Song and Noh; 2006). Consequently, this section reviews NPD in small-sized firms and TBEs, although, it has not been restricted to the review of NPD and design process to underline key themes.

2.5.1 Definition of new product development

Product Development and Management Association (PDMA, 2009) refers to new product development activity as *'the overall process of strategy, organization, concept generation, product and marketing plan creation and evaluation, and commercialization of a new product'*. This implies that there are two lines of study to approach the term offered in the previous definition; as new product strategy and as new product development (NPD). New product strategy establishes the focus of the new product development effort (Narayanan, 2001). This means that it is not specific to one project but rather comprehends the corporate vision and strategies translated into a framework that is going to be used as an approach to achieve the firm's aims through the development of new products or services. Thus, new product strategy tends to address the following issues: type of new product to be developed, the types of market is aimed at, type of technology employed, and the nature orientation and commitment of the process to undertake (Porter, 1983). Indeed, these issues are determinate by both the firm and industry characteristics. In what respect new product development is considered as the process by which a new product/service is developed, and therefore it requires a combination of steps/activities to achieve it.

There is a wide range of generalised and theoretical views about the definition of NPD. The most basic and classic definition of new product development relies on the identification of an opportunity into the market that ends in the successful launch of a product. To launch a product within a market, businesses require defining a product strategy, and managing and supervising different activities (physical and material sources) throughout the overall process. This infers that NPD process focuses on the generation of activities that aim to define requirements; to develop and test a product concept; to develop a product; to plan the manufacturing and supply chain; and to prepare the marketing program (SAP, 2006). Ulrich and Eppinger (2003) argue that a NPD process begins with the perception of a market opportunity and ends in the production, sale, and delivery of a product. Thus, a well-performed combination of steps/activities/goals can result in the development of new products or services. Both definitions regard the NPD process as a merely sequence of steps that transform a set of inputs into a set of outputs. This view of the NPD process is considered among engineering literature (Armstrong, 2005; Jones, 1997; Ulrich and Eppinger, 2003).

On the contrary, from a marketing perspective NPD process is considered as a continuous process that achieves better results through experience. In the opinion of Crawford and Di Benedetto (2000), the implementation of NPD does not secure the success of a product, but it will go a long way to introduce a structure that can assist in establishing success. They remark that the most dramatic hallmark of product innovation is the complexity of operations and decisions in the NPD process. It is due to the fact that in order to produce innovation as an outcome (product or service), it is necessary to hold a development process (section 2.3.1 b). In this process enterprises employ more intellectual and organisational activities than physical to conceive design, and commercialise a product and managers are the orchestrators of the new product operation. It is important to highlight that under this perspective, the market pushes the organisation to produce product/service innovation. During the NPD process, managers endeavour the process through the combination of art and science skills. They deduce that art is an area based on intuition, experience, hunch, or gut feel, and it is useful when the managers lack the experience of information to make a reasoned decision (Kotler and Rath, 1984). The science area assists in offering techniques to produce a better product such as benchmarking, market analysis, marketing plan, and market research among others.

The previous review on definitions shows that generally NPD process remains at its essence. However, when the same concept is approached from the perspective of small sized organisations its definition becomes vague. It is agreed and emphasised (Filson and Lewis, 2000; Peters, et al., 1999) that *SMEs may not have a long-term business or product development strategy. Consequently, it is difficult to set clear aims that direct the work force to achieve the final goal and this, in turn, leads to have a misunderstanding among the different areas or employees. Similarly, the lack of experience of the manger/owner provokes that the implementation of NPD process becomes a difficult task for the staff involved. It is mainly because NPD is not a straightforward activity that is easy to identify and to define the multi-functional involvements that occur in the process.*

2.5.2 New Product development process

The NPD process is of high importance for those companies aiming to become more innovative as there is a strong association between introducing new products/services and innovating. NPD considers a set of activities that lead the business to plan a product strategy, to manage and to supervise different activities (physical and intellectual) in order to produce an outcome at any stage of the process. Researchers (Cooper, 1993, 1998; Cooper and Edgett 2003; Cooper and Kleinschmidt, 1995; Crawford and Di Benedetto, 2000; Owens and Cooper, 2001; Ulrich and Eppinger, 2003) have agreed that a well-defined development process is useful for achieving quality assurance, coordination, planning, management and improvement within the operation of businesses. Therefore, a series of NPD models have been developed to use them as guidelines for managing the NPD process (Trott, 1998). These represent the organisation's frame to improve new product introductions, maximize the benefits from a company's product portfolio, and improve the performance of the process. Nevertheless, the use or implementation of a structured NPD process neither guarantees success nor innovation. According to Rothwell (1992), Von Stamm (2004) and Trott (1998), there are five generations of NPD (Table 2.23). The evolutions of these models were the result of the impact of environmental and technical variables adequate in their infrastructure, to satisfy customers' needs and desires.

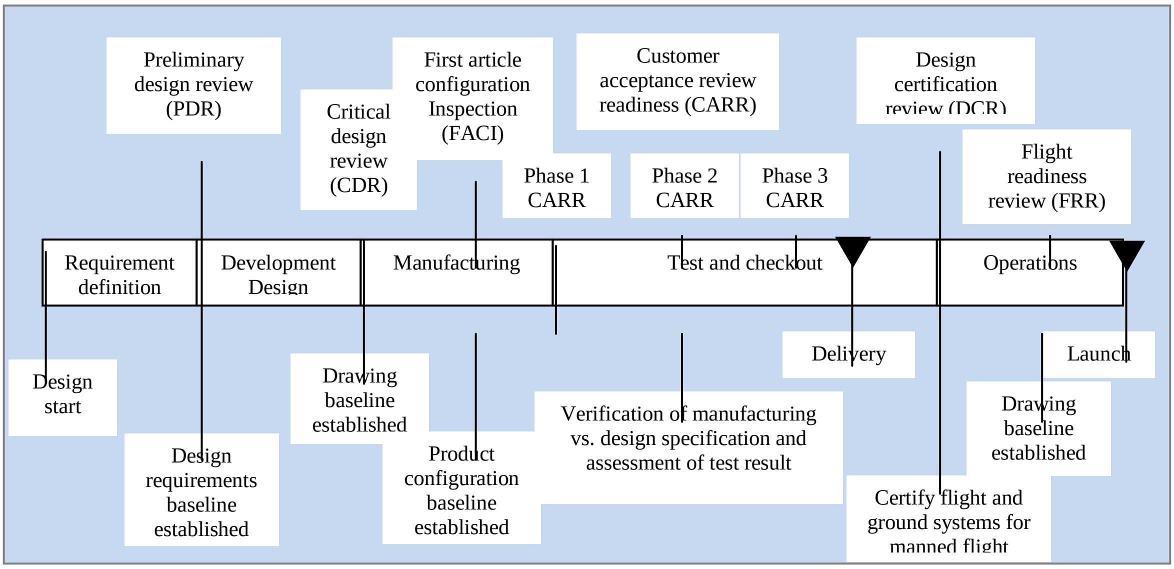
Table 2.23 Five generations of NPD models

Generation	Type of model	Key NPD model	Characteristics of model
First	Technology push model	Over the wall model	Linear sequential process; Emphasis on R&D, technology driven; Market is a receptacle for the fruits of R&D; Little room for integration
Second	Need pull model	Activity stage model	Linear sequential process, project as a whole; Market is the source of ideas for directing R&D; R&D has a reactive role; Null integration between R&D & strategy
Third	Coupling model	Total design	Sequential but with feedback loops; Push or pull or push/pull combinations; R&D and marketing more in balance; Holistic strategic framework; Extensive communication process; Major emphasis on product design phase;
Fourth	Integrated model	Stage/gate systems Rugby game	Parallel development with integrated teams; Need for cross-functional teams; Stages are multi-functional; Full integration within the organisation; Supplier linkages with leading-edge customers; Faster time to market
Fifth	Systems integrating & networking model	Networking model	Integrated parallel development with flexibility & fluidity between stages; Strong linkages with leading customers & suppliers; Use of expert systems & simulation modelling; Extensive networking; Knowledge accumulation that requires inputs from a wide variety of resources; Increased focus on quality & other non-price factors;

Source: Adapted from Von Stamm (2004), Rothwell (1992), and Trott (1998)

Table 2.23 summarised the stages on the evolution in the NPD process, and thus, it is important to provide examples that allows extending the understanding of the different NPD processes. One of the first approaches recorded was the one produced by NASA in 1960's, in which it described a sequential approach consisting of four phases: preliminary analysis (Phase A), definition (Phase B), design (Phase C), and operation (Phase D). This model was named 'Phased Project Planning' because it was introduced to facilitate the management of activities on highly complex projects (Fig. 2.7). One of the most important contributions of this concept was the introduction of checkpoints in order to ensure that mistakes would not move forward and affect next phases. Nevertheless, it was also recognised that this process was time-consuming and used many resources (human and financial) that affected the result of the projects.

Figure 2.7 The NASA management process of projects

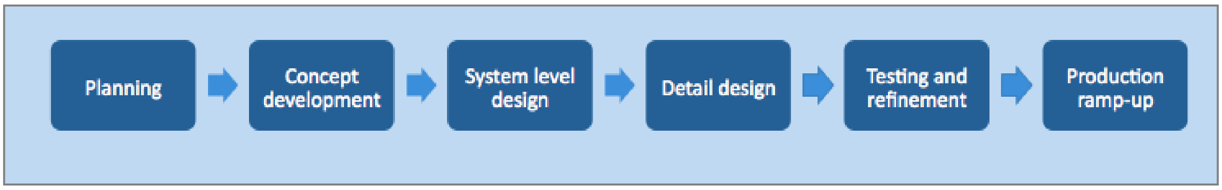


Source: Von Stamm (2004)

The subsequent approach developed was the linear sequential process. Its premise relied on its process in different phases that needed to be fulfilled in order to pass the information gained to the next function until it was achieved the end result. It was recognised that its fundamental problem focused on the information flow, as it moves sequentially from department to department, and forms a problematic ‘over the wall’ development. This increases the lapse of time from product concept to product launch and the number of engineering changes late in the process. As a result, it affects and delays the introduction of the product/service into the market and thus the start of making profit. According to Cooper (2003), the predictable result of a sequential NPD process is the delay in all the activities that lead the process to finish with an expensive product cost and marginal profits.

The generic product development was the next concept produced (Fig. 2.8). It consists of six phases; it begins with a ‘planning phase’ (phase zero), which involves advance research and technology development activities. The output of this phase is the project mission statement which has two aims; firstly, to begin the concept development phase, and secondly to be the guide for the development team through the process. The second phase, ‘concept development’, focuses on the identification of target market need in order to produce concepts that require further development and testing. Therefore, ‘system-level design’ includes the definition of the product architecture and the decomposition of the product into subsystems and components. As well, it considers the final assembly scheme for the production system. Subsequently, the ‘detail design phase’ comprises the complete specification of geometry, materials, tolerance of all the unique parts in the product, and the relation with suppliers. Managers need to prepare a process plan to document and control de product. 'The testing and refinement stage' involves the construction and evaluation of multiple preproduction version of the product. The development of early (alpha) prototypes are required to determine whether or not the product will work as designed and whether or not the product satisfies the key customer needs. In addition, they help to improve later (beta) prototypes that recreate the production process. Finally, 'production ramp-up' phase emphasises the product system of the future product. Its purpose is to train the work force, and to work out any remaining problems in the production processes. The output of this stage is the product launched within the market. Criticism about this model relates to the little relevance on team working and the lack of understanding between departments resulting on late introductions, over-expensive and poor quality products. As well, it was recognised the lack of a feedback loop to the different teams increase the likelihood in the failure of the process.

Figure 2.8 Generic product development process



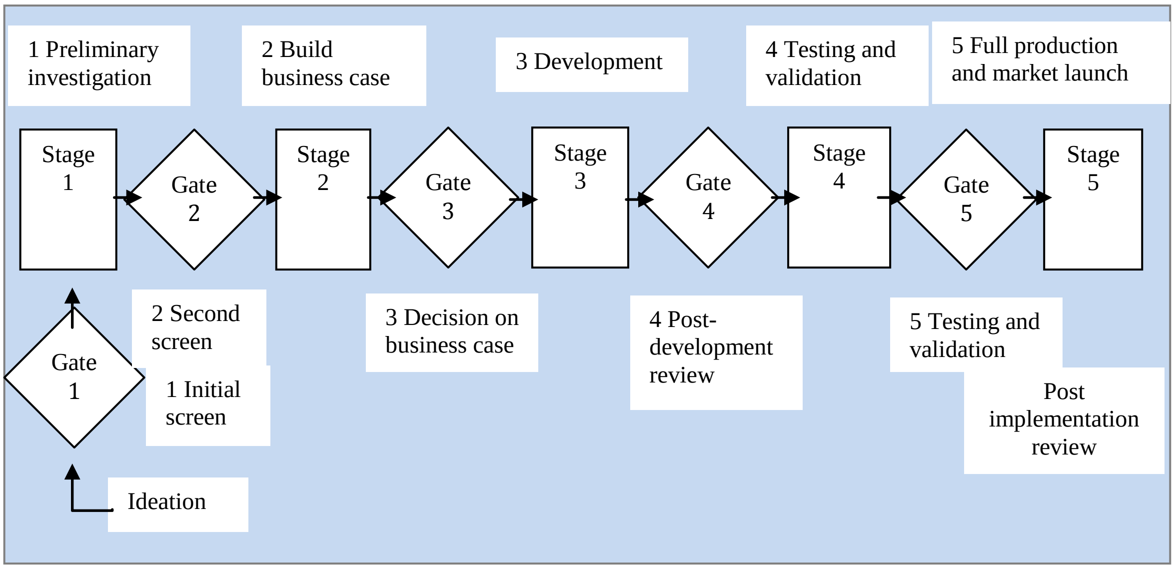
Source: Ulrich and Eppinger (2003)

In 1982, Booz-Allen and Hamilton led research that concerned the understanding of how companies defined the product development stages. This research found out that six key activities were essential for companies to undertake the product development:

0. Development of new product strategy
1. Idea generation
2. Screening analysis
3. Development
4. Testing
5. Commercialization

They concluded that any company interested to produce a new product need to consider these six key phases. Thus, the vast majority of textbooks represent the NPD process as six-stage or eight-stage models (Trott, 1998). New research on process models does not differ from past contributions. In fact, the new models have few variations on their structure, but the importance of these works relies on the understanding of multiple units that interact within the process. For example, Cooper (1979) provided a new model that leverages the understanding of new product development. He recognised that it was important to consider the human capital within the process. Therefore, he produced a model with fixed set of stages, which consist of a set of prescribed, interdisciplinary and parallel tasks to produce accumulative knowledge and interrelations (Fig. 2.9). Therefore, each stage consists of a set of parallel activities undertaken by personnel from different functional areas that work together as a team. He considered that the stage-gate scheme reduces the risk on management because stages were designed to gather vital information, and evaluation gates to drive out technical and business uncertainties. This process depends on incremental commitment from different areas to speed products to market. However, its design remains linear, inflexible and cumbersome limiting innovation and the NPD process itself. As well as, this model assumes that organisations are well structured and have expertise and resources to undertake the NPD process. Thus, these types of NPD models are useful to improve the performance of old models or routine models. This implies that there is not a conscious concern about how to deal and adopt innovations that come from new technologies, technical capabilities or technical platforms that can produce a breakthrough within the society, the industry or the own company.

Figure 2.9 Stage gate process



Source: Cooper (1979)

Recent models of NPD process encourage managers to take an integrated approach to NPD process and these are based on knowledge-intensive activities. This means that rather than making decisions on individual projects, their approach suggests the management and coordination of product development activities from a company-wide perspective, starting with a link to company strategy (Von Stamm, 2004). Therefore, NPD should be viewed as a knowledge accumulation process that requires input from a variety of sources. These models are called network models of NPD, as the process aims to accumulate knowledge from a variety of different inputs, both internal and external to the organisation (Hagedoorn, 1990; Nonaka and Takeuchi, 1995; Trott, 1998). According to Trott (1998:218-219), the knowledge builds up gradually over time as the NPD project progresses. In general, this process of knowledge is usually divided in two knowledge processes: 'knowledge acquisition' and 'knowledge utilisation' (Soo, et al., 2002). Consequently, the 'knowledge acquisition' is discovered or inspired by the external environment and then transferred into the NPD process. Indeed, knowledge triggers new ideas and affect the internal knowledge creation. Then, 'knowledge utilisation' integrates this knowledge with the existing knowledge base and into the NPD process, turning the knowledge into new products/services. This implies that in order to use this type of model, it is required to have high-specialised personnel that are able to manage and transform the inputs (knowledge) in outputs (products/services/process).

2.5.3 Success and failure factors within the new product development

Most organisations require bringing successful new products into the market because they represent business' lifeblood. However, this task represents a complex and difficult activity. According to Balachandra and Friar (1997), more than ever, companies are experiencing difficulties to achieve their objectives. In the opinion of diverse researchers (Balachandra and Friar, 1997; Cooper; 1999; Cooper and Edgett, 2003; Cooper and Kleinschmidt, 2007, 1995, 1987; Crick and Jones, 1999; Griffin and Page, 1996; Jassawalla and Sashittal, 1998; Kraus, et al., 2006; Larsen and Lewis, 2007; Ledwith, 2000; Lindman, et al., 2008; Millward and Lewis, 2005; Montoya-Weiss and Catalone, 1994; Mullins and Sutherland, 1998; Scott, 2000; Song and Noh, 2006; Yap and Sounder, 1994), it is hard to predict why some new products succeed while most fail. According to Griffin and Page (1996), success is not just elusive; it is also multifaceted and difficult to measure because it is highly situational. To assess whether the project was successful or not, companies require considering the individual project (project level) and the overall programme (programme level). Researchers that base their studies at firm level argue that success will depend on the strategy adopted by the firm.

Contrary, scholars who argued that success is based at the project level tend to see it as a multidimensional activity that requires attention for itself. The success factors used by small sized enterprises and TBEs consider mainly actions that lead organisations to adapt, structure, and formalise the NPD process with respect to their business context (Table 2.24).

Table 2.24 Success factors in the NPD process at the firm level

Firm level success factors
Development program ROI;
New product fit business strategy;
Success/failure;
% Profits from new products;
% Sales from new products;
Program hit 5-year objectives;
Products lead to future opportunities;
Overall program success;
% Sales under patent protection;
% Profits under patent protection;

Source: Adapted from Cooper & Kleinschmidt (1995); Griffin & Page (1996); and Montoya-Weiss & Catalone (1995)

Cooper and Kleinschmidt (1995) used previous research findings to develop a conceptual framework that set the program level prepositions. They found out that the company's overall new product performance depends on:

1. Process: the firm's new product development process and the specific activities within this process;
2. Organisation: the way the program is organised (e.g., a cross functional team vs. functional approach);
3. Strategy: the firm's total new product strategy (as part of its corporate strategy);
4. Culture: the firm's internal culture and climate for innovation (e.g., support for teamwork and intrapreneurs); and
5. Commitment: senior management's involvement with and corporate commitment to new product development.

These five main areas cannot be assessed solely because they are interrelated to achieve a successful performance in the business. However, it is recognised the difficulty for enterprises to embrace these five main considerations. Consequently, it is suggested that managers/project leaders must consider three core competences: strategy, process and people, in all the projects. It is because the process relates with project outcomes and the quality of execution of activities that staff execute. Thus, these activities are the reflection of company's strategy. Contrary, Griffin and Page (1996) suggest in their study that the measure to evaluate success depended on the strategy adopted by the firm. They discovered that there are four different groups where companies can cluster in relation to their characteristics: prospector, analyser, defender, and reactor. This means that success will differ from strategy to strategy. Griffin and Page (1996) emphasise that even the ultimate objective of the business is the financial success, it does not implicate that it will necessarily be the principal objective at the project level.

Contrary to programme level, there is substantial information on success factors at the project level. This large body of knowledge (Griffin and Page, 1996; Montoya-Weiss and Catalone, 1994) is diverse in scope because different fields of study have produced insights that provoked rich discussions about the variables that lead businesses to succeed. The main problem in determining the success of individual products arises from the multidimensionality of product development outcomes. Montoya-Weiss and Catalone (1994) carried out a meta-analysis study in order to reduce different determinants of new product performance at the product level. Their meta-analysis synthesised the results of empirical research on the determinants of new product performance and they identified eighteen factors in four major activities (Table 2.25). From this total number of factors, they determined six factors that had not been considered in other studies such as: the environment, financial/business analysis, cost, strategy, speed to market and company resources. They also highlighted the most frequent factors used into strategy (product advantage, technological synergy and marketing synergy) and development process (proficiency of technical activities, proficiency in marketing activities, protocol, top management support/skill, and proficiency of development activities).

Table 2.25 Success factors in the NPD process at the project level

Project level success factors
Strategic factors: Product advantage; Technology synergy; Company resources; Strategy; Marketing Synergy;
Development process factors: Speed to market; Professional technical activities; Professional marketing activities; Protocol; Top management support/skill; Professional pre-development activities; Financial/business analysis; Costs;
Market environment factors: Market potential; Market competitiveness; Environment;
Organizational factors: Internal/external relations; Organizational factors

Source: Adapted from Montoya-Weiss & Catalone (1995);

Griffin and Page (1996) contributed to this area of research through the discovery of six different strategies that firms adopted in the development of a new product, new to the world, new to the company, product improvement, line extensions, repositioning, and cost reductions. Consequently, they set three main drivers that helped companies to evaluate the project:

1. Customer-based success: customer satisfaction; customer acceptance; market share goals; revenue goals; revenue growth goals; unite volume goals; and number of customers;
2. Financial success: met profit goals; met margin goals; IRR or ROI; and break-even-time; and
3. Technical performance success: competitive advantage; met performance specification; speed to market; development cost; meet quality specifications; launch on time; and innovativeness;

The importance of their research relied on the introduction of intangible values such as customer preferences and innovativeness, which are vital on the production of a product.

The success factors discussed previously were centred on large sized enterprises that have a well-defined product development process. As well, these studies were focused on businesses within stable and traditional industries. Thus, there was no consideration in those variables of success in technology-based enterprises or small sized enterprises. For example, TBEs in new technological industries develop products/services for rapidly changing technology markets; therefore, the success factors assume for large enterprises do not have relevance on this condition. Another example is that small sized enterprises tend to have low market share and less market credibility than large enterprises; thus, they rely more on a small number of key customers. This fact has a significant impact on how they should manage the launch of new products. Table 2.26 highlights measures that are useful to execute the process effectively in small sized enterprises and TBEs. It accentuates the need for a process model to guide the actions that are required to follow. This will help the owner to understand the relationship between the parts and the whole, so that the vision is not lost when functions focus on their specific needs.

Table 2.26 Success factors in the NPD process in SMEs and TBEs

SMEs & TBEs success factors
Use formal control procedures; Make process description of the NPD process; Identify review moments and milestones in the process; Pay attention to marketing and design activities; Use concurrent engineering tools; Basic channels of information flow

Source: Adapted from Winterscheid & McNabb, 1994

In opinion of Winterscheid and McNabb (1994), there are two key competencies to success in high technology environments:

1. The perceptual ability to recognise an opportunity, to match ideas within technological knowledge stocks, to seek a niche market need, or to improve technologically an existing product; and
2. The capability to design and deliver a product that matches technology and market needs.

Researchers (Crick and Jones, 1999; Ledwith, 2000; Millward and Lewis, 2005) on Small sized enterprises entrust to the perceptual ability to the entrepreneurial function. According to Crick and Jones (1999), small sized enterprises require considering customer knowledge and relationships in order to implement basic channels for information flow. It is also important to hire skilled labour forces that are able to understand technological and marketing data in order to facilitate the transition of knowledge into a product/process/service. Furthermore, enterprises need to consider adopting an effective organisational process that facilitates the flow of information, control and monitor the development of the product and the achievement of goals.

In 2000, Ledwith contributed to extend the understanding of the NPD process in small sized enterprises based in the electronic industry through highlighting the relevance of external relations to develop new products. These organisations tend to look outside their boundaries for services in order to reduce cost and improve the quality and efficiency in the development of products. Thus, it was important to explore the relationship between the companies and industrial services, subcontracting relationships, licensing, networking, and collaborative research and development. It was recognised that these types of businesses consider of main importance the use of cross-functional or multidisciplinary teams with strong leadership, high level of ownership and accountability, and personnel with skills to manage external relationships. This view relates to the clear consensus among high technology enterprises literature (Braglia and Petroni, 2000; Cosh and Hughes, 2003; Courseault-Trumbach, et al., 2006; Soderquist, et al., 1997; Tidd, et al., 2005; Yap and Sounder, 1994) that underline the importance of high levels of cross-functional integration. Finally, it was recognised that successful enterprises integrated within their NPD the following elements: close relationship with customers and suppliers in technology/product development process; adopt features of horizontal, boundary-less organisations; implement innovative ways of managing technology and people; and experiment with cross-functional teams to manage NPD task environments.

Song and Noh (2006) produced important insights in their research within Korean high-tech businesses. Firstly, they recognised that successful businesses use marketing skills and resources rather than technical skills and resources. In addition, Korean managers value more the marketing driven NPD process over the technology driven process. In addition, project managers' leadership style and skills are core to achieve successful new products. Similarly, the close fit between long-term strategy and the project greatly affects the success of the project. Furthermore, the level of information flow, and contact between commercial and technical entities has greater impact on NPD performance. These findings are similar to Mishra et al. (1996) conclusions, in which they accentuate the relevance of marketing tools to produce a competitive advantage within Korean firms.

Small-sized enterprises and TBEs suffer a series of barriers that halt their NPD development, but also they have advantages that can leverage their performance. In essence, the barriers that face both types of businesses concern five key aspects: processes; culture and management competencies; skilled labour; finance and external information linkages (Crick and Jones, 1999; De Toni and Nassimbeni, 2003; Freel, 2000; Ledwith, 2000; Millward and Lewis, 2005; Winterscheid and McNabb, 1994); whilst, their advantages are fundamentally behavioural (Siu, et al., 2006). Table 2.27 summarises the main constrains faced by small firms and TBEs in order to comprehend holistically their conditions. It is clear from Table 2.27 that one problem creates other problems. For example, the main barrier of these types of businesses is the informality and weak structure of the NPD, as this affects the major quantity of factors that lead to not achieving a new product, service or process.

Table 2.27 Barriers of small-sized enterprises and TBEs related to NPD

Aspect	Barriers	Researchers
Processes	NPD is often informal; NPD process is often weakly structured; NPD process is conducted in an ad hoc manner; Sequence of activities & corresponding responsibilities are frequently vague; Insufficient measurements of NPD progress & performance	Cosh & Hughes, 2003; De Toni & Nassimbeni, 2003; Filson & Lewis, 2000; Millward & Lewis, 2005; Mintzberg et al., 1998;
Culture	Expertise in technological or scientific areas; Lack of management skills & techniques; Insufficient planning; Poor financial decisions and evaluations; Inadequate delegation of activities; Strong influence of dominant owners/manager; Driven by short term requirements; Focus on time & cost; Engage in manufacturing too late; Reluctance to change	Cosh & Hughes, 2003; Millward & Lewis, 2005; Romjin & Albu, 2002; Scozzi, Garavelli & Crowston, 2005
Skilled Labour	Hindered in the ability to recruit, train & retain highly qualified competent personnel;	Freel, 2000; Rotwell, 1994
Finance	Lack of financial resources; Access to finance; Dependence on angel investors, governmental programs, and bank &/or personal loans	De Toni & Nassimbeni, 2003; Drazin & Sandelands, 1992; Freel, 2000; Miller & Toulouse, 1986; Monz; 1992
External information & linkages	Need for external information; Poor awareness of external opportunities; Lack of functional experts	Freel, 2000; De Toni & Nassimbeni, 2003; Ledwith, 2000; Mishra et al., 1996; Song & Noh, 2006

Source: Adapted from De Tony & Nassimbeni, 2003

Lindman, et al., (2008) argue that design is a key issue in NPD. They consider that products go far beyond of the consumer's preference. Issues such as good usability, functionality, pleasure, and personal self-expression of the product become an important part of the development of products. Millward and Lewis (2005) suggested in their study the classification of design tools and techniques that facilitate the NPD process. Due to design being at the hub of the process linking the front-end customer interactions with the final manufacturing solution. They found that those companies with in-depth product knowledge, full resources support, commitment to quality, and a vision to innovate and implement change tend to use design within their NPD. Therefore, those enterprises that use design to lead technology can enhance design and development, but a process or system would also appear to be necessary to overcome the downstream and upstream product development boundaries.

In summary, *small sized enterprises and TBEs have advantages that let them overcome lack of resources and managerial knowledge. These advantages concern mainly with behaviours such as great commitment among employees and motivated management; flexible organisational process; receptive structure to organisational and operational changes; personal, direct and oral communications; close relationship with customers and suppliers; and the capability to design and deliver a product that match technology and market needs* (Crick and Jones, 1999; Ledwith, 2000; Milward and Lewis, 2005; Winterscheid and McNabb, 1994).

2.6 Design as a value asset within the business environment

Throughout the last three decades, design has become more than a simple activity within organisations (Bertola and Teixeira, 2003; Borja de Mozota, 2003; Bruce and Bessant, 2002; Cooper, et al., 2009; Gorb and Dumas, 1987; Lauche, 2005; Oakley, 1990; Stevens, 2007; Tether, 2005). Design has become an asset that has shifting from an economic view to a strategic view of resources (Borja de Mozota, 2006; Borja de Mozota and Young-Kim, 2009; Bruce, et al., 1999; Design Demand, 2007; Inns, 2002; Oakley, 1990). This implies that it has turned into a strategic asset to achieve better competitiveness. Therefore, the number of connotations and associations between firms, societies and nations, and design has increased sharply within the last two decades. Even, it has become an integral part of the daily life vocabulary and its use goes beyond other areas. Nevertheless, it remains a wide misunderstanding about its use, expertise and benefits within the different arenas, business, society, and nation, in which it is implemented. Thus, this section seeks to define design, its values, processes, roles and interactions within the business environment.

2.6.1 Defining design

Design is a broad field of study that groups diverse specialisations and has ramifications that pertain to other areas of knowledge; this, in turn, makes it difficult to define. From an academic perspective, it is subject to ad hoc definitions and tends to relate to activities and outcomes that have imprecise boundaries (Tether, 2005). In respect to the business view, it is related to aesthetics, to new product development as part of the creative thinking process and to strategic business tools. However, it is clear that design refers to processes and outcomes, as both actions are constant throughout all studies. Commentators (Borja de Mozota, 2003; Bruce and Bessant, 2002; Cooper and Press, 1999; Dickson, et al., 1995; Gorb, 1990; Peters, et al., 1999; Oakley, 1990) describe design as an outcome (tangible or intangible) of a process, and the process (creative thinking and planning) that allows for solving of problems. This section explores different definitions that have been produced over time.

The etymology of the word design derives from the Latin *'designare'*, which means 'to designate' and 'to draw'. When it is translated into English, it keeps its bivalent use and refers to nouns and verbs that mean 'a plan' or 'a sketch' (Oxford English Dictionary, 2010). In the opinion of Borja de Mozota (2003), design can represent, depending on the context of use, 'a plan, project, intention, process' or 'a sketch, model, motivate, decor, visual composition, style'. Design is integrated by a family of disciplines that share specific skills and expertises that base its foundations on either sciences or arts (Table 2.28). Consequently, the area of specialisation determines the use of certain design process and the specific outcome obtained. In any case, design techniques combine the logical character of the scientific approach and the intuitive and artistic dimensions of the creative effort. Design becomes a bridge between art and science, where both are complementary in the nature of both domains (Borja de Mozota, 2003).

Table 2.28 Design family ramification

Subject	Art		Science		
Design divisions	Graphics	Fashion	Products	Environments	Engineering
Specialisation	Illustration Web design Packing	Textile Fabrics Fashion	Furniture design Industrial design Automotive design	Exhibition Interior design Architecture Structural engineering	Mechanical design Electrical engineering
Expertise	Drawing		Modelling		Simulation
Skills	Perception Imagination Geometry Visualization		Geometry Manipulation Tactile properties Testing Dexterity Processes and Materials		

Source: Borja de Mozota (2003)

Most of the design definitions focus on the process (the design process) or an outcome of that process (product or service). For instance, this duality between the process and the outcome is the origin of confusion for designers and non-designers. Borja de Mozota (2003) suggested that design has three characteristics that shape its work: problem-solving activity, systematic activity and coordinating activity (Table 2.29). Thus, design entails thinking and seeking about the consistency of a system or the intelligence of an object. Similarly, the International Council Societies of Industrial Design (ICSID, 2008) regards design as an activity, which deploys an effective management of resources within a process in order to generate an outcome. This implies that designers have to be able to convey the external requirements through the process in order to produce an outcome that satisfies the firm and consumer.

Table 2.29 Design characteristics

Design Characteristics	Design definition	Key words/Terms
Problem resolution	Design is a plan to manufacture something that one can see, touch, hears. P. Gorb	Planning manufacture
Creation	Aesthetics is the science of Beauty in the domain of industrial production. D. Huisman	Industrial, production aesthetics
Systematization	Design is the process by which needs of the environment are conceptualized and transformed in instruments to satisfy these needs. A. Topalian	Transformation of needs process
Coordination	The designer is never alone, never works alone, therefore, he is never a whole. T. Maldonado	Teamwork Coordination
Cultural contribution	The profession of designer is neither that of an artist nor an aesthetician; it is that of a specialist in semiotics. P. Starck	Semantic Culture

Source: Borja de Mozota (2003:5)

Academics and organisations (Best, 2006; Bruce and Bessant, 2002; Design Council, 2008; Walsh, 1996) consider that this process is creative, as it helps to solve problems within the development of new products/services. Walsh (1996) and the Design Council (2008) agreed that all the activities covered by the word 'design' involve '*the creative visualisation of concepts, plans and ideas aimed to provide the instructions for making something which did not exist before, or did not exist in that form'*. Bruce and Bessant (2002) argued that design is an innovative process, in which designers use their skills to understand peoples' needs and companies' requirements and translate them into a product/service. Thus, it can be suggested that designers are creative thinkers that use the process, as a means to employ their skills to produce innovative outcomes.

Another line of research describes design as a planned process. Wolff and Gonçalves (2008) suggest that design is akin to management because its nature tends to be a problem-solving activity. Designers are the medium that conceives signs, spaces or artefacts using methodological process in product development to fulfil specific needs. Similarly, the Japanese Ministry of International Trade and Industry (MITI) supported the idea of design as a planned process within the business approach. It describes it as *'the decision making-process that deals with the manifestation of objects with consideration to economy and technical function and in answer to various consumer demands'* (cited in Cooper and Press, 1999:36). Finally, Kotler and Rath (1984:18) share a similar opinion, and termed design as *'the process of seeking to optimize consumer satisfaction and company profitability through the creative use of major design elements (performance, quality, durability, appearance and cost) in connection with products, environment, information and corporate identity*'. These definitions agree that design is a process that aims to produce benefits for consumer and companies through the effective use of design resources.

Under this brief review of diverse design definitions, stand two main concepts of design: one as a process and another as an outcome of this process. Thus, design under this research represents *'a process that employs different resources in order to fulfil the requirements established by the company and external factors to satisfy and optimise the market expectations using outcomes (products/services) that can be tangible or intangible'*.

2.6.2 Defining design management

A substantial amount of research on design management has been undertaken during the last three decades. Academics and practitioners have recognised that design management has become an asset for businesses, as it impacts their performance internally and externally (Best, 2006; Blaich, 1993; Borja de Mozota, 2006; Chiva and Alegre, 2007; Cooper and Press, 1999; Cooper, et al., 2009; Corfield, 1979; Design Council, 2009; Gorb, 1990; Hands, 2009; Joziasse and Selders, 2009). Thus, the theoretical framework of this field of study is based on a wide and rich array of individuals' and professionals' backgrounds that have their roots in marketing, sociology, psychology, engineering, and indeed design. Even though, the scope of this area is wide, there is concise material that attempt to provide agreed definitions for specific aspects of design management. Consequently, it is important to examine its transition to establish a theoretical underpinning.

It can be considered that design management is a new area of study and practice because its discourse became popular within businesses in the late 1960's, and its academic development started in the 1990's. Nevertheless, Johansson and Svengren (2002) argue that the practice of design management began since the industrial revolution when entrepreneurs hired artist to develop the 'right design'. This activity evolved further during the 1950's because artists became designers; therefore, their actions become more conscious. Under this context, the main purpose of design management was to produce products that succeed in a competitive market. Hence, its concern with managing actions that were directly related to the process of product development (Blaich, 1993). Academics focused on searching for the best practices in product development processes; the relationships among product designers, engineers and marketing experts; and the role of the designer in a product development team (Cooper, et al., 2009). The complexity of using design increased, thus provoking the employment of designers within firms' operations. This in turn led to recruiting experts that would be able to recognise the specific skills of every designer and to coordinate and manage the divergent outcomes of a group of designers.

In 1979, Corfield submitted a major report to the UK government, in which he argued that effective design management is key to companies that wished to remain competitive in increasingly difficult markets. The report recommended that product design should be recognised by companies as a key business function specifically identified as a board level responsibility, on a par with production, finance. It cited that *'failure to adopt a good, strong design policy can only be interpreted as one of the steps on the road to bankruptcy for companies. Thus, companies should designate an appropriate member of their boards to take on the design function as a prime responsibility where that is not already the case'* (Corfield, 1979:12). Reviewers of the Report have criticised Corfield for not making a clear recommendation that designers should be appointed to company boards. A year later, Topalian (1980) commented on the Corfield report, about the contribution to position designers on boards. Nevertheless, the design profession should concentrate instead on a more sensible approach in where managers and designers focus on their respective roles whilst increasing the sensitivity and understanding between them. Consequently, during this time design management represented the effective deployment by line managers of the design resources available to the company to help on achieving its objectives (Gorb, 1990). Above all, it centred on the integration of design (design process) within the product development. Hence, designers were involved on the understanding of different management topics such as strategic management, organisational learning and especially innovation. Ergo, the academia centred its curricula on product design (relating to gross margin of businesses), environmental design (relating to those actions that businesses use to achieve their main purpose) and information design (referring to those means by which businesses communicate their purpose to their audiences).

Blaich (1993:13) defined design management as *'the implementation of design as a formal program of activity within a corporation by communicating the relevance of design to long-term corporate goals and co-coordinating design resources at all levels of corporate activity to achieve the objectives of the corporation'.* This definition represented a breakthrough on the theory of design management, as it constituted the beginning of a more holistic view about its use within a business context. Indeed, it was a discussion about the clash between design and management and the gap on the collective cultures of both groups (Callaway, 1990; Cooper and Press, 1999). According to Cooper and Press (1999), the concept of design management contains a fundamental contradiction. For one side, design relies on creativity, exploration and risk-taking; whereas, management is based on control and predictability. Thus, when both areas amalgamate, the danger pertains on the overlapping of actions between them provoking a reduction on their scope and performance. To overcome this problem, research has emphasised the relevance on the relationship between designers and managers and their professional experience. In 1990, Oakley edited a book that provided a rich overview on the strategic use of design management within the business context and the experience on its application throughout different areas. He concluded that it was necessary to implement an interfunctional collaboration among design activities. In 1998, Design Management Institute published an article where eighteen practitioners defined design management. The importance of this article relied on two key aspects, the first concerned the awareness of design within the business context, and the second dealt with the widening of the design field among students and managers. The following key points emerged from the contributors: design is seen as a strategic and purposeful organising activity; design is experienced as facilitator to take effective decisions in the design process; and design is considered as applied innovation that lead organisations to generate creativity.

Since 2000, design management has been considered as a core competence (Lockwood and Walton, 2009). Most design-oriented companies have transformed their views from design as differentiation value to design as transformation value (Borja de Mozota and Young-Kim, 2009). Businesses are adopting a design leadership ideology when they are planning their business strategy. Borja de Mozota and Young-Kim (2009) suggest that the strength of this strategy relies on companies thinking of design processes, as not only like a set of project management tools, but also as organisational capabilities that repeatedly provide superior customer care. Cooper, et al., (2009) suggest that this new context for the practice and the research of design management is empowering organisations to adopt design thinking and design activities either in manufacturing or in marketing and branding. Design management is changing its course from designing as managing to managing as designing.

The varied definitions approached throughout this section underline the complexity of design management (Table 2.30). It has stressed the gap between theory and practice and the wide spectrum on design and its typologies and connotations (Chiva and Alegre, 2007). For the purpose of this research, design management refers to *'the formal implementation of design activities within a business leading to adopt a design core competence that allows the business to have a sustainable growth through the most suitable application and coordination of long-term and day-to-day strategic activities with the aim to achieve the firm's final objective. This means that it is an approach whereby organisations make design-relevant decision to achieve the aims of the firm and fulfil the consumers and market requirements, as well as optimising design relevant (corporate) processes. Thus, it is a comprehensive activity used at all levels of a business and it affects all the functions that interface with it'*.

Table 2.30 Historical development of design management

Period	Main Perspective	Design Role	Design Management Focus	Progression of Design Management
1940s to 1950s	Design as function	Product quality	None	Market and context of manufacturing
1960s to 1970s	Design as style	Quality communication	Project management	
1980s to 1990s	Design as a process	Innovation	NPD innovation management	Process performance
1990s to 2000s	Design as leadership	Creative strategy	Brand	Strategy and context of brand and marketing
2000s to Now	Design thinking	New business model	Creative organisation	Context of organisation and society

Source: Adapted from Borja de Mozota and Young-Kim (2009) and Cooper, et al., (2009)

2.6.3 Design as a strategic asset within business activity

The value of design within the business context has been explored throughout the constant development of studies in different context and areas of application (Bertola and Teixeira, 2003; Borja de Mozota, 2006, 2003; Borja de Mozota and Young-Kim, 2009; Boyle, 2003; Bruce and Bessant, 2002; Cho, 2004; Cooper and Press, 1999; Design Demand, 2007; Dickson, et al., 1995; Geraghty, 2008; Gorb, 1990; Jerrard, et al., 2002; Joziasse and Selder, 2009; Lauche, 2005; Oakley, 1990; Perk, et al., 2005; Peters, et al., 1999; Salmanki and Gabrielson, 2005; Stevens, 2007). However, it does not mean that all the values have been recognised, as design is an area that is still changing and highlighting new ways in which it can be attained. Indeed, there is often a misunderstanding on the value of design (the process) and the designer (professional) within the business context. This part aims to investigate the areas in which design contributes to the different levels of a firm and the different approaches it can adopt.

The new economic system depends on the generation of new products, systems and services to develop a sustainable advantage. Design management plays a key role, as it is the gateway to integrate design at the corporate, tactical, and operational level (Borja de Mozota, 2006; Bruce and Bessant, 2002; Cooper and Press, 1999; Design Council, 2005; Lockwood and

Walton, 2009; Oakley, 1990; Walsh, et al., 1992). It is then possible to deploy creative people that can use analytical skills, to solve a wide range of problems. Table 2.31 summarises the specific areas in where design can add value.

Table 2.31 Levels in where design add value

	Corporate Level	Business Level	Process Level
Lockwood and Walton (2009)	Purchase influence/emotion; Brand image & corporate reputation; Design (ROI)/cost saving; Enable product & service innovation; Design patents/trademarks/ IP;	Enable strategy/enter new markets; Increase customer satisfaction/develop communities;	Improve time to market & development processes; improve usability; improve sustainability;
Joziasse and Selders (2009)	More sales transactions; Distinctiveness & user awareness; More intellectual property; Faster & smoother internal change; Lower environmental degradation; More solutions for social issues;	Higher premium prices; Better reputation & user reputation;	Lower production cost; Lower marketing cost; Shorter time to market;
Design Demand (2007)	Small business tend to grow faster; Better performance on share prices;	Increase sales;	Introduction of product & services;
Design Council (2005)	Company image; Communication with customers; Increase profits;	Break into new market;	Quality; Reduce costs;
DTI (2005)	Affect competitiveness; Enhance exports; Retain and regains market share; Improve financial performance;		
Bruce and Bessant (2002)	Powerful mean to convey persuasive ideas, attitudes & values	Change patterns; Diversify design;	
Cooper and Press (1999)	Design and social values;	Contribute to both price and non-price;	Vital in innovation cycles; Made values visible;
Walsh, et al., (1992)	Company image;	After-sales services;	Delivery time; Non-price quality & price;
Oakley (1990)		Superior products; Inject life in mature markets;	Introduce new/adapted products;

Design at the corporate level contributes to improving the financial performance, competitiveness and levels of innovation of the businesses. Most commonly, the implementation of design management aims to create a company image that helps businesses to position or to differentiate their products/services in the market context. Indeed, this corporate image also endeavours to create linkages with the prospect customers and provide a bond between customer and business. In order to create a company image (brand) the firm requires that its products/services, and locations (physical and virtual) in where the customer interacts, provide a powerful means to convey persuasive ideas, attitudes and values. When there is a great expertise on design management, it is possible to evolve the firms' business model to better seize market opportunities considering with it the environmental impact and degradation and to provide better solutions for social issues. Another powerful strategy is to focus on the market in which it is used altogether marketing, management, engineering and design. In order to exploit the market through products/services that meets the needs and desires of the targeted customers. Companies also base their strategy on cost in which they rely on management and engineering to reduce costs in the new product/service development. This allows them to compete through low costs in the market.

At the tactical (business) level, design management aims to create models that help to unify user (market) awareness, enterprise values and employees skills to produce an outcome that delivers value to the three groups involved. Fraser (2009) suggest that when these three groups works altogether, it is possible to have a large number of breakthroughs using insights and unmet needs to inspire high-value conceptual solutions and extract strategic intent from the concepts to recast strategic business models.

According to Best (2006), design is beneficial to those enterprises that want to produce more distinctive products and services. Due to influences from initial research ideas moving through the supply-chain management to the point of sale. In the opinion of Gorb (1990), design can affect the performance of the company through its contribution to a range of critical management issues which determine the nature and so the profitability of the product. These critical issues are: product innovation in which design is the determinant in the amount of innovation and its rate of flow; quality which is best controlled by designing; and product range development where design has a key role in co-ordinating, simplifying and promoting it. In addition, there is a significant relationship between increasing investment in design and the percentage of sales that comes from new product developments launched (Dickson, et al., 1995). The influence of design on achieving new product development goals, mostly in technological innovations; and in the positive association of design with higher product quality (Swink, 2000).

Design also provides advantages in three activities that steer innovation: 1) mean that help to generate innovation; 2) agent knowledge that foster innovation; and 3) improve the design practices of the company (Bertola and Teixeira, 2003; Borja de Mozota, 2003; Hargadon, 2005; Lauche, 2005; Verganti, 2003). According to Borja de Mozota (2003), design can take two critical paths to improve the innovation value. (1) Creating a better product through the conceptual dimension of design innovation, radical innovation and design. (2) Improving the innovation process through coordinating design on three levels: marketing time, project team innovation and innovation as a learning process. Therefore, this process needs to be based in an idea-building process[2] and idea-formalising process[3]. Indeed, this value of design to innovation tends to be used in large-sized enterprises. Therefore, Bertola and Teixeira (2003) suggest that there are two distinctive ways in which design acts as a knowledge agent: as a 'knowledge integrator'[4] in global corporations and 'knowledge broker'[5] in local companies. These two strategies emphasise the opportunity of envisioning design as a multi-functional activity, capable of flexibly adopting to specific contextual factors and contribution to the development of product and business innovation in any given situation. This statement is supported by Verganti (2003) in the idea of design as a brokering language, and Hargadon (2005) in the idea of multidimensional tasks. Nevertheless, it is important to emphasise this potentiality of design, it has to be supported by the organisation to enable designers to interact with colleagues proactively, to share relevant information and to learn collectively (Lauche, 2005). Under this premise, Lauche (2005) based on a framework of proactive design and psychological theories, four criteria for job design: control over the design process, availability and clarity of design-relevant information, feedback on results and management support.

As it can be seen, the benefits of design can be quantitative and qualitative, but its nature is intangible (Fig 2.10). Indeed, the benefits that offer design at the different levels are not isolated but rather intrinsic. Consequently, it is important to explore how these benefits can be achieved through a series of actions and implementations.

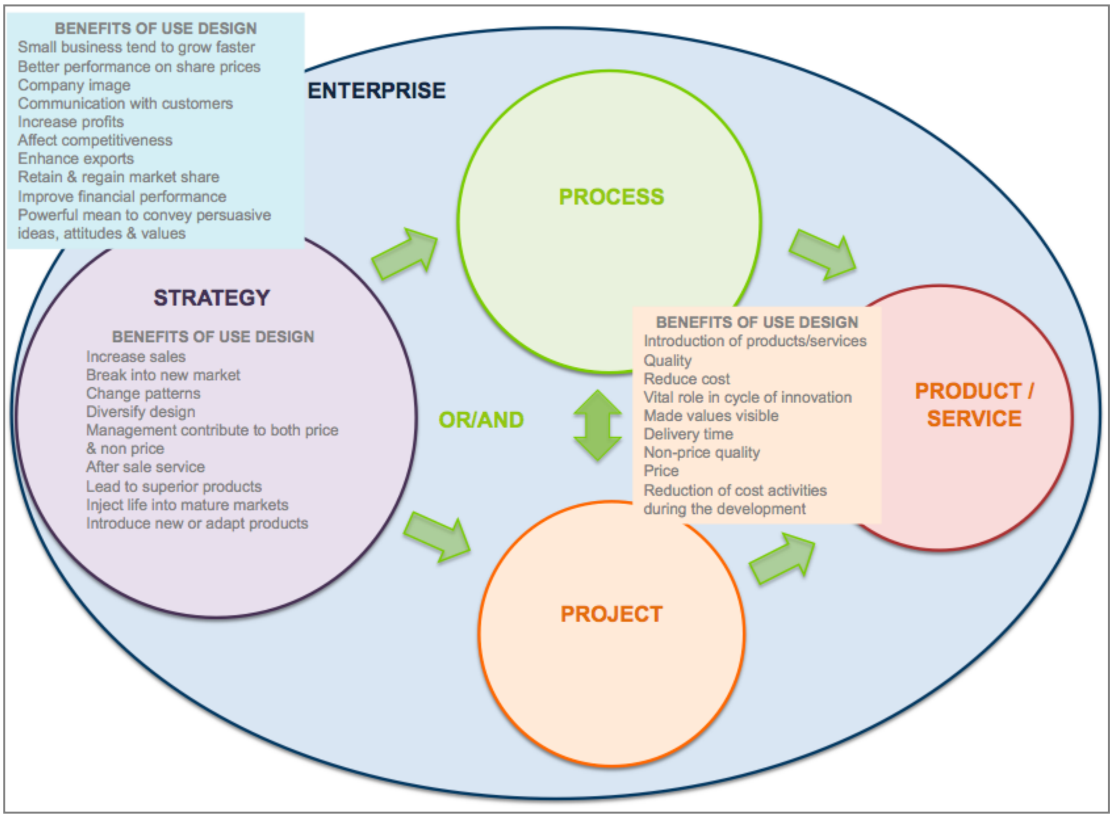
[2] **Idea-Building Process.** A convergence of a problem and a resource, establishing a focal point that identifies the source and forges the way (Borja de Mozota, 2003).

[3] **Idea-Formailising Process.** The formalisation of the idea in order to make it understandable to others and set up an idea processing system (Borja de Mozota, 2003).

[4] **Knowledge Integrator.** By mediating through formal and structured methods, the knowledge of technological capabilities developed inside global corporations for application outside the organization and intended to transform (desirably for the better) users' community knowledge (Bertola and Teixeira, 2003).

[5] **Knowledge Broker.** Promoting knowledge flow from outside to inside organisations. The knowledge diffused outside is internalised as a strategic resource for developing incremental innovation on products meaning and functions, based on the social and cultural rtends generated by users' communities (Bertola and Teixeira, 2003).

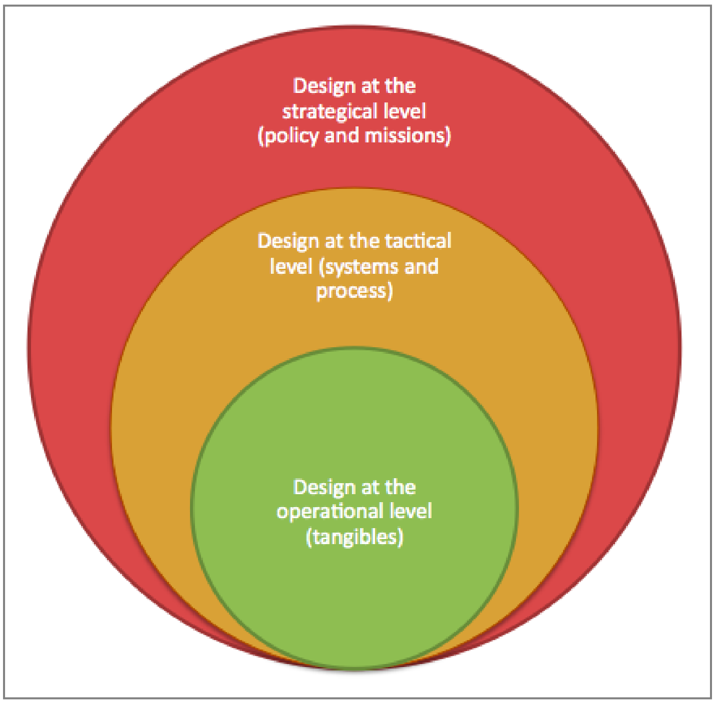
Figure 2.10 Design benefits



2.6.4 Design management levels

Design is an activity that influence and affect the management of a business on different levels. According to Best (2006:16), *'design can affect management on many different levels and different ways, as it is a function, a resource and a way of thinking. It can be active at the strategic, tactical or operational level, in setting either long-term goals or day-to-day decision-making'* (Fig. 2.11). When design is adopted at the strategic level, it deals with overall policies, missions and agendas. At the tactical level, it interacts with teams that deal with processes and systems of specific business units or functions. At the operational level, design participates on the generation of physical and tangible products, services and experiences that customers can actually 'touch' or 'feel'. For the purpose of this research, the strategic level deals with the strategies implemented in TBEs. The tactical level deals with the new product development process and finally, the operational level concerns in the design activities and culture.

Figure 2.11 Design levels in a corporation



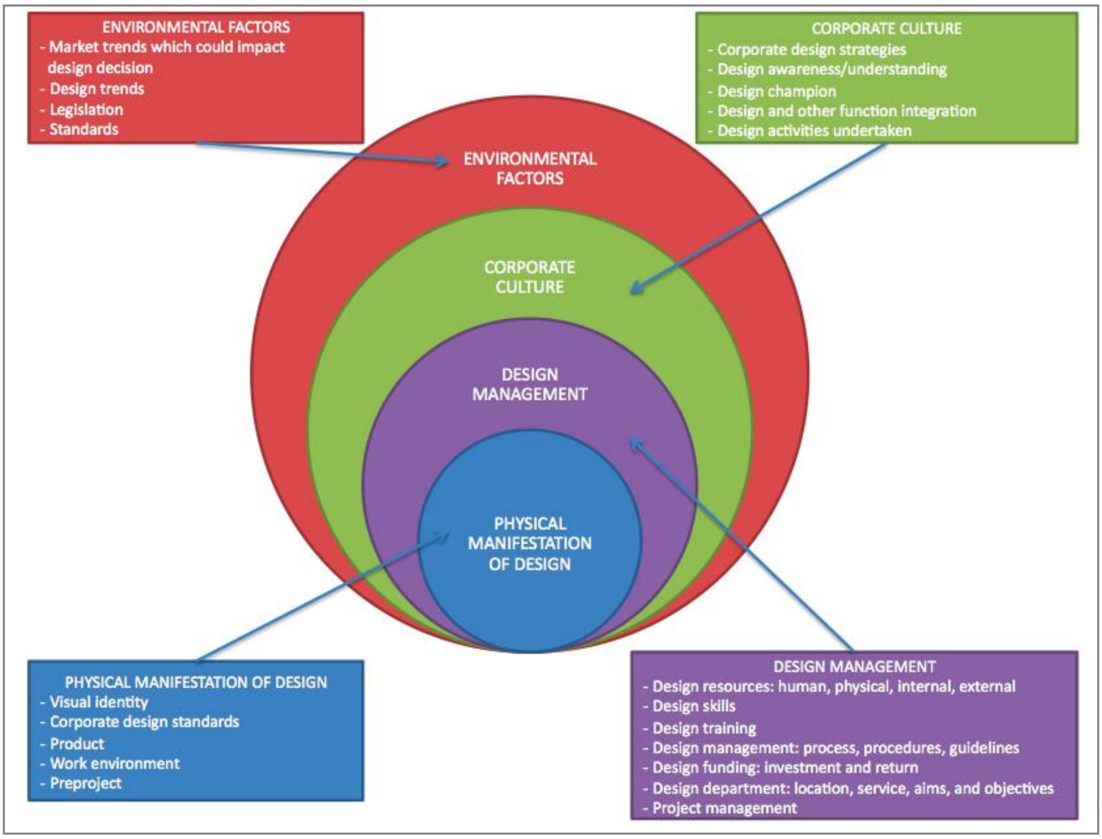
Source: Best, 2006

a) Design management at the strategic level

Design at the strategic level concentrates on the management of corporative level activities and the coordination of inter-organisational decision-making activities. It conceives the corporative level as a 'production line' that aims to achieve its goals and objectives. Its main concern is to understand the demand from the market in order to acquire the necessary requirements to assess better the translation of ideas into a product/service (Tunstall, 2000). According to Gorb (1990), linear managers need to deploy effectively the design resources available within the company to achieve this state. Sebastian (2005) suggested that the inter-organisational decision-making becomes less complicated because management relies on the optimisation of techniques to make decisions without conflicting goals from different areas. Therefore, a design leader is required to exercise design into the overall development of activities, to lead the firm, to manage projects, and to supervise the contractual relationships with other parties. This implies that this leader should be in charge to respond to the individual needs of the business and to contribute using design effectively within its activities (Cooper and Press, 1999). Oakley (1990), Clipson (2005) and Topalian (1994) argue that managed design at this level is critical as it allows the injection of creativity and innovation at the tactical and operational level. However, this approach is criticised because it consists of the excess of rational judgement and it loses the flexible and creative part of design. As well as, it suffers from a limited involvement on the activities of designing.

Cooper and Press (1999) were one of the first academics that explored holistically the design activities within an organisation (Fig. 2.12). They considered four levels in which design is termed and related to all the activities of the organisation. In their aim to develop a design management audit, they address the importance of environmental issues, corporate culture, management of design and the physical manifestation of design. It is clear that in order to apply effectively and efficiently design throughout the organisations' activities it is necessary to understand it.

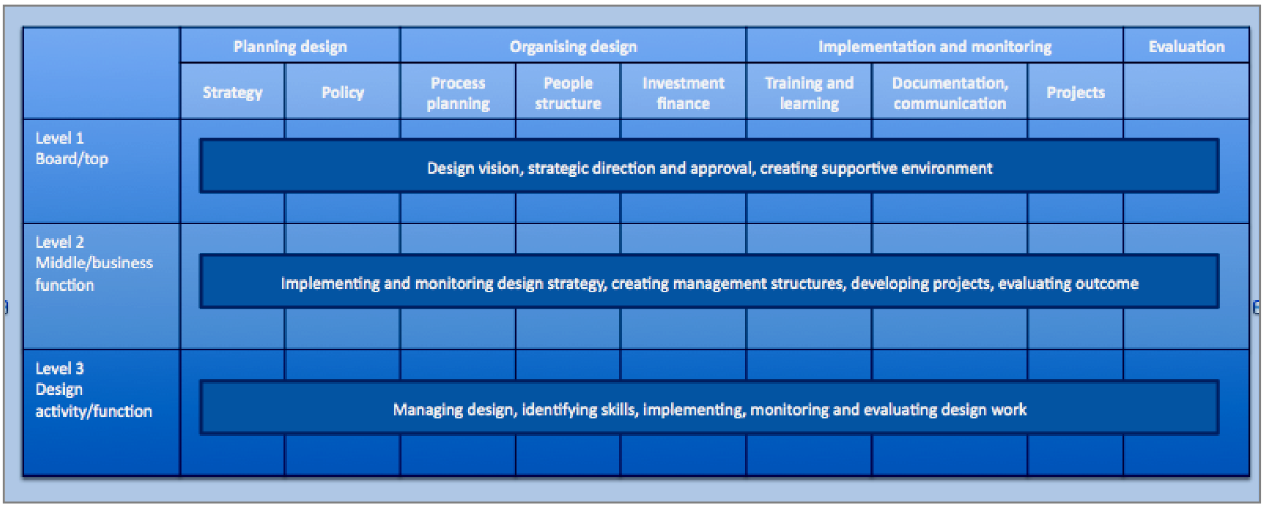
Figure 2.12 The levels that a design audit might address in an organisation



Source: Cooper and Press (1999)

Cooper and Press (1999) also proposed a guideline to manage the design within the business using a design management matrix (Fig. 2.13). They accentuate four significant management activities, planning, organising, implementing and monitoring, and evaluating, that are general at any level of a company. Design managers at the top level are able to envision the strategic use of design to set directions to employees and to approve the work using creative and supportive environments. These knowledge and experiences can be introduced to the business function. At this level, designers need to implement and monitor the design strategy generated at top level to create management structures, to organise people and investment, and to evaluate continuously the project and outcomes. Finally, design managers can make tangible the strategy generated at the top level through the implementation of the employees' abilities and skills in purposeful activities. It is important to mention that the matrix emphasises the strong link between levels and the importance of each one for the better development of each activity.

Figure 2.13 Design management matrix of issues to address



Source: Cooper and Press (1999)

This design management matrix was mainly adopted by large sized enterprises. By 2003, Borja de Mozota explored design management and its wide range of outcomes and advantages. This work reviewed the different design expertises that can play a role to achieve a strategic approach within the business (Table 2.32). It explained the reasons why the results in the businesses can vary from tangible to intangible aspects or to price factors to no-price factors. Table 2.32 shows that the results expected from the design activities depend on the level of implementation of design within the organisation. This refers that the more specific its use within business activities, the faster and tangible its contribution. Thus, the more general its use the slower, intangible and valuable its contribution.

Table 2.32 Matrix of design integration within the company

Function/Design	Graphic Design	Package Design	Product Design	Environmental Design
CEO	Corporate identity		Innovation	Work space/ factory
Corporate Communication	Corporate identity			Event/tradeshow/ welcome area
R&D Production	Technical documentation	Logistic packaging	Innovation	Factory
Marketing	Brand graphics Web site	Packaging product/ promotion	Product range	Trade show/store

Source: Borja de Mozota (2003)

Both studies helped to outline the basis of the activities that need to be considered when a designer manages and supervises activities within the organisation. In turn, this assisted to produce a series of design strategies that were consistent with generic visions of companies. Under this idea, Trueman and Jobber (1998) classified four different design strategies that aim to facilitate the introduction of design within companies (Table 2.33).

Table 2.33 Levels of design strategy

Design strategy	Design attributes	Company goals
Value	Product styling Aesthetics Quality Standards Added value	To add value for consumer and enhance company reputation
Image	Product differentiation Product diversification Product identity Brand identity Brand creation	Company image and strategy
Process	Generate new ideas Idea communication Interpret ideas Integrate ideas Promote products	Culture for new ideas, creativity and innovation
Production	Reduce complexity Use new technology/materials Reduce production time	Improvement and reduce tie to market

Source: Bruce and Bessant (2002)

Table 2.33 illustrates that depending on the companies' goals and necessities, the manager can use and implement the most beneficial design strategy. For example, if the company requires enhancing its reputation, it should focus on the final product/service and its brand identity. Alternatively, if it needs to market position the company then it should concentrate on the information that its products/services convey through its brand to consumers. When the company needs to improve its process, then it should use design as activity that sources the culture of innovation and creativity. If it wants to improve the production, then it should use design to improve and to reduce ties to market. Since 2000, the role of design, at the corporative level, was extended as it does not focus on design strategies but also in business models (Fraser, 2009). This can be achieved by expanding design thinking across the organisation and throughout the business development process.

According to Brown (2009:149), design thinking is '*an approach to creative problem solving based on a human-centred design process. Thus, design thinking can be practices by everybody and should migrate outward into all parts of organisations and upward into the highest levels of leadership*'. Thus, Cooper, et al., (2009) suggest that design thinking encompasses three dimensions that pertain to the overall business context: thinking of (related to imaging, visualising, dreaming up), think about (related with consideration, reflection and deliberation), and think through something (related with understanding, grasp and figure it out). Indeed, these three design thinking propositions can be implemented at any level and by any person in their everyday life. Nevertheless, it is important to consider the expertise of designers to provide more insights in the methods to match people's need with what is technologically feasible. Then, the organisation can transform these ideas or knowledge in a viable business strategy to convert them into customer value and market opportunity (Brown, 2008). Therefore, design managers need to be able to influence the way of thinking within the business. The effects that design thinking had in design management, at the organisational level, concern on transforming business strategies and the way they do business.

Design leadership is an approach that has been gaining attention from the business community, as it concerns on explaining the potential of design as a transformative force in business and society by examining the intersection of leadership with design strategy. According to Turner (Turner in Best, 2006:186), design leadership is about helping organisations to envision the future and to ensure design is used to turn those visions into reality while design management is about delivering successful design solution in an efficient, cost efficient way. This implies that design leadership defines what the future should look like, aligns people with that vision, and inspires them to make it happen despite obstacles (Kotter, 1996:25). Turner and Topalian (2002) suggest that design leadership had three additional aspects: the difference in leading through design, sustaining design leadership overtime, and gaining of acknowledge for achievements through design. Therefore, leaders and/or managers, non-designers and designers, need to consider six main activities: envisioning the future; manifesting strategic intent; directing design investment; managing corporate reputation; creating and monitoring environment of innovation; and training for design leadership. Thus, design leadership aims to lead design and to lead business by design.

The introduction of design leadership within business is possible because designers are specialist in general and holistic approaches. Designers are able to communicate with a multitude of other disciplines, and gain information that later will transform the whole vision of the business context. They need to balance their scientific, technical, technological, economic, artistic and cultural approaches and construct foundations for the development of: soft-reflexes (creativity to conceptualise and to maturity); hard skills (intellectual skills and methodologies); and responsible attitudes (environmental awareness, cultural integrity and respect). Thus, design leadership requires broadening its boundaries to adopt a more holistic approach, as the one provided by Gloppen (2009). According to Gloppen (2009:2), service design leadership is as '*an approach where leaders in service organisations understand and use the power and value of design and design thinking's contribution to a visionary strategy process intended to create innovative services. Service design leadership involves a multidisciplinary and interdisciplinary synthesis approach to problem solving and innovation*'. Nevertheless, to achieve this approach design leadership needs design management, as it comes into play in the implementation of the strategy.

Several researchers have linked design management to business management and design leadership issues (Borja de Mozota, 2003; Cooper and Press, 1999; Dumas and Mintzberg, 1989; Gorb and Dumas, 1987). This is due to design management aim to link design, innovation, technology, management and the end-market across the triple bottom line of economic, social/cultural, and environmental factors, to produce improvements. They argue that even though design management and design leadership differ in their target, their execution, and their result, both are dependent by their reciprocal effects. Design leadership describes future needs and selects a direction in order to arrive at the described future. Contrary, design management answers to given situations by the application of special abilities, tools, methods and techniques. This implies that design management needs design leadership to know where it goes and design leadership needs design management to know whether it arrived to its aim.

It is important to highlight that in the context of SMEs and TBEs, design specialities are scarcely adopted. This is due to two reasons, first leaders/owners of the organisation are not trained designers, and in-house designers do not have the expertise to use design comprehensively. However, this does not mean that leaders/owners do not influence design decisions and processes, as they often do in unacknowledged ways. Gorb and Dumas (1987:150) have coined to the action of *'design by people who are not designers and are not aware that they are participating in design activity'*, silent design. By 1991, Dumas and Mintzberg further explored how the role of manager as designer can have a profound impact on innovation. Thus, it is of key importance to turn this unconscious 'silent designers' into conscious strategic 'design thinkers', meaning a leadership attitude that acknowledges the power and value of design, and include design thinking in their design leadership approach (Gloppen, 2009).

Consequently, case studies in SMEs and TBEs are important in order to understand the implementation and use of design. For example, in Borja de Mozota's (2006) study of European SMEs, was developed a design model in which were described four types of strategies that bring value to the businesses. Design was introduced in business strategies as differentiator, integrator, transformer, and good business (Table 2.34). This value model was based from the management science. Therefore, design managers require understanding from the business perspective about what type of strategy is the most adequate for SMEs that need to position themselves and to grow over time in a sustainable manner. Evidently, this model leads businesses to adopt actions at three levels, corporate level, business level and process level. It is important to point out that research developed in SMEs and TBEs suggest that they develop their corporate strategy at the same time as undertaking new product development. Likewise, it is also recognised that is hardly difficult that they have a long-term business strategy and a product development project (Filson and Lewis, 2000; Peter, et al., 1999).

Table 2.34 Four characteristics of design within European SMEs

Design strategy	Design focus
Design as differentiator	Aims to create brand equity, customer loyalty, price premiums and costumer orientations.
Design as integrator	Focuses on improve new product development process -time to market, building consensus in teams, use visualisation skills- using design to favour a modular platform of product lines, user oriented innovations models, and fuzzy-front-end project management
Design as transformer	Emphasises the creation of new business opportunities to improve the company's ability to cope with change, or in case of advance design as an expertise to better interpret the company's market place.
Design as good business	Utilises design as a source to increase sales and margins, brand value, market share, and return on investment.

Source: Borja de Mozota, B (2006)

Therefore, studies such as 'Design Atlas' and 'Design Demand' are important to understand whether it is possible to adopt design (management) within SMEs and TBEs. In 2002, the 'Design Atlas' provided businesses with a complete tool to assess design capabilities and to provide actions according to the results obtained by the firm. The relevance of this tool relies on the fact that it provides designer and non-designer with a thorough tool that helps to understand the use of design and to perceive its contribution within a business context. Later, the 'Design Demand' (2007) emphasised the positive results experienced by SMEs involved in the programme. It specially highlighted the results accomplished by TBEs, as they are able to adopt their technology development to meet the needs of customers and users; to define the best routes to market; to attract more investment and to improve long-term funding prospects; to shorten time to market; to set strategic objectives based on design opportunities; and create coherent market roadmaps.

In conclusion, design management at the strategic level emphasises the transition from an economic view (increasing market share) and a process performance view (increasing market share and brand) to a strategic view of resources (creating new markets) (Borja de Mozota and Young-Kim, 2009). It is difficult to deny the relevance of design management as an asset that can affect the strategic activities of a business.

b) Design management at the tactical level

Managing design at the tactical level focuses on supporting the product development process. Its aim is to make the process effective and efficient through the coordination of tasks and information (BSI, 1999; Bruce and Bessant, 2002; Bruce and Cooper, 1997; Cooper, et al., 2009; Hollins, 1991; Sebastian, 2005). Designers have a wide range of tools and methods to achieve good design through an effective individual and collaborative process. According to Bruce and Bessant (2002), good design does not emerge by accident but as the result of a well-managed process. Designers must have a holistic view of the total design process, but at the same time, they must break down the process into development faces, units of work and product components. Consequently, designers can manage easily the process by analysing, identifying, mapping and arranging various design tasks in sequential or concurrent order. Design managers have to precisely control, store, present and distribute the information generated among the team members of the process.

Considering that this process changes among companies, designers must recognise the organisation style in order to effect the process to its necessities. For example, the mechanical and linear approach is more suitable for engineering design and production process in which efficiency has the highest priority. Nevertheless, the weakness of this procedure is that even though the process is well managed does not guarantee positive results. Empirically, the design process is very dynamic and there are some tasks that cannot be aligned into a unit of work because there are not systematically linked, especially in small enterprises. Peters, et al., (1999) commented that in many companies this process could be difficult to discover, as it is not formal. The implementation of design management and design activities can lead SMEs and TBEs to capitalise from innovation opportunities and respond to change factors. Thus, design has five key roles: help to create a niche market; focus the resources and flexibility to introduce a product platform for a single market segment; build internal resources and competencies to creates a sustainable advantage; build credibility among customers; and handling better disruptive innovation (Bruce and Bessant, 2002; Bruce and Cooper, 1997; Cooper, et al., 2009; Cross, 2008; Lorenz, 1987; Sebastian, 2005).

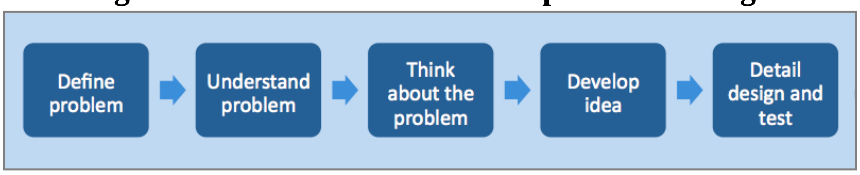
According to Tidd, et al., (2005), those enterprises that favour the utilisation of knowledge, technological skills, and expertise to create new products, processes, and services become the hub of innovation. It is regarded that small TBEs continuously produce innovation through products, services and processes. To generate any type of innovation is necessary to manage the process that leads to generate something new. According to Freel (2003:751), it is regarded as *'an iterative, cumulative and cooperative phenomenon, which incorporates more than simple phased dyadic or bilateral interactions between users, industry and science base'*. Companies need a wide range of abilities to manage the innovation process such as execution of ideas, implementation of activities, capacity to manage innovation, develop and build a distinctive competences in particular field, and adapt and absorb new and different knowledge. This implies that design management can be the means that can harness the entire variables to produce innovation, meanwhile managing the NPD process. In the opinion of Geraghty (2008), design links resources and capabilities from which it seeks to create economic value. Therefore, he suggests to '*use "design thinking" to help harness the internal resources of a company to guide innovation and deliver sustainable competitive advantage through new product and service developments and creative communications*' (Geraghty, 2008:5).

In order to be successful, design managers need to encompass diverse key issues such as: understand the nature of the NPD process; formulate projects proposals; select specialist; constitute and manage NPD teams; plan, organise, implement, monitor and evaluate the NPD process; and consider cost work and drawing up project budget (Topalian, 1994). In opinion of Cooper and Press (1999), there are four significant management activities, planning, organising, implementing and monitoring, and evaluating design, on conducting the NPD process. Thus, design managers need to implement and monitor the design strategy generated at the top level to create management structures to organise people and investment, and to evaluate continuously the process and outcomes. In what respect organising, designers need to be able to clarify roles, responsibilities, project objectives, and stage of approval. Indeed, a project brief is helpful at this stage as it sets all the requirements of the process/project. Thus, budgeting and selection of personnel for the cross-functional team becomes an easy task. It is important to highlight that the structure of a team must allow it to maintain a common and simple language, to set an environment that motivates the team, and to incentive the rotation of roles among team members. Also, it is important to document the process in a clear, simple and quick manner for effective and rapid decision-making. To evaluate the overall project, it is required to compare the outcome against the plans to assess whether the objectives set were achieved in terms of process and product. The results must be collected and delivered to all members involved in the process.

According to Imbesi (2008), design (process) is connected and influenced by, and based on, theories from many different disciplines such as social science, philosophy and anthropology. As well as, it is affected from new perspectives as cultural studies or semiotics to understand the symbolic meaning or the user's interaction with the product. Therefore, design process comprises a number of activities that require specific characteristics and qualities to translate a series of details and ideas into reality. These activities occur at the operational level of a company where design is present in the day-to-day operations. At this level, design makes visible and tangible the business strategies through the development of projects that may result in an outcome (product/service/process) (Best, 2006). This also suggests that design constitutes an opportunity for organisations to give form and shape to the business strategy. Thus, the design process adopted will depend on the organisations' expertise in design. Hence, designers are key to implement, develop and manage the design process. In the opinion of Ilipinar, et al. (2008), the design process must consider designers characteristics. Designers are visual thinkers trained to explore and think about what should be; inquirers that are influenced by the human side of the world and their limits are their own imagination; creators that have a good understanding of manufacturing; and developers that understand quality as aesthetics, playfulness, and mean to address emotions. According to Moisala and Toikka (2008), design process and the personal study paths to becoming a designer are rooted in affective elements, feelings, and ethical and aesthetics reflection.

Researcher and practitioners have developed NPD processes from the design perspective in order to produce more ad-hoc stages that allow producing comprehensive NPD strategies. The first model developed, consisted of five stages where designers use their creative thinking to find a solution (Fig. 2.14). Design is regarded as a sole activity, sourced with an idea that is developed through a linear process until an outcome is produced. Although, the process is considered linear, it rarely follows that order because at any stage new insights may require that designers return to an earlier stage and amend their design.

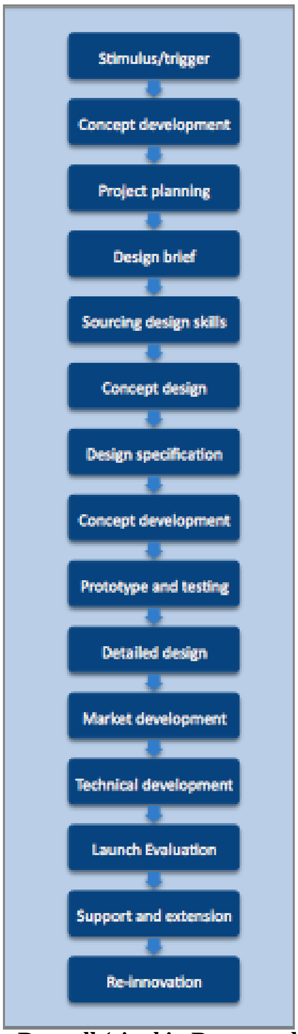
Figure 2.14 The internal creative process of design



Source: Cooper and Press (1999)

In 1983, Rothwell developed a design process that comprises fifteen activities that lead organisations to start their process by triggering ideas and ending with a continuous re-innovation of products (Fig. 2.15). The process starts with the emergence of an idea that expresses the need for something new. This idea needs to be test in terms of viability considering issues such as production capability, quality and cost. If the team decides to explore further the idea, then a product plan is necessary and a design brief too. Thus, the design team requires information in order to generate a design concept that aligns with the brief's objective. Subsequently, the most appropriate concepts are chosen and further developed using models or prototypes. When they are finished, and the concept decided, designers are on charge to generate design specifications for production and trails. The outcome has to pass through market and technical evaluations to find problems and solve it before launch. Finally, the design is ready to launch and designers are in charge to evaluate its performances within its market context in order to have feedback from customers. This process relied on integrated design teams to bring more certainty to the process, as it continuously had to produce bi-dimensional and tri-dimensional outcomes. One important contribution of this process relies on the extension of the stages, as it considers feedback from customers in order to improve the product and to continuously trigger the cycle of innovation within the business. This process is appropriate for large enterprises that have already expertises, and detailed departments within their organization.

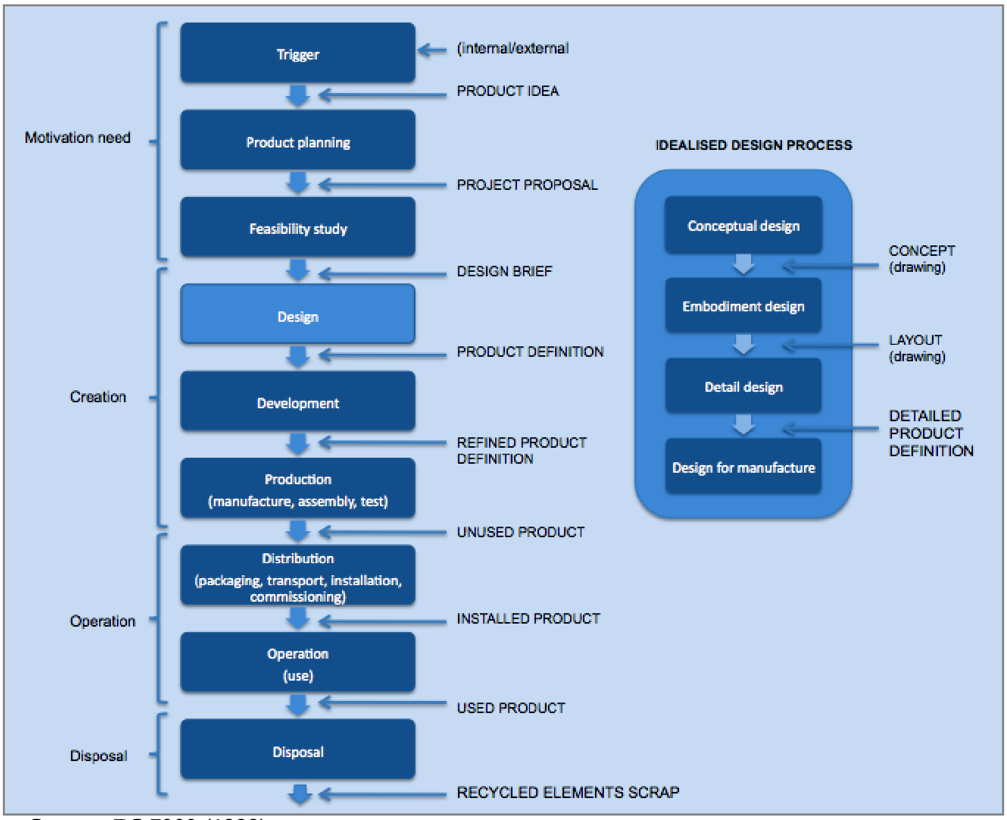
Figure 2.15 Design process model



Source: Rotwell (cited in Bruce and Bessant, 2002)

Another key model is the British Standard BS 7000, a guide to managing product design. This works as a complete guide to understand the formative stage of the manufacturing process within a product design. It underlines the importance to consider market competences such as performance, appearance, price, delivery, reliability, safety and maintainability. It also sets tasks for senior manager, project manager, design manager, and personnel. To adapt this model, organisations need to fulfil certain number of prerequisites such as: (1) sincere and visible commitment to good product design on the part of management at all levels, including senior; (2) motivated staff; (3) provision of clear objectives; (4) adequate resources in terms of both personnel and equipment; (5) the provision of organisational systems. This model has similar stages to Rothwell's model (1983), but its main difference is the inclusion of the disposal stage. One of the downsides of this model is the lack of an iterative process, as it does not focus on gain feedback from customers to generate improvements and continuous innovations (Figure 2.16).

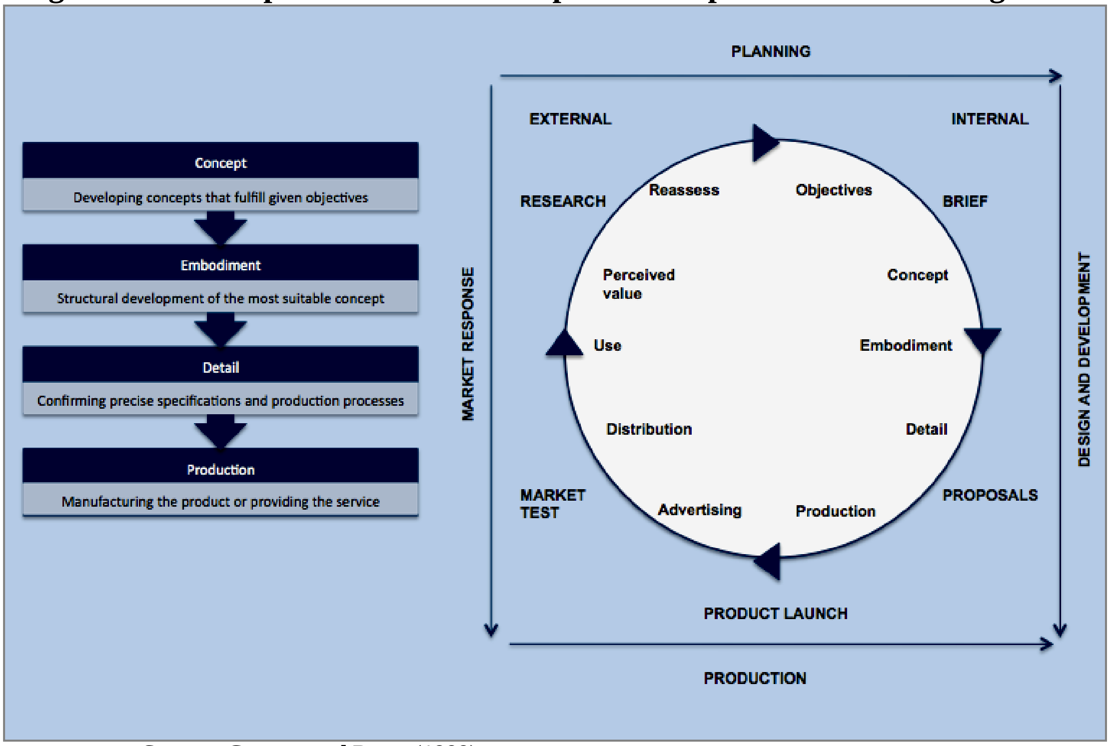
Figure 2.16 BS 7000 managing product design



Source: BS 7000 (1999)

Walker (cited in Cooper and Press, 1999) generated a design model from a meta-analysis of all the design models developed during that time. He generated a design process that focused on four phases that are needed to meet the external needs of the market and the wider environment (Fig. 2.17). The core driver of Walker's process was the design brief because it evolves through the process with the insights that designers add in each stage. As other models, the process started with the input of the problem definition to later evolve in a product/service launched into the market. It also considered, extra stages to research on the perceived value that the product/service had within the market, and the data obtained allow assessing the NPD process. This led to improve continuously the employees' abilities and capabilities, and the firm's knowledge. Another important contribution was the integration of design with other areas: marketing, finance, engineering, and new technologies within the product development. In the opinion of Best (2006), the problem-solving and non-linear nature of design leads the process to be an iterative process. The aim of this design process is to reduce the complexity of the interaction between people and the decision-making process involved in bringing a product or service to market. It offers an opportunity to any company to have a flexible process in order to deal with the dynamic, chaotic, and fuzzy front end process to satisfy customers' preferences that are beyond any standard model. Nevertheless, the problem of this process relies on its nature as it provokes a lost of time and financial resources that are scarce in the NPD process, especially for SMEs and TBEs.

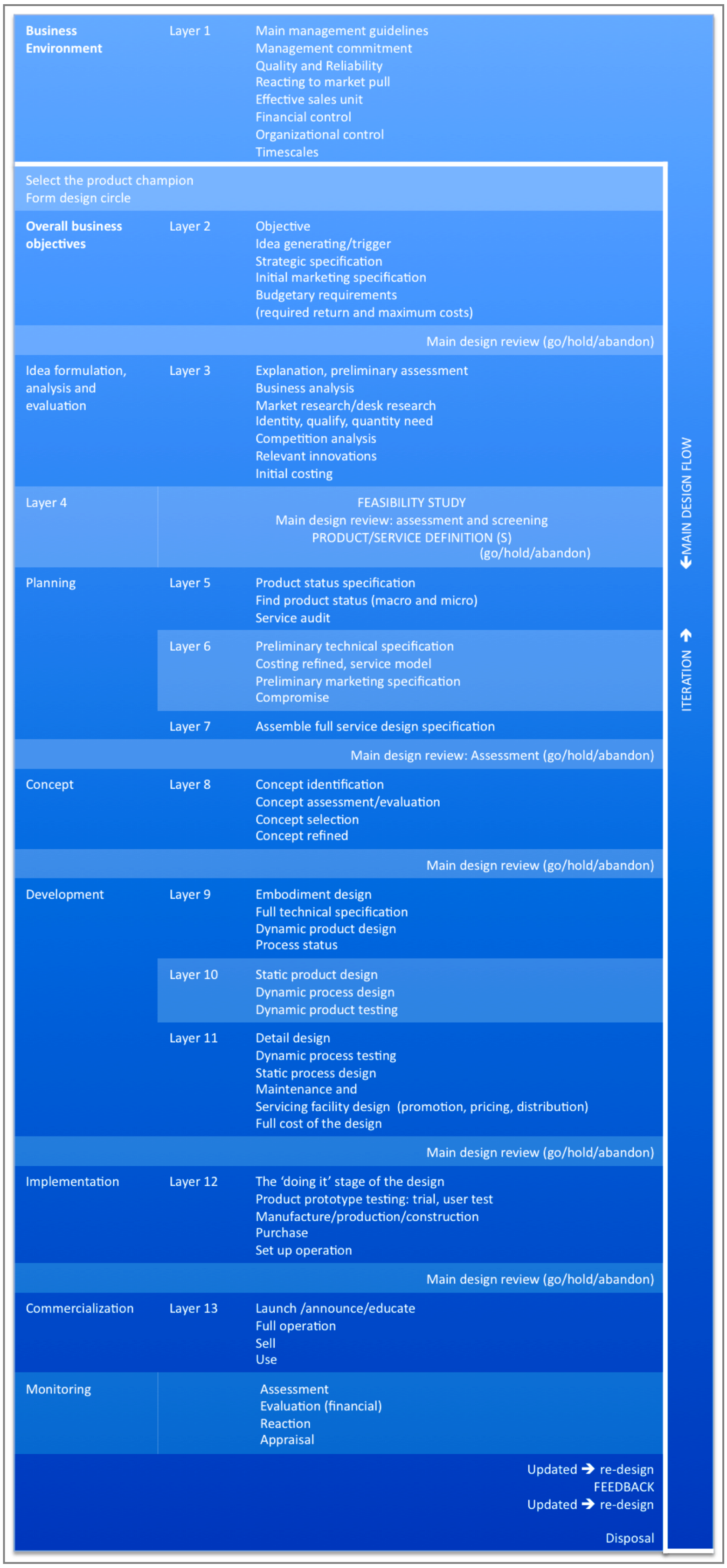
Figure 2.17 Total process and external productive process within management



Source: Cooper and Press (1999)

In 1991, Hollins developed the well-known 'Total Design'. This process relies on a multidisciplinary team that input constantly the project development (Fig. 2.18). This process is iterative as it takes an idea and/or market needs forward until an outcome is on the market and then it leads the cycle to start again. The process includes all aspects from idea generation up to the point of product disposal and customer feedback for the next idea formulation.

Figure 2.18 Total design



Source: Hollins (1991)

Hollins (1991) emphasised that it is necessary to consider the model as a set of linear stages that work as a guide instead of a compulsory law to follow. His contribution relies on process design, as it is adapted to attend the necessities of different industries, manufacturing and service, and sizes of companies, SMEs and large. Researchers (Bruce and Bessant, 2002; Cooper and Press, 1999), emphasise that standards models suit better within large enterprises that are in mature markets. This type of processes is linear with no overlapping stages because they are a checklist of performance criteria that defines the project steps, timeframe and outcomes. They are effective when the purpose is to raise levels of quality, safety and efficiency. It is important to mention that the rigidity of a standardised process can result in an uninspiring assembly line solution. For these reasons, researchers recommend that enterprises find the most suitable design process that relates to their specific/individual organisations.

Best (2006) argues that design is a rigorous cyclical process of enquires and creativity. Due to this, it groups together a range of skills, characteristics and talents to address any situation, problem or opportunity within the organisation. Therefore, designers are meant to produce imaginative and relevant ways to approach a challenge using a series of methods that suit better the nature of each design project. Borja de Mozota (2003) considers the design process as a creative act (Table 2.35). These creative phases are conventional for any design discipline and design project. It starts with the investigation of an issue that will move through a series of stages with the aim to produce an outcome. Therefore, designers produce on each stage a visual output. This implies that in each phase designers gain knowledge until they achieve the optimal solution. Holt (1991) suggested that there are four essential stages in the creative process, preparation, incubation, illumination, and verification. The preparation stage includes the recognition of a need that leads designers to think and to get involved in a series of activities that allow them to define and to formulate the problem. In the incubation stage, designers use a subconscious processes (intuitive by nature) to transfer it to a conscious level. Then, the illumination stage synthesises this conscious problem through the creation of an idea that later on the verification process is refined and tested. According to Holt (1991), this creative process requires a creative behaviour from the different participants of the team.

Table 2.35 The design process

Phases	Objective	Visual outputs
0. Investigating	Idea	Brief
1. Research	Concept	Visual concept
2. Exploration	Choice of style	Roughs of ideas, sketches Roughs of presentation Reduced-scale model
3. Development	Prototype detail	Technical drawing Functional model 3-D mock-up for visual correctness Working capabilities
4. Realization	Test	Documents of execution Prototype
5. Evaluation	Production	Illustration of the products

Source: Borja de Mozota (2003)

Finally, it has been recognised that they should consider customised design process to adopt any model that satisfy the necessities of the organisation. Thus, it is important to consider the overall business' strategy and the development of a brief (design or product) to establish the aims of the project. In turn, this will lead to adopt the best strategy to undertake the NPD process.

To manage the process, designers need methods, techniques and tools that enable them to take the most adequate decision. For example, tools can be used to solve mind problems as it was regarded by Ullman (1997). He provides an excellent overview of the five areas to which tools can contribute:

1. Learning: Tools help to set instructions allowing others to be trained in its use and implementation;
2. Structuring information: tools are used to reduce the complexity of information generated by different means and break it in smaller and comprehensive chunks for analysis;
3. Prompts to thinking: tools are used as trigger of ideas and means of analysis as they provide specific guidance on how to gather and process information as a platform for effective decisions;
4. Communicating effectively: tools are used to provide a platform in where all the team speak a common language; and

5. Knowledge management: tools can be used as an extremely efficient form of knowledge management within a business. Most tools allow tacit knowledge to be experienced explicitly.

Indeed, in order to adopt design at this level it is required that managers have a positive design attitude. This leads to embrace an approach to problem solving and problem finding in the mind-set of the members of the organisation. According to Birminghan (1997), design strategies, at this level, concern methodologies for translation from problem statement into product definition. Thus, three dichotomies of thinking style are applicable: convergent and divergent design, serialistic and holistic thinking, and linear and lateral thinking (Cross, 1984). For example, the designer’s overall aim is to ultimately converge on a detailed proposal (Cross, 2008). Whereas, divergent design activity is usually most prominent in the early design stages when attempting to generate potential solutions, as it seeks to stimulate new ideas or possibilities to improve existing proposals. This cycle between convergent activities has been referred to as controlled convergence (Hollins and Pugh, 1990).

According to Little (1990), in large enterprises design managers need project management software to organise tools, schedule, monitor and control routines. These simple tools can work as guidelines for design managers to gain control over project activities and teams. In the opinion of Bruce, et al. (1999) and Frias-Peña (2005), SMEs owners need mastery in three methods: sourcing, briefing, and evaluating design, to implement design management effectively within the organisation. Bruce, et al. (1999: 300) refers to sourcing as the acquisition of design skills that are appropriate for the creation and implementation of new products/services. A good designer should ideally combine the following qualities (Table 2.36).

Table 2.36 Competency model for designers

Design Competencies - Objective creativity - Technical - Colour and conceptual design
Business Orientation Competencies - Organisational, planning - Problem solving - Commercial skills
Driving the Process Competencies - Commitment, enthusiasm, self-confidence - Results orientation - Team orientation
Perspective and Framework Competencies - Gathering and using information - Strategic thinking - Consumer/customer focus
Interpersonal Competencies - Builds relationship - Presentation skills - Flexible

Source: Bruce, et al., (1999)

In conclusion, managing design activities at the tactical level requires a comprehension of the corporative strategies as the decision to adopt certain type of NPD strategy depends on the size and environment of the business. Indeed, it involves a series of tactical actions to undertake the responsibility of the NPD process. This will implement the strategy at the operational level, thus it is necessary to have previous awareness of the distinct abilities and capabilities of employees.

c) Design management at the operational level

Design managers within design activities have to be responsible for setting up all procedures related on the management and control of design jobs, in-house or external designers (Sebastian, 2005). They have to implement a criterion to select designers, to settle requirements for each stage of the project, to evaluate it, to choose suppliers and type of contract, to monitor and to record it (Bruce, et al., 1999). Once design managers establish the criteria of these procedures, they need to communicate this information to all personnel involved. This approach guarantees that designers can fulfil the parameters and can assume the work. The early stages of the project are of key importance on shaping the future cost of the project; time required; detail and clear technical issues; and the most specific guideline to meet the need of the client and stakeholders (Birminghan, 1997; Borja de Mozota, 2003; Bruce and Bessant, 2002; Buchanan and Margolini, 1995; Cross, 2008). Therefore, the design brief becomes the source that encourages the designer to be creative, and the framework that entails the most promising principles to embody the project aims (Eder, 1998).

Design managers are key actors because they are in charge to organise the budget and to schedule the rest of the project team to guarantee the project success. Indeed, it implies that design mangers have to have the necessary experience, skills and knowledge to implement a successful project. A serious vulnerability of this approach regards the idea that if the designer does not have the capabilities, skills and knowledge to undertake the process, then the results are going to be poor. Contrary, if the outcome is well performed, it is just going to represent an effort to "polish" the product, but not the solution of the problem. Sebastian (2005) argues that design management, at this level, neglects the overall process through which the initial demand is assessed, and the output generated.

The main concern of a design manager at this level is to be able to manage the tangibles (physical) and intangible (human) resources. Especially human resources as many researchers (Best, 2006; Cross, 2008; Holt, 1991; Ilipinar, et al., 2008; Walsh, et al., 1992) argued that designers have specific abilities and capabilities to translate a series of details and ideas into reality. Therefore, when they undertake design projects, tend to shape it according to distinct skills (Table 2.37). Walsh, et al. (1992) stated that designers could provide four essential characteristics in the development of activities:

1. Creativity. Design requires the creation of something that has not existed before;
2. Complexity. Design involves decision on large numbers of parameters and variables;
3. Compromise. Design requires balancing multiple and sometimes conflicting requirements (such as cost and performance, aesthetics and ease of use, materials and durability);
4. Choice. Design requires making choice between many possible solutions to a problems at all levels, from the basic concept to the smallest detail of colour or form.

Walsh, et al. (1992) suggested that these four characteristics are iterative through the design process. Although, depending on the uncertainty and risk of the project some of the characteristics will be more effective and efficient on dealing encounters within the design operations.

Table 2.37 Designers' array of skills

Applied Skill	Knowledge	Processing	Values & Perspectives
Practical design skills; Creative techniques; Commercial skills; Cognitive models	Strategy; Process; Materials; Technical; Commercial; Technological	Visualising; Researching; Analysing & prototyping; Scenario building; Adapting & inventing; Presenting & persuading; Synthesising information; Understanding & balancing stakeholders requirements; Inductive & deductive thinking & action	Risk taking; Originality; Anticipating future trends; Proactive in developing relationships; Managing uncertainty;

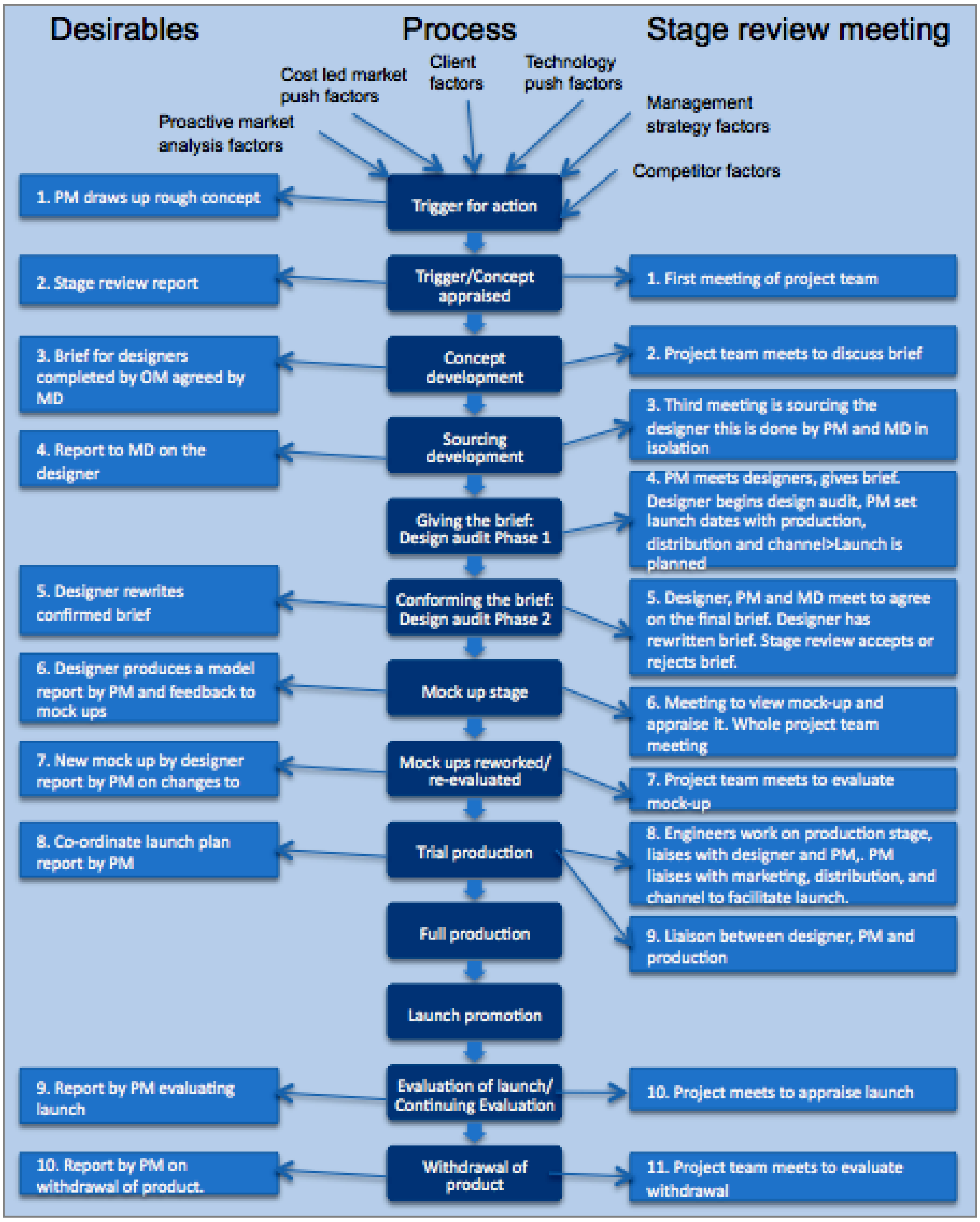
Source: Adapted from Cross (2008); Holt (1990); Ilipinar, et al., (2008); Walsh, et al., (1992)

Holt (1991) argued that there are four different types of design process: design as a problem solving; design as a creative process; design as a need to fulfilling process; and design as a human activity process. He assessed that the problem solving process has a multiple presentation because there are three models identified, analytical design process, iterative design process and the visionary design process. It is recognised that companies use the analytical process, when there is little uncertainty about the alternatives and the outcome is only a modification of something already on existence. The iterative process suites better to medium-risk projects such as radical improvements and adopted innovations. Whereas the visionary process helps those process in where the problem is vague and its definition is not precise. Therefore, designers must break new ground and develop original solutions. Design as a creative process has stages that are flexible and can vary, decrease or increase, depending upon the nature of the project. Design process as a need to fulfilling aims to avoid discrepancies between needs and product characteristics within the operation. Design process as a human activity concerns on the series of actions undertaken by the designer to contribute to the design operation. However, it does not matter which type of process is adopted by designers as long as they have a concise design brief to ensure meeting the product's values and performance criteria (Sebastian, 2005). Likewise, it is possible to produce physical objects and intangible outcomes that meet the aesthetics and functional expectations of the consumer, and support the economical and technical requirements of production (Boyle, 2003; Candi, 2007; Dreyfuss, 1967; Eder, 1998; Klotler and Rath, 1984; Powell, 2004; Sebastian, 2005).

With respect to managing tangibles, Cooper and Press (1999) argue that it represents a common problem that design managers face within a project. They face challenges on budgeting and planning cost because it is difficult to monitor issues such as man-hours, materials and equipment cost, and then controlled on job and time sheets. Another frequent criticism of project management is the designers' lack of understanding of businesses and other functional areas. This can lead to problems when there is a need for them to work in teams. Borja de Mozota (2006) emphasises that negative perceptions and attitudes between groups can provoke conflict, miscommunication and misunderstanding. Therefore, designers need to extend their core competences to improve the relation with other areas. According to Cross (2008), designers need to be able to provide clear descriptions of the outcome that is to be made. Thus, the ultimate purpose of the design process remains the communication of proposals for a new artefact. Design managers need to be able to document plans, brief, costs, time schedules, processes, concepts, details and drawings. The use of a design brief can facilitate the monitoring of activities and better assess the functional, technical, production, and distribution of the desirable's requirements of the project. Finally, evaluations must involve designers, other functional areas, and consumers. Indeed, the outcome must be to compare against the requirements set in the design brief.

According to Oakley (1990), to get the right management for a project it is necessary to consider the staff, organisation, and management of the organisation. Likewise, designers need to set a goal, some constrains within which the goal must be achieved and some criteria by which a successful solution might be recognised (Cross, 2008). Thus, designers will be benefited if they prepare a project brief to make the correct decisions at the different stages of the project, as comprehensive information must be available, especially concerning the various constraints, external and internal, that will shape the project. External constraints relate mainly to two groups of people, customer and competitors. Contrary, internal constraints involve issues such as utilisation of equipment and capabilities of employees, material procurement and handling quality norms and methods of check in, among others. The brief is the core of the design project because is the guideline to develop the entire project and the basis for the product/service final evaluation. Bruce, et al. (1999) recognised the need of design to briefing, sourcing, launching and evaluation the overall project. In their research in SMEs in United Kingdom, they find that the importance of a design management framework that helps the mangers to effectively manage design (Fig. 2.19). This model highlights the critical actions in the process and suggests the key stages in where designers should review critical milestones.

Figure 2.19 Framework for design management



Source: Bruce, et al., (1999)

Regarding briefing, they allude to it as the method the company use to brief the designer; these include verbal and written methods. It has been proven that designers encounter many problems if the brief is not prepared correctly. Designers must ensure that the design brief provide answers to how, what, why, where and when questions. It also needs to assess questions about cost and time-scale, consumer, materials and manufacturing facilities. According to Cooper and Press (1999), the design brief should contain the following data: background of the company; the design problem; design specifications; product attributes; consumer and market information; cost and budgets; and timescales. As stated by Oakley (1990), the brief should cover two main areas:

1. The new or modified product or service which is to be the outcome of the design exercise (features, customers, cost, etc), the product brief;
2. The design project that will be set up to do the work (time, resources, etc), the project brief.

Finally, evaluation of design can occur in many forms and at various levels within the organisation. The evaluation can be the analysis between the pure costs of the design against sales ratio or the assessment of a concept against the brief. Indeed, these evaluations can take the form of more tangible outcomes such as the analysis of the design's market success measured by such criteria as sales performance, increased awareness of the service, etc.

Design thinking at this level is central as it triggers the many different roles that designers, as possible mavericks, can play. This leads designers to be prone to adapt to diverse situations. They ensure that the design processes, procedures and internal functions are adding value to the organisation through the internal resourcing of design thinking into a cross a range of business units and projects. Nevertheless, designers need methods, techniques and tools to externalise design thinking and produce outcomes that can help to take critical decisions within projects (Jones, 1980). Many researchers (Asimow, 1962; Brown, 2008; Buchanan and Margolin, 1995; Cross, 2007; Inns, 2002; Jones, 1980; Laurel, 2003, Vogel, et al., 2004; Watts, 1966) agree that the action of designing has three essential stages, analysis, synthesis and evaluation. These can be described in simple words as 'breaking the problem into pieces', 'putting the pieces together in a new way' and 'testing to discover the consequences of putting the new arrangement into practice' (Jones, 1980). This means that these three actions aim to diverge, transform and converge information that later will turn into an outcome. Therefore, a design brief can help them to unlock the potential of a proposal on time within the budget in order to satisfy clients and customers' needs. In conclusion, designers become creative managers.

2.7 Conclusions

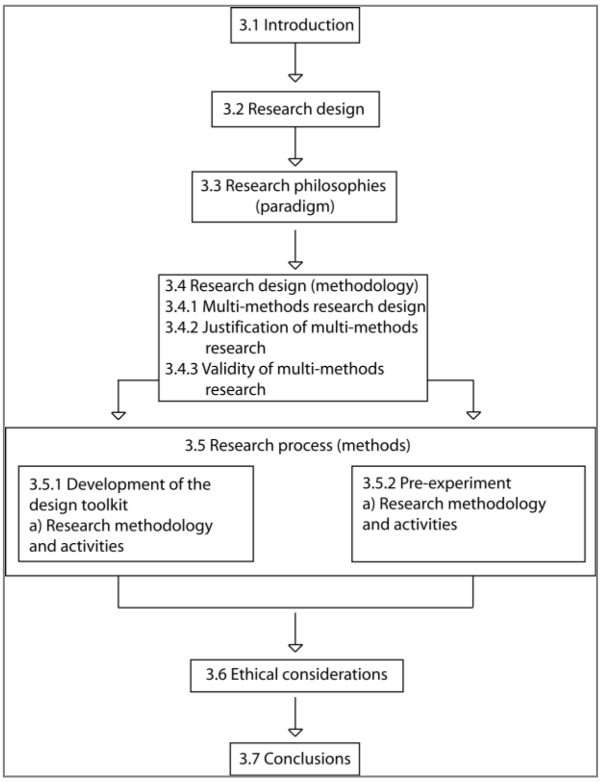
This chapter explored the extant literature pertaining to the contextual overview of Latin America and Mexico, the definition of small TBEs under the context of the study, the organisational structure and management style of this type of firms, the different new product development processes, and design management. This review provided the necessary information to develop a theoretical underpinning and a framework for the research with respect to the subject of study, that is, small Mexican technology-based enterprises in new technological industries. From this literature review, it was found that previous research did not consider different issues related to the interrelation between small technology-based enterprises in new technological industries and design management to harness their innovative activities and to lead them to improve their performance or to succeed in the market. As a result, three research questions were developed to close the gaps between the different issues involved in this study and to provide an understanding on their relationship. (1) '*How do small Mexican technology-based enterprises in new technological industries use and embed design in their business activities?'*; (2) *'How can small Mexican technology-based enterprises in new technological industries use, implement and integrate design management within their activities?';* and (3) *'Do small Mexican technology-based enterprises in new technological industries improve their performance using design management within their business activities?'.* Thus, it is required to outline the research design that leads the research to collect the data to address the three research questions. Chapter 3 provides a detailed explanation of the research design, multi-methods methodology, considered to undertake this research, and the methods and techniques used to collect and to analyse the data.

CHAPTER 3.0 RESEARCH METHODOLOGY

3.1 Introduction

The purpose of this chapter is to outline the key components of this research study, the research problem and questions, the research design and the research process. In order to provide a detailed exploration of this research, it is necessary to cover three basic elements that compose any research: research philosophies (paradigm), research design (methodology) and research process (methods). The first section briefly explores research design (section 3.2) in order to establish the philosophical foundation used for this research (section 3.3). Then, it is further discussed the research design, multi-method design (section 3.4), along with the justification and criteria employed for judging its quality. The multi-method design chosen QUAL⇒quan (section 3.5) considers two main stages, development of the design toolkit (section 3.5.1) and pre-experiment (section 3.5.2), that need to be examined separately. Due to it offers the opportunity to present the methods used to collect and to analyse the data. Finally, it concludes with a discussion of the ethical considerations (section 3.6) relevant to this research. An outline of this chapter is provided in Figure 3.1.

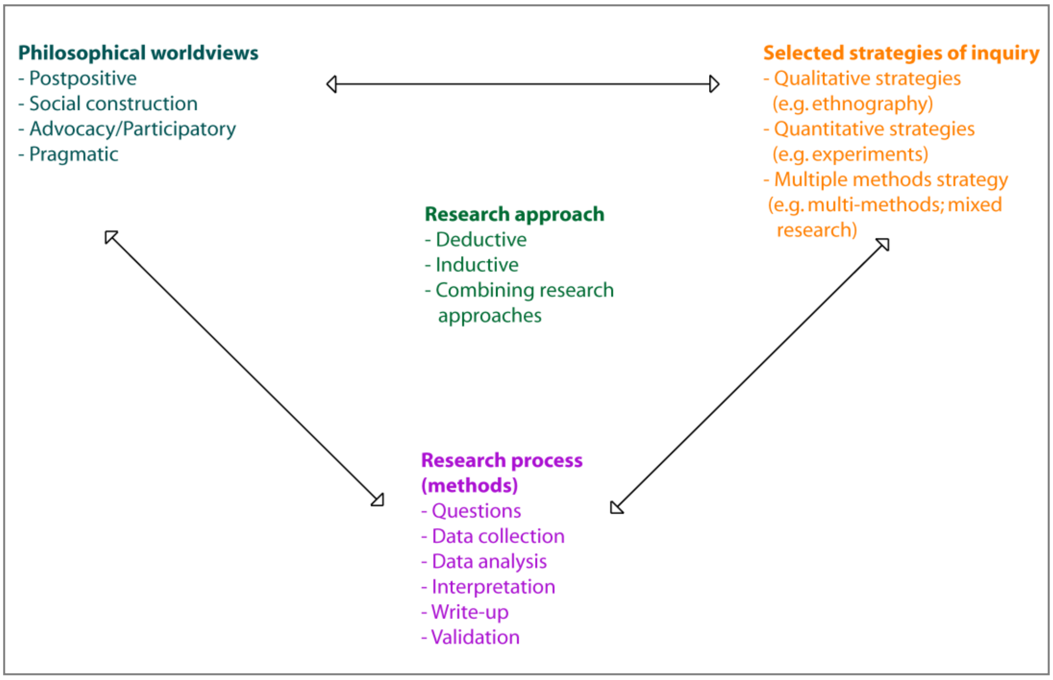
Figure 3.1 Outline of the chapter



3.2 Research design

The research design looks at the stage of research where agendas, plans and strategies are created. It is conceived to obtain answers from the problems or research questions established. According to Kerlinger (1986:94), a research design includes an outline of what the investigators will do from writing the hypotheses, problems or questions and their operational implications to the final analysis of data. This implies that it should reflect the worldview assumptions bring to the study; procedures of inquiry; and specific methods of data collection, analysis and interpretation (Creswell, 2009). The consideration of an overall strategy is useful for the researcher to span the decisions from broad assumptions to detail methods of data collection and analysis (Fig. 3.2). Hence, researchers need to decide under which research approach they are going to position their study (deductive, inductive or combined approach) because depending on that decision it is possible to choose the philosophical worldview (advocacy, post positivism, pragmatism, social construction). Subsequently, it can be chosen the strategy of inquiry and the research methods required to collect the data. Indeed, there has to be a logic that links the data to be collected and the conclusion to be drawn to the initial question of study. In summary, through research design, researchers: (1) conceptualise an operational plan to undertake the various procedures and tasks required to complete the study, and (2) ensure that these procedures are adequate to obtain valid, objective and accurate answers to the research questions (Kerlinger, 1986; Thyer, 1993). The research approach adopted for this study is of a multi-method design, which is going to be explored throughout this section.

Figure 3.2 Research design



Source: Adapted from Creswell, 2009

3.3 Research philosophies

According to Guba and Lincoln (2005), all investigations are guided by a set of beliefs and feelings about the world and how they should be understood and studied. Thus, every research needs a foundation for its inquiry and inquirers need to be aware of the implicit worldviews they bring to their studies (Creswell and Plano-Clark, 2007). This implies that researchers need to choose means that accept certain assumption about the way in which they view the world. As these assumptions provide the underpinning from which to launch the research strategy. These worldviews also called paradigms combine 'ontology[6]' and 'epistemology[7]' in order to lead the researcher to adopt the most suitable methodology to gain knowledge of reality. Indeed, researchers tend to use worldviews and methodologies that are common in their particular scientific subject (Creswell, 2009). Paradigms are based under different stances on their approaches (Creswell and Plano-Clark, 2007; Guba and Lincoln, 2005, 1994; Paul, 2005). Each one epitomizes a unique view of the nature of reality (ontology); in the way they gain knowledge of what they know (epistemology); the roles they

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[6] **Ontology** is a philosophy concerned with the nature of beings. It refers to the form and nature of reality and comprises the fundamental assumptions made about the elements of reality, specifying what exists (Parkhe, 1993).

[7] **Epistemology** is the branch of philosophy that deals with knowledge. It focuses on the nature of the relationship between the knower/inquirer and the known or knowable (Craig, 1998))

play in the research (axiology); the process they undertake in the research (methodology); and the language they use in the research (rhetoric) (Creswell, 2009). These different stances influence the way researchers conduct and report their inquiries. Table 3.1 shows four worldviews used in social science in order to explore their essential elements relating to ontology, epistemology, axiology, methodology and rhetoric.

Table 3.1 Common elements of worldviews and implications for practice

World view element	Post positivism	Constructivism	Advocacy and participatory	Pragmatism
ONTOLOGY (What is the nature of reality?)	Singular reality (e.g., researchers reject or fail to reject hypotheses?)	Multiple realities (e.g., researchers provide quotes to illustrate different perspectives)	Political reality (e.g., findings are negotiated with participants)	Singular and multiple realities (e.g., researchers test hypotheses and provide multiple perspectives)
EPISTEMOLOGY (what is the relationship between the researcher and that being researched?)	Distance and impartiality (e.g., researchers objectively collect data on instruments)	Closeness (e.g., researchers visit participants at their sites to collect data)	Collaboration (e.g., researchers actively involve participants as collaborators	Practically (e.g., researchers collect data by 'what works" to address research question)
AXIOLOGY (What is the role of values?)	Unbiased (e.g., researchers use checks to eliminate bias)	Biased (e.g. inquirer starts with participants' views and build "up" to patterns, theories, and generalisations)	Biased and negotiated (e.g., researchers negotiate with participants about interpretations)	Multiple stances (e.g., researchers include both biased and unbiased perspective)
METHODOLOGY (What is the process of research?)	Deductive (e.g., researchers test an a priori theory)	Inductive (e.g., researchers start with participants' view and build "up" to patterns, theories, and generalisations	Participatory (e.g., researchers involve participants in all stages of the research and engage in cyclical reviews of results)	Combining (e.g., researchers collect both quantitative and qualitative data and mix them)
RHETORIC (What is the language of research)	Formal style (e.g., researchers used agreed-on definitions of variables)	Informal style (e.g., researchers write in literary, informal style)	Advocacy and change (e.g. inquirer uses language that will help bring change and advocate for participants)	Formal or informal (e.g. researchers may employ both formal and informal styles of writing)
APPROACHES	Determination Reduction Empirical observation and measurement Theory verification	Understanding Multiple participant meanings Social and historical construction Theory generation	Political Empowerments and issue oriented Collaborative Change oriented	Consequences of actions Problem centred Pluralistic Real-world practice oriented

Source: Creswell and Plano-Clark (2007)

In the post positivist's perspective, the world can be measured objectively (Lincoln and Guba, 1985). Post positivists' consider that the world comprises discrete, observable elements and events that interact in an observable, determined and regular manner. Thus, individual cases are subsumed within hypotheses about general laws of nature and assume that human beings and human societies are subjected to laws in the same way that the nature world is (Phillips and Burbules, 2000). Researchers adopt an impartial and distant stance in the research process, as they use instruments that allow them to objectively collect data. Thus, they use quantitative techniques with deduction thinking representing the primary mode for testing propositions to confirm a theory and provide an unbiased position (Deshpande, 1983). They make claims for knowledge based on (a) determinism or cause-and-effect thinking; (b) reductionism, by narrowing and focusing on select variables to interrelate; (c) detailed observations and measure of variables; and (d) the testing of theories that are continually refined (Guba, 1990; Perry, et al., 1997; Slife and Williams, 2001). They argue that by taking an objective design approach, statistical generalisation can be achieved and replicable findings will therefore be consistent (Guba and Licoln in Denzin and Licoln, 1994).

Constructivism adopts a critical relativism ontology, in which truth about a proposition of the world is constructed based on the belief system held in a particular context (Perry, et al., 1997). Its epistemological view argue that all knowledge is dependent on social actors being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essential social context. It is typically associated with qualitative approaches as truth is a subjective belief that one holds about a particular proposition. This results in multiple realities because the understanding or meaning of phenomena is formed through participants and their subjective views. Thus, this worldview is social and experimental based rather than objectively determined (Hunt, 1993; Leong, 1985). Its findings are created through the interaction between interviewer and respondent. Due to respondents provide their understanding, and speak from meaning shaped by social interaction with others and from their own personal histories. This research is shaped 'from the bottom up' from individual perspectives to broad patterns and, ultimately, to theory (Creswell and Plano-Clark, 2007).

The advocacy and participatory paradigm is influenced by political concerns. It focuses upon analysis and transformation of social, political, cultural, economic ethnic and gender values (Perry, et al., 1997). Researchers use this worldview for the necessity to improve our society in issues such as empowerment, marginalization, hegemony, patriarchy, among other issues affecting marginalised groups. They are active participants in the field study, as they collaborate with the subjects of study in order to experience their individual injustices. For this reason, this approach is more often associated with qualitative approaches than quantitative approaches. The epistemology of this inquiry involves and interactive link between the inquirer and the subject matter of the research, as the researcher influences the inquiry through his or her value. In the end, the advocacy-participatory research plans for the social world to be changed for the better, so that individuals will feel less marginalised (Craig, 1998).

Pragmatism is a pluralistic worldview that is based on multiple realities as well as singular realities. Researchers use this worldview because it focuses on the question asked rather than the methods. Its main concern is on the consequence of the research and thus, its epistemology is oriented toward 'what works' and its practicality. Inquirers use multiple methods of data collection to inform the problem under study. It is common that this approach combine deductive and inductive thinking, as both qualitative and quantitative data is mixed.

After reviewing the different paradigms, it is possible to decide which one is the most suitable for this research. But before, it is important to restate the three questions that gives life to this research: (1) '*How do small Mexican technology-based enterprises in new technological industries use and embed design in their business activities?'*; (2) *'How can small Mexican technology-based enterprises in new technological industries use, implement and integrate design management within their activities?';* and (3) *'Do small Mexican technology-based enterprises in new technological industries improve their performance using design management within their business activities?'.* The three research questions presented follow a sequential ladder to achieve a theoretical thrust. This implies that each question represents an individual project that is interrelated with each other in order to solve an overall research problem. This leads to consider the use of multiple methods to be able to provide an answer to the research problem. Consequently, the most suitable worldview for the purpose of this research is pragmatism.

The pragmatic philosophy is presented as a way to clarify intractable metaphysical and epistemological disputes. Pragmatists are persuaded that an inquiry can start only when there is some actual or living doubt; but they point out that researchers cannot genuinely doubt everything at once. The pragmatist proceeds from the basic premise that the human capability of theorising is integral to intelligence practice. Theory and practice are not separate spheres; but rather theories and distinctions are tools or maps for finding a way in the world. Thus, pragmatism drawn a philosophical moral with the idea that philosophy is not prior to science, but continuous with it (Dewey, 1949; Quine, 1961). In opinion of Scheffler (1986), knowledge is the product of inquiry, a problem-solving process by means of which researchers move from doubt to belief. Inquiry cannot proceed effectively unless researchers experiment. All beliefs and theories are best treated as working hypotheses, which may need to be modified (refined, revised or rejected), in light of future inquiry and experience (McDermid, 2006).

Pragmatists see no point in making one form of inquiry any more important or valuable than any other makes, since they help to cope with aspects of the world. Researchers must be eclectic in their search for truth (Rorty in Brandon, 2000), as there is no special and distinctive method in which philosophers as a social order can pride themselves; no transcendentalist faculty of pure reason or intuition; and no reality inaccessible to philosophy to understanding. This provides the opportunity to combine research approaches (deductive and inductive) and use diverse methods at different stages of the research, as pragmatism concerns on answering the questions asked.

The strengths of this paradigm represent at the same time its weaknesses. Some pragmatists such as Pierce see pragmatism more as a technique that helps researchers to find solutions than a philosophy. Contrary, some researchers (Dewey, in Hickman and Alexander, 1998; Mead, 1934; Murphey, 2005) consider pragmatism as a philosophy because they believe that what is essential is that a theory pays its way in the long term, as it is functional until it is replaced by some theory that works better. McDermid (2006) claimed that ideas come true just as far as they help us to get into satisfactory relationship with other parts of our experience. The meaning of an idea or a proposition lies in its observable practical consequences rather than anything more metaphysical. Truth is what works for this specific context and time, and it will change over time. As the knower is an agent, who obtains empirical support for their beliefs by making experimental interventions in her surroundings and learning from the experience that her activities elicit (Turrisi, 1997). Dewey complemented this idea and recognised that not just our beliefs about the situation change, but the situation that is objectively indeterminate is transformed during the course of inquiry.

Consequently, pragmatism involves the exploration and description of a social phenomenon that consists of both observable and unobservable elements, as realistic as possible (Perry, et al., 1997). Thus, when researchers first face a problem, their first task is to understand their problem through describing its elements and indentifying their relations. Identifying a concrete question that we need to answer is a sign that we are already making progress. The logical forms we use in the course of inquiry are understood as ideal instruments, tools that help us to transform things and resolve our problems (Stanford Encyclopaedia of Philosophy, 2010). Hence, no one can claim to possess any final or ultimate truth.

In conclusion, pragmatism is the most appropriate paradigm for this research for the follow reasons: (1) its epistemology relies on practicality; (2) it focuses on the question asked rather than the methods; (3) researchers can use multiple methods of data collection to inform the problem under study; (4) it combine deductive and inductive thinking, as both qualitative and quantitative data is combined; and (5) it is real-world practice oriented.

3.4 Research design

It looks at the stage where research projects and agendas are developed. It explores alternative methods and outlines their intents, procedures, and strengths and challenges associated with each approach. As well as, researchers are encouraged to explore the skills required and to consider the time, cost and weight of the strategy chosen. This implies that researchers are required to decide their methods and with it set the logic by which they make interpretations at the end of studies. Consequently, this section commences with a discussion of the different design strategies in the research process, qualitative, quantitative or combined methods research (section 3.4.1). Then, it justifies the use of multi-method design (section 3.4.2) and its validity (section 3.4.3) to answer the three main research questions.

3.4.1 Multi-methods research design

In the previous section, it was discussed that research design needs strategies of inquire to provide specific directions for procedures (Creswell, 2009). These strategies can vary depending on the requirements of the research problem or questions. Consequently, the researcher needs to decide which approach should be used, qualitative, quantitative or combined methods, to better address the study. As each approach has specific procedures and aims that are necessary to explore.

Quantitative strategies are used as means for testing objective theories by examining the relationship among variables (Creswell, 2009). These variables aim to rationally justify assertions using logical and mathematical proof, and then establish the results as general laws or principles. Researchers who engage in this form of inquiry have assumptions about testing theories deductively, building in protections against bias, controlling for alternative explanations, and being able to generalize and replicate the findings (Burns, 2000). Some researchers (Burns, 2000; Creswell and Plano-Clark, 2007; Graziano and Raulin, 1993; Holliday, 2002) tend to consider that this strategy follow a linear sequence of actions that can be summarised in three main actions, decide the focus of the research, devise research instruments, and approach the subject. However, it is important to recognise that quantitative strategies are more complex and comprise additional activities that are key for the research development such as developing a theoretical and conceptual framework, selecting a sample, collecting, and processing the data (Burns, 2000; Graziano and Raulin, 1993; Kumar, 2005). These strategies include two types of research design; experiments that consider true experiments and the less rigorous experiments called pre-experiments and quasi-experiments (Campbell and Stanley, 1966; Cooper, et al., 1987; Creswell, 2009); and no experiments or surveys that comprise cross-sectional studies and longitudinal studies (Sampieri et al., 1998).

The strengths of this approach rely on three main actions: (1) control, it is achieved through the sampling and design precision through quantitative and reliable measurements; (2) statistical analysis, hypotheses are tested through a deductive approach and the use of quantitative data; and (3) experimentation leads to statements about causation, since the systematic manipulation of a variable can be shown to have a direct causal or not. Its limitation are based on do not consider human being complexity, as they can interpret and respond to forces in an active way. They differ from an inner matter that is studied in physical science (Burns, 2000). Table 3.2 provides a summary of the key elements that distinct qualitative research in the research process.

Table 3.2 Elements of qualitative and quantitative research

Process of research	Elements of Qualitative Research	Elements of Quantitative Research
Research strategy	Unstructured	Structured
Scope of findings	Ideographic	Nomothetic
Image of social reality	Processual and socially constructed by actor	Static and external to actor
Nature of data	Rich, deep	Hard, reliable
Intent of the research	Understand meaning individuals give to a phenomenon inductively	Test a theory deductively to support or refuse it
How literature is used	Minor role; Justifies problem	Major role; Justifies problems; Identifies questions and hypotheses
How intent is focused	Ask open-ended questions; Understand the complexity of a single idea (or phenomenon)	As closed-ended questions; Test specific variables that form hypotheses and questions
How data are collected	Words and images; From a few participants at few research sites; Studying participants at their location	Numbers; From many participants at many research sites; Sending or administering instruments to participants
How data are analysed	Text or images analysis; Themes; Large patterns or generalisations	Numerical statistical analysis; Rejecting hypotheses or determining effect size
Role of the researcher	Identifies personal stance; Report bias	Remains in background; Takes steps to remove bias
Practices of research as the researcher	Position him or herself; Collects participant meanings; Focuses on a single concept or phenomenon; Brings personal values into the study; Studies the context or setting of participants; Validate the accuracy of findings; Makes interpretations of the data; Creates an agenda for change or reform; Collaborates with the participants;	Test or verifies theories or explanations; Indentifies variables to study; Relates variables in questions or hypotheses; Uses standards of validity and reliability; Observes and measures information numerically; Uses unbiased approaches; Employs statistical procedures;
How data are validate	Using validity procedures that rely on the participants, the researcher, or the reader	Using validity procedures based on external standards, such as judges, past research, statics

Source: Adapted from Bryman (1988) and Creswell and Plano-Clark (2007)

Alternatively, qualitative research strategies are used as a mean for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. This process of research involves emerging questions and procedures, collecting data under the participants' context, analysing it inductively building from particular to general themes, and making interpretations of the meaning of the data (Table 3.2). Qualitative research places stress on the validity of multiple meaning structures and holistic analysis, as it aims to provide avenues that can lead to the discovery of deeper levels of meaning. Researchers who engage in this form of inquiry support a way of looking at research that considers an inductive style, a focus on individual meaning, and the importance of rendering the complexity of situation (Creswell, 2009). It has been emphasised that much of the rationale for the qualitative approach rest within the criterion of meaning. Eisner (1979:14) described this emerging form of research as being considerably relevant, since there can be little meaning, impact or quality in an event isolated from the context in which it is found. He explains that, essentially, qualitative methods are concerned with process rather than consequences, with organic wholeness (the understanding of the phenomenon) rather than independent variables, and with meanings rather than behavioural status. Therefore, it employs diverse philosophical assumptions; strategies of inquiry; and methods of data collection, analyses, and interpretations. There are many strategies to qualitative inquiry, Tesch (1990) identified 28 approaches, Wolcott (2001) recognized 19 types, and Creswell (2009) considered five procedures. The most common approaches used by scholars are phenomenology, ethnography, case study, grounded theory, participatory action research, and discourse analysis.

According to Burns (2000), the strengths of qualitative research relates to its methodological eclecticism; hypothesis free orientation; an implicit acceptance of the natural scheme of things; and its role of suggesting possible relationships, causes, effects and even more dynamic processes. Contrary, its limitations are concerned with validity and reliability because the subjective nature of data, its origins and its difficulty to apply conventional standards of reliability. As well as, its contexts, situations, events, conditions and interactions cannot be replicated to any extent nor generalisation be made to a wider context than the one studied with any confidence. A major limitation of qualitative research is the time required for data collection, analysis and interpretation, as there is a critical need for the researcher to spend a considerable amount of time in the research setting.

The goal of social science is to understand the complexity of human behaviour and experience. In opinion of Morse (2003), by combining and increasing the number of research strategies used within a particular project, researchers are able to broaden the dimensions and hence the scope of their project. This implies that using more than one method within a research program, researchers are able to obtain a more complete picture of human behaviour and experience. Thus, researchers are able to hasten their understanding and achieve their research goals more quickly. The use of multiple methods has become an option to use research tools from qualitative and quantitative methodologies to answer a research question. This strategy is not well known, as there are diverse propositions to undertake this strategy such as mixed methodology, quantitative and qualitative, methodological triangulate design, methodological integrity, and multi-method. In order to explore further the most relevant approaches, it is important to provide a foundation of this strategy of inquiry.

In the social sciences at large, combining methods research have become increasingly popular and may be considered a legitimate, stand-alone research design (Creswell, 2009, 1994; Grenne, et al., 1989; Tashakkori and Teddlie, 2003, 1998). Although, as other research approaches in their origins, mixed research has faced criticism about its validity as an approach because the use of different methods can provoke a contradiction in the paradigm choice (Filstead, 1979) and the contradiction in technical issues (Walker, 1992). Its emergence began in 1959 when Campbell and Fiske used multi-methods to validate a study of psychological traits. During this time, it started an initial interest in using more than one method in a study wondering whether it was possible to combine both quantitative and qualitative data (Jick, 1979; Sieber, 1973), or if it was possible to combine both forms of data when they arose from different perspectives (Cook and Reichardt, 1979). In the follow decades, 1970s and 1980s, the debate continued. On one side, Smith (1983) argued that mixed methods research was incompatible as they asked for paradigms to be combined. On the other side, Bryman (1988) challenged the argument and began suggesting that a clear connection existed between the two traditions, even if there are differences between qualitative and quantitative research in the epistemological and technical accounts. Bryman (1988) encourages researchers to ensure that one set of results is not artificially construed as providing a ‘true’ picture. Caution is also necessary in ensuring that the two sets of results are not in fact addressing different issues.

In the early 1990’s, the idea of mixing data moved from seeking convergence to actually integrating or connecting the qualitative and quantitative data. It was also considered that qualitative and quantitative data can be merged into one large database or the results used side by side to reinforce each other (Creswell, 2009; Creswell and Plano-Clark, 2007). Researchers recognised that all methods have limitations, and no single method could neutralise the biases as triangulation of data source does. By 1989, Grenne, et al. generated a forefront study in where they analysed 57 evaluation studies, developing a classification system of six types, which in turns provoked an increment on the number of types of inquiry. Since then, the use of multiple methods has become popular among researchers as a separate design in its own right. There has been an agreement in the different principles that give life to diverse multiple methods research designs. In this study, two major research designs are going to be explored, mixed research methods and multi-methods.

Mixed research methods strategy provides a central premise that concern the combination of quantitative and qualitative approaches to provide a better understanding of research problems than either approach alone (Creswell and Plano-Clark, 2007; Hanson, et al., 2005). It incorporates various qualitative and quantitative strategies within a single project that may have either a qualitative or a quantitative theoretical drive (Morse, 2003). Thus, this process of research involves philosophical assumptions, the use of qualitative and quantitative approaches, and the mixing of both approaches in a study. Researchers using mixed methods can generate a theory deductively, in quantitative theory testing and verification, or inductively, as in an emerging qualitative theory or pattern. When using mixed methods, the major design principles to be considered are to: (1) recognise the theoretical drive of the project; (2) recognise the role of the imported component in the project (how to inform the base of the project); (3) adhere to the methodological assumptions of the base method; and (4) work with as few data sets as possible (Morse, 2003).

Conducting mixed methods research is not easy task, it takes time and resources to collect and analyze both quantitative and qualitative data. The researcher needs to be skilled to present the different procedures used in the research and acknowledge with both forms of inquiry, quantitative and qualitative methods. When mixed methods are used, researchers need to provide a methodological congruence, that is, that all of the assumptions of the major methods to be adhered to and that components of the method be consistent. Researchers need to use supplemental research strategies to collect data that would not otherwise be obtainable by using the main method and incorporating these data into the base method. Therefore, there are three ways in which mixing methods occurs: merging or converging the two datasets by having one build on the other, connecting the two data sets by having one build on the other, or embedding one data set within the other data set (Creswell and Plano-Clark, 2007). The major strength of mixed methods design is that it allows developing research as comprehensively and completely as possible. When compared with a single method, the domain of inquiry is less likely to be constrained by the method itself and certainty is attained by verifying supplemental data with data strategies used within the core study (Creswell and Plano-Clark, 2007). The strengths of comprehensiveness from using mixed methods may also be perceived as weaknesses (Morse, 2003). Research may be challenged on the grounds of being less rigorous than if a multi-method design were used, and the supplemental data may be considered thin and therefore suspect. Hence, researchers are advised to take care in describing both the methods and the way in which less saturated data sets and complementary relationships between data sets were verified.

Multi-method design conducts two or more research methods, each conducted rigorously and complete in itself, in one project. The results are then triangulated to form a comprehensive whole (Morse, 2003:190). This design has three main principles: (1) identify the theoretical drive of the research project; (2) develop overt awareness of the dominance of each project; and (3) respect methodological integrity. The first principle analyses the importance of the theoretical drive definition. As it is the primary way in which the researcher is thinking overall about a research topic, is the theoretical drive or the overall thrust of the entire research program (Morse, 1991). The theoretical drive may be inductive (for discovery) or deductive (for testing). The second principle is related with the awareness of working inductively or deductively at any given time that will ensure that the assumption of each method is not violated. In order to achieve this principle there are two types of multi-method designs: concurrently (simultaneous) and sequential design. This leads to have different configurations about the awareness of the theoretical drive indicating the major methods and then the supplemental projects. This implies that the research projects may have complex designs containing diverse combinations, depending on the scope and the complexity of the research program. Finally, the third principle emphasises the need to keep the integrity of each research method.

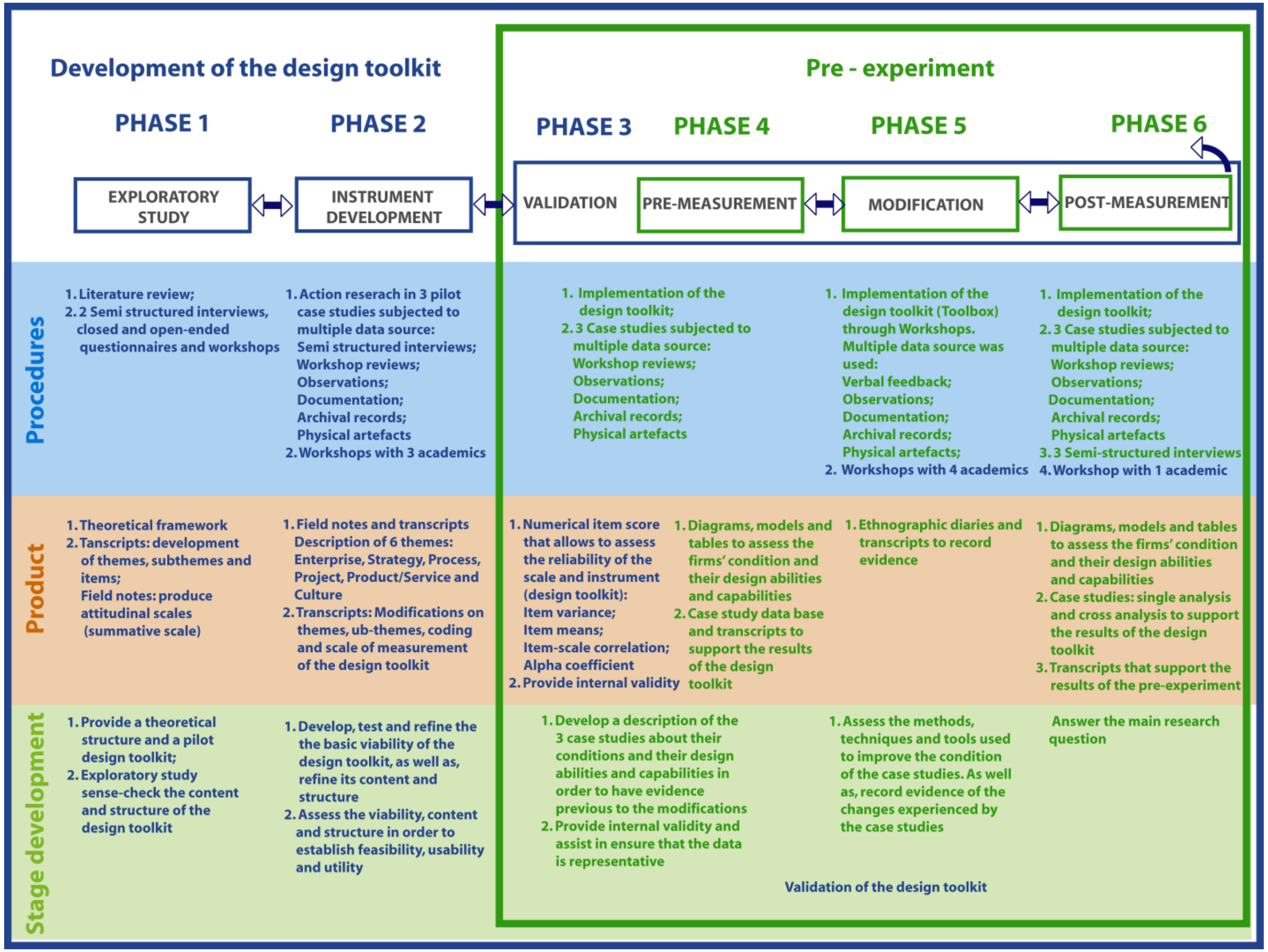
The process to undertake multi-method design is laborious as each study is distinct, and each is congruent with its own assumption. Thus, Mingers (2001) proposes a framework for mapping the research methods in a multi-method design approach. This framework is based on two important features for multi-method research: its multidimensionality and the different types of activity that need to be undertaken within the phases of research. Regarding multidimensionality, research methods can be categorised in terms of their relationship to three worlds, the material world[8], the social world[9] and the personal world[10]. The second dimension considers the phases of the research process, in which four phases are considered: (1) appreciation of the research situation as experienced by the researcher, expressed by any actors in the situation, and prior literature and theories; (2) analysis of the data produced to understand the history that has generated it, and the particular structure of relations and constraints that maintain it; (3) assessment of the postulated explanation(s) in terms of other predicted effects, alternative possible explanations; and (4) action to report on and disseminate the research results, and if necessary or desired, to bring about change to the situation. The obvious strength of using multi-method design is that it overcomes each method's weaknesses and limitations by deliberately combining different types of methods within the same investigations (Brewer and Hunter, 2003). While some authors have described this view or perspective as having a different lens or side (Sandelowski, 1993), the real strength of multiple methods is to obtain a different level of data. Meanwhile, its weakness relies on the ad hoc mixing of strategies or methods, as it may be a serious threat to validity as methodological assumptions can be violated (Morse, 2003). Based on the previous information and for the purpose of this research, the most adequate design is multi-method.

3.4.2 Justification of multi-methods research

The use of multi-methods research can be justified for a number of reasons, but specifically for the type of questions established for this research. As previously discussed, the aim of this research is to explore the impact of design management on the performance of small Mexican technology-based enterprises in new technological industries. In order to accomplish this purpose, a QUAL⇒quan design was considered as a qualitative and a quantitative method are used sequentially with an inductive theoretical thrust. This design is most often used to develop a model (or theory), and then test the model (or theory) (Figure 3.3). Two general stages were considered, 'development of the design toolkit' (model) and 'pre-experiment' (test), in order to highlight the transition of the research. These two stages were subdivided in six different phases (projects) in order to source sequentially each of the phases.

[8] **Material world** is outside and independent of human beings. This world can be categorised as objective in the sense that is independent of the observer, although clearly our observations and descriptions of it are not. (Mingers, 2001)
[9] **Social world** is the world that we share and participate in. Our relation to it is one of intersubjectivity because it is, on the one hand, a human construction, and on the other, it goes beyond and pre-exists any particular individual. (Mingers, 2001)
[10] **Personal world** is the world of our own individual thoughts, emotions, experiences, and belief. (Mingers, 2001)

Figure 3.3 Multi-method design research



The first general stage explored the context of study (Mexico) through qualitative methods to produce a design toolkit that enables the researcher to assess the firms' condition and their use of design (abilities and capabilities) within their current businesses practices. The second general stage concerned on implementing the design toolkit in small Mexican technology-based enterprises to later introduce design management practices to improve their performance and then prove whether the treatment was positive or not.

The first stage 'development of the design toolkit' considers three phases to explore the context of study to create an instrument that is not available by the time of the research. This phase aims to answer the first question '*How do small Mexican technology-based enterprises in new technological industries use and embed design in their business activities?'*. Thus, the first phase explores the topic qualitatively to develop themes from qualitative data. These findings will guide the development of items and scales for a quantitative survey (design toolkit). The second phase aims to test the design toolkit and its feasibility to confirm the basic viability and to inform its content and structure. Finally, the third phase concerns the refinement of the design toolkit on its viability, content and structure in order to validate it. This first stage uses qualitative and quantitative methods that were connected through the development of the instrument items. The methods used in each phase enable a straightforward design to describe and report outcomes. The challenges faced were related to the considerable use of time to explore the context, to collect the data, and to analyse the data that built the quantitative instrument.

The second stage 'pre-experiment' regards three phases to develop a modification (treatment) and to follow up the results of the pre-experiment. This phase intents to answer two research questions: *'How can small Mexican technology-based enterprises in new technological industries use, implement and integrate design management within their activities?'* and *'Do small Mexican technology-based enterprises in new technological industries improve their performance using design management within their activities?'*. Hence, the researcher considered the implementation of the design toolkit to produce a description of the case studies' situation (phase 4). This set of results will define the interventions that need to be introduced in each one of the case studies during a period of 6-7 months (phase 5). Finally, the researcher needs to implement the design toolkit, once again to assess whether the evidence shows an improvement or not in the case studies. This phase uses a collection of both quantitative and qualitative data, although, the qualitative data was regarded to play a supplemental role. The methodology chosen was structured as shown in Figure 3.3 to make more manageable the approach. Thus, the researcher can have enough time and resources to commit to extensive quantitative and qualitative data collection.

In brief, QUAL⇒quan design was considered the most appropriate approach for this research. Due to this design is most often used to develop a model (design toolkit), and then test it. This allows the researcher to consider different projects sequentially to explore the context of study; to produce the design toolkit; to assess the use of design within Mexican TBEs in new technological industries; to explore how these organisations can introduce design within their activities; and to seek whether design can improve their performance or not.

3.4.3 Validity of multi-methods research

This section discusses the measures that were contemplated to achieve quality in this multi-methods research design. As discussed previously, this design considers each project (phase) as methodologically independent and adherent to its own methodological assumptions (Bryman, 1988; Morse, 2003). Even though, this series of projects are interrelated in a broad topic and designed to solve an overall research problem. Nevertheless, it is important to understand essential issues of rigour in quantitative research (reliability, validity, experimental control, and generalisation) and qualitative research (credibility, trustworthiness and common validation strategies), as the design aims to develop a design toolkit and then implement it in three case studies.

In quantitative research it is important to bring to the study validity[11] and reliability[12]. Thus, the study has to be subject to standards that are drawn from statistical procedures or external experts. There are two contexts in where validity and reliability can be obtained. The first pertains to scores from past uses of the instruments and whether the scores are valid and reliable (Burns, 2000; Creswell and Plano-Clark, 2007). The second relates to an assessment of the validity and reliability of data collected in the study (Burns, 2000; Creswell and Plano-Clark, 2007). In this case, the researcher adopted both types of evaluation. First, previous instruments developed in design and design management were reviewed to explore the

[11] **Validity** (quantitative research). It refers to whether one can draw meaningful and useful from scores on particular instruments (Creswell, 2009).
[12] **Reliability**. It refers to whether scores to items on an instrument are internally consistent, stable over time, and whether there was a consistency in test administration and scoring (Creswell, 2009).

validity and reliability of the scores as well as the content analysis and criterion-related to validity. The previous review along with the data collected from the three phases were used as guideline to develop the design toolkit and to provide validity to it through content validity, construct validity and criterion related to practice and academia. In what respects to the pre-experiment stage, the researcher take into consideration a design strategy to reduce the threats to internal validity. The internal validity was controlled using qualitative techniques to check on participants' attrition and on selection bias, and to reduce the impact of maturation of participants. A literature review was used as a source to draw the features that could affect the external validity of the research such as features of the sample, settings, and past and future situations that can affect the treatment. Finally, when the results of the design toolkit were obtained from the pre-measurement and post-measurement phases, it was possible to assess the reliability of the scale and instrument through item-variance, item means, item-scale correlation and alpha coefficient.

In qualitative research, validity has its origin on the analysis of the researcher, the information gleaned whilst visiting participants and external reviewers (Creswell, 2009). According to Lincoln and Guba (1985), there is more focus on validity to determine whether the account provided by the researcher and participants are accurate, credible, and trusted. Thus, the approaches adopted to obtain validation in this research were: (1) member checking in where the researcher feedback to participants summaries and asked them whether the findings were an accurate reflection of their experiences; and (2) triangulation of data from different sources (transcripts, ethnographic diaries, field notes) in where the researcher built evidence for a code or theme from several sources. In qualitative research, reliability plays a minor role, as it relates primarily to the reliability of multiple coders on a team to reach agreement on codes for passages in text. Consequently, the researcher considered to a small number of external researchers (external academics) to reach an agreement on the codes used to analyse the data produced from the qualitative research such as interviews, observations and ethnographic methods.

Up to this point, we have discussed validity for quantitative and qualitative research methods. Therefore, it is necessary to discuss the potential threats to the general design research, especially in the pre-experiment. In the pre-experiment stage, it was necessary to consider the several threats to validity that could raise questions about the experimenter's ability to conclude the experiment. Due to the intervention affects an outcome and not some other factor (Creswell, 2009), thus researchers need to identify potential threats to the internal and external validity of their experiments. It is important to emphasise that the pre-experiment was based on three case studies, and consequently the intent of this form of inquiry is not to generalize findings to individuals, sites or places outside of those under study (Creswell, 2009). Its value lies in the particular description and themes developed in context of a specific site; this means its particularity (Greene and Caracelli, 1997). Table 3.3 displays threats that could affect the pre-experiment, provides a description of each one of them, and mentions the actions considered by the researcher to prevent that these threats do not occur.

Table 3.3 Potential threats to the validity of the pre-experiment

Type of Threat		Description of Threat	Minimising the Threat
Internal validity	History	Events can occur during the time of an experiment that unduly influence the outcome beyond the treatment	The researcher documented the external events that affected the pre-experiment group
	Maturation	Participants may change during the experiment, thus influencing the results	The researcher used multiple source of data collection to record changes experienced
	Regression	Participant with extreme scores are selected for the experiment	It was chosen as much participants as possible to bring parity to the study
	Selection	Participants can be selected according to certain characteristics that predispose them to have certain outcomes	The researcher selected randomly the participants
	Mortality	Participants drop out during an experiment due to many possible reasons	The researcher recruited one more case of study to account for a drop out;
	Diffusion of treatment	Participants in the control and experimental group communicate with each other and influence how both groups scores	As it was a pre-experiment, there was no division. Each case study was also kept as separate as possible for confidential reasons
	Compensatory/ Resentful demoralization	The benefits of an experiment may be unequal or resented when only the experimental group receive the treatment	As it was a pre-experiment, each case study received a unique treatment that was shaped according to their necessities
	Testing	Participants become familiar with the outcome measure and remember responses for later testing	The researcher have an interval of six-seven month between the pre-measurement and post-measurement
	Instrumentation	The instrument changes between a pre-test and post-test, thus impacting the scores on the outcome	The researcher use the same design toolkit in the pre-measurement and post-measurement
External validity	Interaction of selection and treatment	Due to the specific characteristics of participants, the scholar cannot generalise to persons who do not have those characteristics	The intent of this research is not to generalise findings, but it is not close to: The instrument can be used by other researchers in other settings to prove whether the same results are obtained To replicate the study to determine if the similar results are obtained;
	Interaction of settings and treatment	Due to the characteristics of the settings in an experiment, the researcher cannot generalise to individuals in other settings	
	Interaction of history and treatment	Due to results of an experiment are time bound, a researcher cannot generalise the results to past or future situations	

Source: Creswell (2009)

The internal validity threats are related in their majority to the participants' behaviour during the experiment (maturation, regression, selection, morality, diffusion of treatment and testing). It also considers the events that occur during the time of the treatment, the benefits that the experimental group have experienced and the changes in the instrument of measurement. The external threats relate to the selection of specific characteristics in the participants, settings and time.

Researchers that consider multi-method designs need to be careful in the conduct of methods and the way results are triangulated to form a comprehensive whole. Thus, it is important to present the methods used and their constraints in order to provide validity to this study. According to Gillham (2000), different methods have different strengths and different weaknesses. If they converge (agree) then researchers can be reasonably confident that they are getting true picture. If they do not agree then researchers have to be cautious about basing their understanding on any set of data. In action research, validity refers to whether or not the problem in the action context is solved and locally valid (Cunningham, 1983:405). Chein, et al. (1948) had a similar contextual validation, but they mention that the job description of action researchers requires that they not only make discoveries, but also see that these discoveries are applied. This implies that any research is valid if it is applied in a particular context and works to solve the original presenting problem. For Winter (1987) validity in action research is not to be found in the degree of correspondence between reality and account, but rather in the theoretical use of the principles of reflexivity and dialectics to discipline both the telling of the account and the telling of the process of understanding the account. Similarly, Argyris and Schon (1991) call for, at a minimum, an operational description of what the researcher actually did, and a critical reflection on the claims or attributions he/she makes about the achievements of the process. In this way, the research can be replicated and competing explanations may be examined for the research results. For the purpose of this research, action research needs to provide a way of representing research results that enhance their usability, to describe clearly the process undertaken in the action research and to ensure that the discoveries are applied in the context of study. These validity issues are going to be further explored in the development of the design toolkit (section 4).

In what respect to case studies, literature shows that it is now widely accepted that validity and reliability can be achieved in case study research (Eisenhardt, 1989; Gabriel, 1990; Miles and Huberman, 1994; Parkhe, 1993; Rodriguez, et al., 1999; Yin, 2003). According to Healy and Perry (2000), case study needs to have an ontological appropriateness that concerns with the ontological basis of the realism paradigm that assumes that the research is dealing with complex social phenomena involving reflective people. Thus, ontological appropriateness was achieved in this research by the use of research questions dealing with a complex social phenomenon that involved ‘how’ questions. Yin (2003) argues that in order to achieve quality it is necessary to provide: construct validity (establishing correct operational measures for the concepts studied); internal validity (for explanatory or casual studies, establishing a causal relationship, whereby certain conditions are shown); external validity (establishing the domain to which a study’s findings can be generalised); and reliability (demonstrating that the operations of the study can be repeated with the same results). Thus, this research used the following tactics to construct validity, use multiple source of evidence and establish a chain of evidence. Then, reliability was achieved using a case study protocol and develop case study database (Healy and Perry, 2000).

In conclusion, this section outlined the validity criteria and how each was addressed within this research. Additional, it discussed and demonstrated the necessary rigour required for the undertaking of multi-methods research in this study.

3.5 Research process

Section 3.3 outlined the rationale for using pragmatism as the most appropriate worldview for this research and section 3.4 established that multi-methods research design was a compatible methodology for the worldview chosen and the research problem. In turn, this section deals with the actual process of using the appropriate methods and undertaking research activities. Thus, it provides a brief description of the management of the research project, including the decision making involved in the collection of data. Consequently, it is going to explore the development of the design toolkit, its research methodology and activities. Subsequently, it is going to introduce the pre-experiment stage, its research methodology and activities.

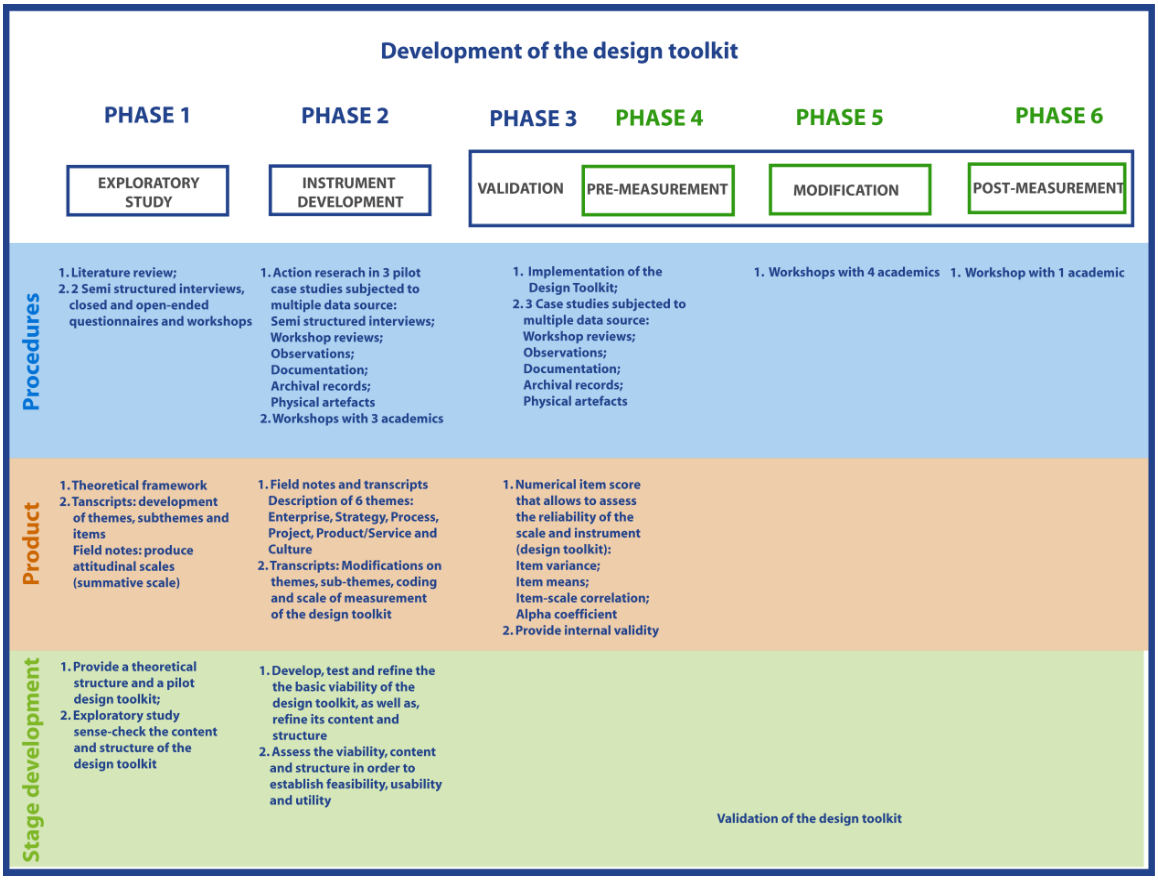
3.5.1 Development of the design toolkit

This phase is constituted from three phases that aim to develop a design toolkit to assess the condition of small Mexican TBEs in new technological industries. Thus, its first stage involves qualitative data collection and analysis in order to produce a prototype of the design toolkit. Then, it involves qualitative methods to test the basic viability, content and structure of the toolkit. Finally, it is validated using quantitative data collection and analysis within the context of study.

a) Research methodology and activities

The procedure used for this section was an exploratory design of three-phases (Fig. 3.4), to gather qualitative data and analyzes it to develop the design toolkit (phase 1), to use the analysis to test and to refine the design toolkit (phase 2) that is subsequently administered to a sample of a population (phase 3).

Figure 3.4 Development of the design toolkit



Phase 1- Exploratory study. At the beginning of this study, I was uncertain about the use of design management in businesses, especially technology-based enterprises, in Mexico. This was as a result of my previous experiences working as an industrial designer, innovator and design manager in different industries and companies' sizes in Mexico. This experience was enriched and extended when I had my own design consultancy in Mexico in design management, as I experienced many of the problems faced by owners of small technology-based enterprises and in-house designers, such as: access to finance, ability to recruit, train and retain highly qualified personnel, expertise in technological or scientific areas, and lack of management skills and techniques. Reading previous literature and consulting with colleagues helped me to identify the importance to explore how design is used and embedded in small Mexican TBEs, and how design management could be integrated to improve the performance of these types businesses. Later, the study was refined with the help of the supervisor, and the main question was elaborated. Initial examination of literature and development of the research problem guided to establish a strong theoretical underpinning that assisted to establish an outline of the themes that could be practical in the elaboration of the design toolkit. Several databases were used to generate a contextual overview of Mexico, a definition of small TBEs and an understanding of their organisation and management style. Likewise, it was possible to explore new product/service development and to attain an overall understanding of design, its value and role in the business context. This information allowed the researcher to provide a structure to produce a prototype of the design toolkit.

In this phase, it was also considered the use of two semi-structured interviews (six overall questions, one concern on biographic, three on experience/behaviour, one on knowledge and one on opinion/value) to develop and to further refine the diagnostic framework prototype. Closed and open-ended questionnaires (26 questions) were prepared to understand how firms (and design) perform at the corporate, process and project level. The information obtained along with workshop reviews of the design toolkit permitted to compare and contrast the views of TBEs and design obtained from the literature and the current situation of the context of study. The participants of this phase had to fulfil the follow requirements: (1) being an entrepreneur of small TBE in Mexico; (2) being a private organisation; (3) utilise design within the operations of their enterprises; (4) being active in the development of products/services; (5) develop innovation (incremental or radical) continuously; and (6) being established in new technological industries. The insights obtained from the data collection phase allow the researcher to refine the themes and structure of the first design toolkit prototype. In addition, the answers obtained from closed and open-ended questionnaires let the researcher to code the items that were part of the 'diagnostic framework'. Hence, this phase was used as an exploratory study to sense-check the content and structure of the diagnostic framework.

Phase 2- Instrument development. This phase concerned on develop, test and refine the design toolkit that aims to collect quantitative data. In the previous phase, the researcher used the data collected to develop themes and write specific items to shape the instrument. However, it was necessary to create subscales from those broad themes, and indeed, to produce and establish items for each subscale. Furthermore, it was required to confirm the basic viability of the approach and to inform the content and structure of the audit, including errors of omission and commission, and the organisation of information. As the purpose of this phase was to reveal the condition of small Mexican TBEs, it was necessary to utilise action research (Moultrie, et al., 2006; Platts, 1993) in three pilot case studies to understand the phenomenon through the perspective of the subjects studied, to establish the feasibility, usability and utility of the instrument. Multiple data sources were used in each case, including semi-structured interviews (n=3) with the general managers and project managers or designers, workshop reviews, verbal feedback from all participants, observation, documentation, archival records and physical artefacts. It is important to highlight the importance of interviews, as they were used to achieve a stable pattern of agreement (convergence) or disagreement (divergence) on issues relevant to the condition of small Mexican TBEs. The pilot case studies were selected under the requirements displayed in Table 3.4. The results were reviewed using field notes and transcripts to refine the themes and codes and to produce the appropriate modifications.

Table 3.4 List of requirements

List of requirements	Sub-variables
Being a technology-based enterprise	Use scientific and technology activities; innovative activities; aim to introduce (technological) innovations within the market
Small sized enterprise	Number of employees from 0 to 50
Mexican enterprise	Owned by Mexicans; National Intellectual Property (IP); Mexican workforce in its majority
Private organisation	
Use design within its activities	At the strategic, tactical or operational level; industrial design, graphic design, engineering design etc;
Active in the new product/services development (Product; service; process)	
Develop innovation continuously	Radical (new to the market or new to the world); and incremental
Established in the business for more than three years	
Establish in new technological industries	Biotechnology; ecology; electronic; energy; new materials; and telecommunications

The next action was to make modifications on the design toolkit based on the feedback from the feasibility phase. This task was possible through refining the assessment on the viability of the content and structure of the tool. Three Mexican academics were chosen for this task because through their experience they could establish feasibility, usability and utility, as well as, to provide academic rigour to the design toolkit. Therefore, the follow requirements had to be fulfilled for the academics: (1) being active lecturers; (2) have awareness about design management; (3) have any postgraduate title; (4) background and current degree must concern with design or management; and (5) have done research concern on design in small-sized Mexican enterprises. The academics were subject to a workshop review in where they could express their insights through a verbal feedback. The most significant changes on the design toolkit were related to modifications in the structure of some questions; reduction in the number of question; modification in the language used; consideration of quantitative parameters; improvement in the interface between the different sections of design toolkit; and reduction on its complexity.

Phase 3- Validation. This phase dealt with the validation of the design toolkit. Ergo, the amended instrument was applied to the three main case studies to validate findings from the development phase. The cases studies chosen fulfil the requirements previously presented in Table 3.4. The multiple cases studies used multiple data source such as workshops review, observations, documentation and assessment of physical artefacts and archival records. In each case, respondents were given a copy of the design toolkit (in the form of a paper workbook) before applying it. The results obtained were analysed through a scale of reliability to assess the instrument using item-variance, item-means, scale correlation and alpha coefficient. The overall results obtained from this strategy helped to summarize dimensions and provide evidence to construct validity. Thus, it was possible to have a reliable instrument to measure dimensions.

After its first implementation within the case studies, the design toolkit was modified from a workbook in paper to a software version. In order to ensure its usability, content and construct, it was once again subjected to four workshop reviews with international academics experts in design (management). Finally, the software version was introduced in the post-measurement phase, and it repeated again the scale reliability assessment. In summary, this stage helped to explore qualitatively the development of an instrument as it is the mean that would help the researcher to assess the condition of the firm and design. The results obtained would lead to develop an intervention treatment in the follow strategy, and finally to evaluate whether design management improve the condition of the firm or not.

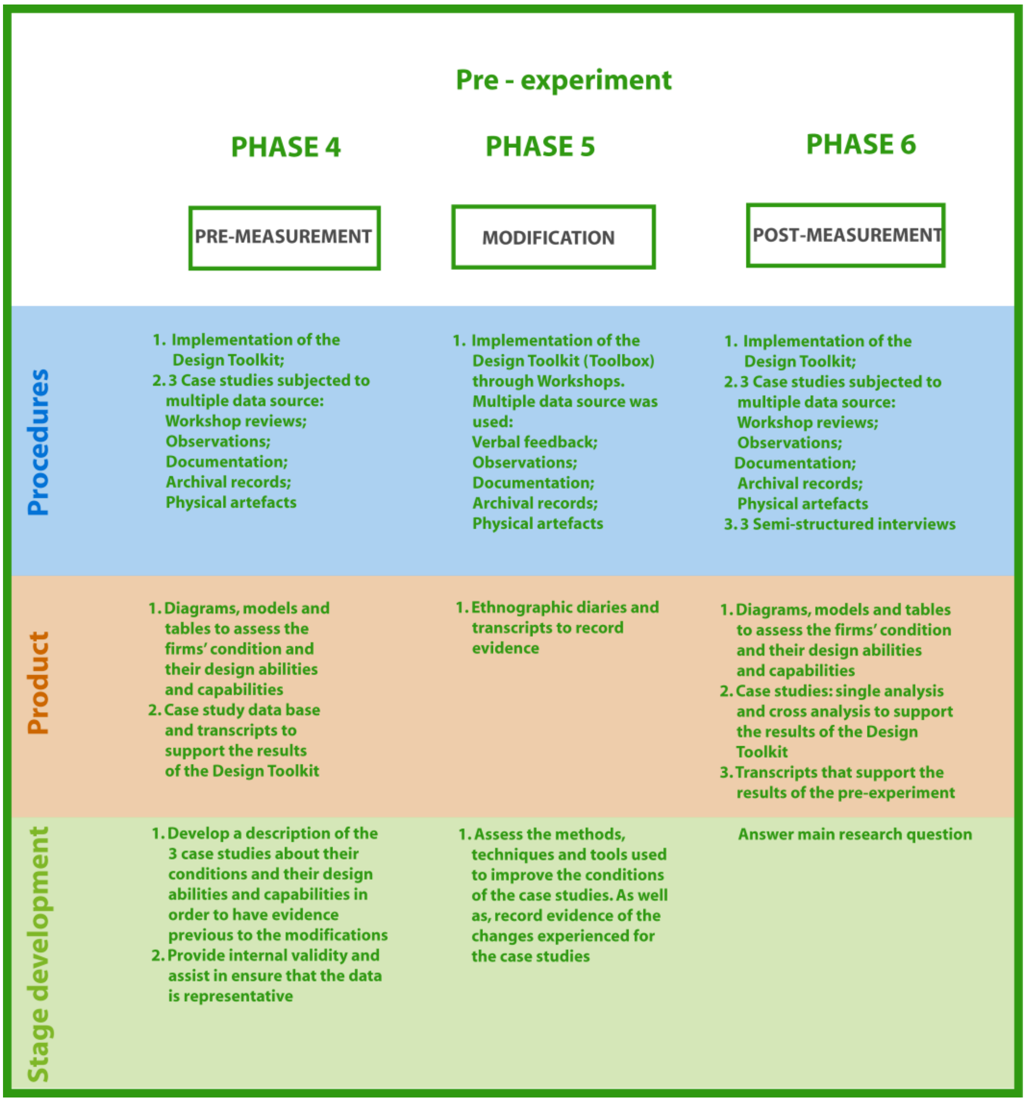
3.5.2 Pre-experiment

This stage considers three phases to conduct a pre-experiment that allow the researcher to answer the two questions established. The primary method used was survey represented by the design toolkit, meanwhile case studies were utilised to provide supporting role to the toolkit. Hence, the secondary method has less priority and it is triangulated within the predominant method. The mixing of the data from the two methods is often used to integrate the information and compare one data source with the other. Researchers use this model to gain broader perspectives because of the employment of different methods as opposed to apply a predominant method alone (Creswell, 2009). Both methods were used in the pre-measurement (phase 4) and post-measurement (phase 6) phases to collect evidence that at the end of the study allowed answer the main research question. It was also considered multiple data source in the modification phase (phase 5) to assess the methods, techniques and tools used to improve the condition of the case studies. As well as, to record evidence of the changes experienced in the case studies during a period of six-seven months.

a) Research methodology and activities

The procedure considered for this section was a pre-experiment model of three phases (Fig. 3.5). Thus, it was applied the design toolkit to assess the condition of the case studies (phase 4) to produce evidence previous of the modification (phase 5). Then, it was possible to assess these results with the post-measurement results (phase 6) to answer the research question.

Figure 3.5 Pre-experiment



Phase 4- Pre-measurement. The purpose of this phase is to implement the design toolkit to enable the researcher to explore whether design management implementation within business activities can provoke an improvement in the performance of the case studies. The first action was to apply the design toolkit to produce a description of the firm condition, its design abilities and capabilities. This information allowed the researcher to develop modifications in each of the three case studies. This was possible using a section of the design toolkit developed to provide a series of diagrams, models and tables with the results obtained. These results were presented to the personnel of the three case studies to discuss the follow actions. After deciding which actions were the most appropriate for each case, an agenda was developed with all the dates in which workshops were aimed to be introduced.

Phase 5- Modification. This phase focused on the analysis of the evidence obtained from the previous phase in order to produce specific modifications in each case study. Thus, each case study experienced a series of implementations and follow up actions during a period of six to seven months. Workshops were used to introduce a series of methods, techniques and tools within the case studies. Furthermore, multiple data source was used at this phase for two reasons: (1) to assess the methods, techniques, and tools used to improve the conditions of the case studies; and (2) to record evidence of the changes experienced for the case studies. Once fulfilled both activities, the researcher was able to implement the next evaluation.

Phase 6- Post-measurement. The post-measurement phase, similarly to the pre-measurement phase, considered the assessment of the design toolkit, supported by cases studies and multiple data source. The results obtained were contrasted with the results obtained in the first evaluation. The procedures used to analyse the data were T-test to statistically evaluate if the two groups of results differ between them significantly with respect to their measures, and descriptive statistics to ascertain the incidence and values in which are manifested one or more variables. Descriptive statistics include measure of control tendency (averages-mean, media and mode) and measure of variability about the average. It gives the reader a picture of the data collected and used in the research project. It is important to mention that the researcher used the diagrams, models and tables developed in the design toolkit in order to describe the outcomes obtained. T-test was considered the most appropriate procedure to compare the means of the results from the pre-measurement and post-measurement assessment of the pre-experiment. The researcher used the statistic package SPSS to obtain the T-value and then determine with the table of significance whether it was large enough to be significant. Through this analysis, it was possible to conclude whether the difference between the means of the two groups of results is different, even given the variability.

Furthermore, it was considered the use of semi-structured interviews to provide support to the results obtained. These interviews explored the process experienced by the personnel in charge to implement the modification within the case studies activities (two owners and a design manager). The interviews were transcribed and analysed by themes and quotes that helped to support the results obtained from the pre-experiment. Mixing both types of approaches represented an advantage for the researcher, as it was possible to draw overall results and interpretations of the study. Hence, it was possible to discuss themes that were triggered in the context of intervention and its outcomes, and finally the intervention effectiveness.

In summary, this strategy helped to develop modifications and follow up action on the results of a pre-experiment, as it was these were needed to answer two research questions. Through the fulfilment of this stage, it was possible to achieve the objectives of this study.

3.6 Ethical considerations

Researchers need to anticipate the ethical issues that may arise during their studies (Hesse-Biber and Leavy, 2006). Therefore, the researcher considered, early in the research, the issues that are required to protect such as the data collected from people, about people (Punch, 2005). This means that it is needed to protect research participants; develop a trust with them; promote the integrity of the research; guard against misconduct and impropriety that might reflect on their organisations or institutions; and cope with new, challenging problems (Israel and Hay, 2006). The primary purpose of research ethics is to protect participating organisations and persons from any possible disadvantages or adverse consequence that may result from this research (Cooper and Emory, 1995), thus the inquirer prepared a strategy to provide protection to them.

The first important consideration was to produce a personalised letter to each of the interviewee, participants, and organisations outlined in the intent of the research. When the interviews started, the researcher gave to the interviewees an informed consent form to sign before they engage in the research. In this form were acknowledges the participants rights, a detailed information about the identification of the researcher, the institution sponsor, the purpose of the research, guarantee of confidentiality to the participant, and assurance that the participant can withdraw at any time. When the researcher was preparing the questions that would be used in the interview, it was considered that these did not stress participants and let understand the consequences of the interview for the interviewees. In the pilot case studies intervention and principal case studies, the researcher signed a confidential contract in order to protect any information that is considered commercial in confidence including all type of images, growth and future plans, financial indicators, details in process, products, services and technologies, attitudes and behaviours. Consequently, given the nature of the information gathered, the research was adopted the conditions of the business involved. As well as, organisations were briefed about who would have access to the data collected and for what purpose.

Concerning the ethical issues in data analysis, it was mandatory to keep the data (in the thesis) confidential for a reasonable period, two years (Sieber, 1992), and did not utilise any information including images that can affect the participant organisations in the thesis. During the analysis of the data, the researcher was committed to provide to the case studies an accurate account of the information. Thus, a series of meetings were held between the researcher and participants in order to debrief the information.

3.7 Conclusions

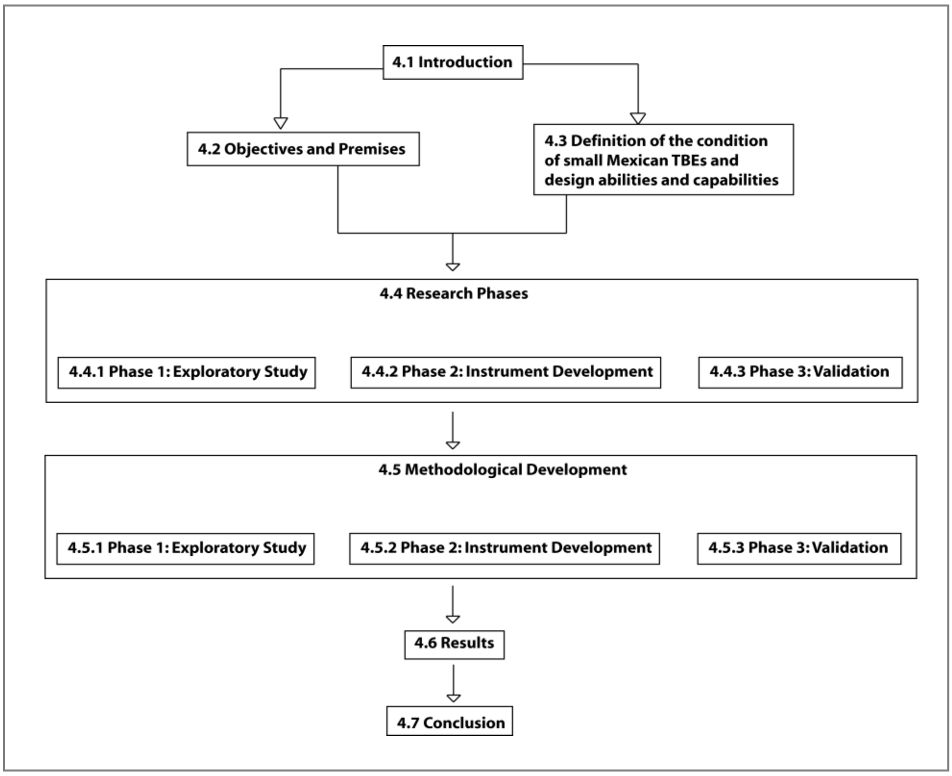
This chapter described the research design adopted to obtain answers to the research questions. Hence, this section began with a brief description of the procedures that comprehend a research design. Then, it explored four philosophical worldviews in order to select the most appropriate foundation for this research, which in this case was pragmatism. Subsequently, it explained the strategies of inquiry, qualitative, quantitative and combined methods strategies in order to understand the advantages and threats that combined methods offered to this research. A discussion was held about the relevance of multi-methods design, its justification and quality. The succeeding sections focus on introducing the different phases that are part of the study. Similarly, it was explained the methods used in each phase of the study and the activities undertaken to obtain data. Finally, the section concluded with a discussion of the ethical considerations relevant to this research. The next two chapters, development of the design toolkit (chapter 4) and pre-experiment (chapter 5), are aimed to extend and discuss further the methods and actions considered in the implementation of each phase.

CHAPTER 4.0 DEVELOPMENT OF THE DESIGN TOOLKIT

4.1 Introduction

Chapter 3 provided a detailed discussion about the research design adopted for this study. It discussed that pragmatism is the paradigm that framed this study and multi-methods design was the most appropriate research design to answer the three research questions identified. Furthermore, the researcher adopted a 'QUAL⇒quan' design strategy that was divided in two sections; development of the design toolkit and pre-experiment. This chapter explores further the stage concerned with the development of the design toolkit. It aims to produce the required instrument to answer the first research question *'How do small Mexican technology-based enterprises in new technological industries use and embed design in their business activities?*. Therefore, it offers an account of the procedures adopted for this stage and resultant outcomes in order to understand the evolution of the design toolkit. It was most important to yield evidence that shows the validity and reliability of the design toolkit, as it is the main instrument to assess the condition of small Mexican technology-based enterprises in new technological industries and their design abilities and capabilities. Figure 4.1 summarises the themes covered within this chapter.

Figure 4.1 Outline of the chapter



4.2 Objective and premises

The main objective of the design toolkit is to identify the condition of small Mexican technology-based enterprises in new technological industries and their abilities and capabilities of design. It is required to conceive a valid and reliable instrument that possesses all the information to present an accurate description of these types of enterprises. Therefore, the researcher adopted an exploratory research strategy to collect data in order to produce a framework related to the context of study.

The following issues were considered prior to the study:

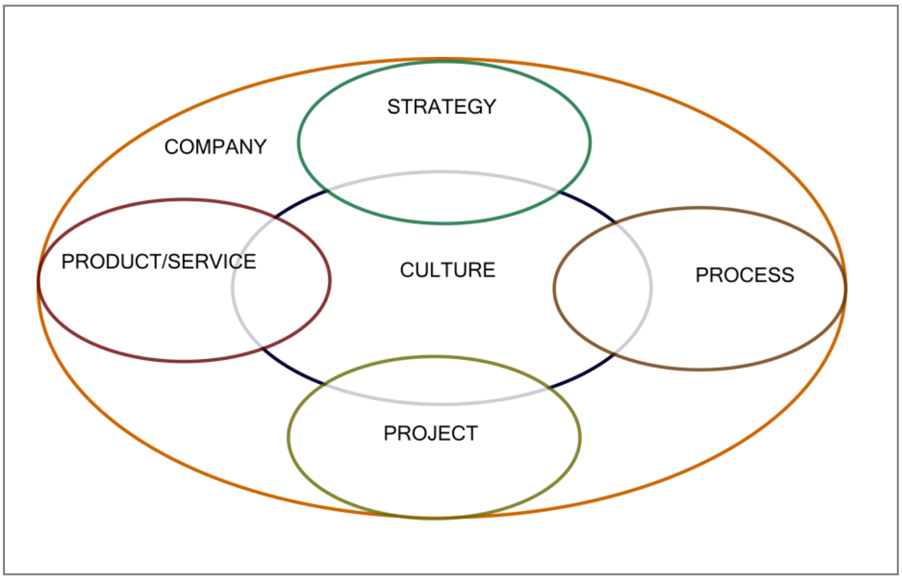
a) Small Mexican TBEs are firms with high-qualified personnel that undertake research and development activities to produce high value goods, services or processes using scientific and technological knowledge. They are experts in high-specialised fields and they apply their advanced technological application within specific market niches;
b) TBEs in Mexico suffer at management level from: lack of appropriate technology; low degree of technology adoption; minimal qualification of their staff or entrepreneurs in the management of activities; management fragility and low productivity; and precarious financial conditions;
c) Small Mexican TBEs have scarce financial resources to invest in areas like design and marketing;
d) Design management is a new area of study and professional practice in Mexico; and
e) Owners or managers of small Mexican TBEs need objective information about their condition in order to improve their business performance.

4.3 Definition of the condition of small Mexican TBEs and design abilities and capabilities

The objective of this study is to assess the condition of small Mexican TBEs in new technological industries and their abilities and capabilities of design. Consequently, it is necessary to define the terms of ‘condition of a company’ and ‘design abilities and capabilities’.

Throughout this study, 'condition of a company' refers to the prevailing situation influencing the performance or outcome of a process. This includes factors that can influence different levels and areas of the firm. Thus, the understanding of these situations provides a clear picture of the overall and current circumstances of the business. Regarding 'design abilities', it alludes to the capacity of the personnel to perform design activities and tasks. 'Capabilities of design' relates to the extent someone has power or abilities to perform effectively and efficiently specific design activities and tasks. Thus, the design toolkit considers the analysis of the company, strategy, process, project, product/service, and culture (Fig. 4.2).

Figure 4.2 Levels considered in the assessment of small TBEs



The 'company' level explores the management style, the organisational structure and the taxonomy of innovation of organisations. This level is key to understanding the way in which the enterprise operates. 'Strategy' level analyses factors that lead to adopt and implement certain strategies. The assessment of design is centred on the management of corporate activities and the alignment in the decision-making of inter-organisational actions. The 'process' level assesses the implementation of the strategy in tangible actions in the process of the development of new products and/or services. At this level, design helps to make this process efficient and effective through the coordination of tasks and information. The 'project' level reviews all the individual and collaborative enterprises that are carefully planned and designed to achieve a particular aim (tangible result). Design assists to improve these activities and obtains enhanced results when it is evaluated against the satisfaction of market needs, cost, technological achievements, economic objectives, and technical quality.

‘Product/service’ level appraises the levels of value delivered in the outcomes. Consequently, design offers added value to the final user and/or consumer in the product/service as a response to their inherent needs. ‘Culture’ level examines the form in which the firm configures and maintains its day-to-day activities. Design considers the work environment, attitudes to design and employees’ performance.

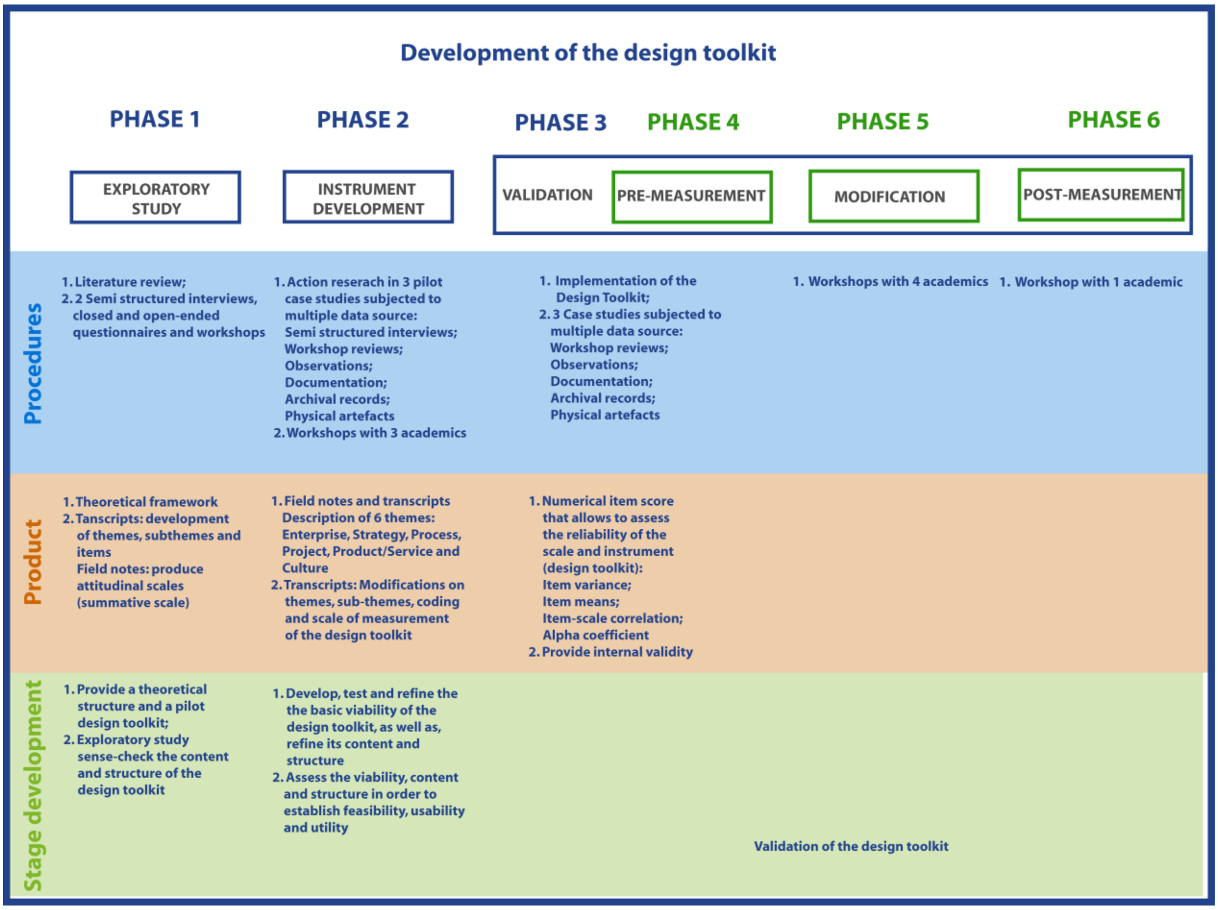
It is important to highlight that ‘culture’ represents the most difficult level (unity) to measure, as it is constituted by the collective mental programming of people in a society who develop common values, beliefs and preferred means of behaving (Kast and Rosenzweig, 1985). This implies that the organisational structure and management style affects the behaviour of personnel activities and actions impacting and transforming the structure. Therefore, it is considered of primary relevance that the design toolkit can assess all the levels that the organisation has available in order to produce an accurate evaluation of its current condition.

4.4 Research phases

As discussed in chapter 3 (section 3.4.2), a ‘QUAL⇒quan’ design is often used to develop a model (or theory), and then test the model (or theory). Firstly, it explored the different topics related to small Mexican TBEs in new technological industries to develop themes and scales of measurement for a quantitative survey instrument (design toolkit). Then, the researcher implements the design toolkit in the subject of study to assess and validate it. In order to achieve this aim, it is necessary to adopt different methods to collect data and to produce an instrument that is appropriate under the context studied.

This stage, ‘development of the design toolkit’, has three main phases, exploratory study, instrument development and validation. The ‘exploratory study phase’ critically reviews the literature to establish a theoretical framework that leads to develop a pilot model. Then, it is further refined through exploring the context of study with semi-structured interviews and closed and open-ended questionnaires with two owners of small Mexican TBEs in new technological industries. Finally, the prototype is tested on its content and construction in two workshops. The ‘instrument development phase’ entails the development, test and refinement of the design toolkit to confirm the basic viability of the approach, as well as informing its content and structure. This stage utilises action research in three pilot case studies to later develop three workshops with Mexican academics. The last phase, ‘validation’, focuses on the implementation of the design toolkit in three longitudinal case studies and five workshops with international academics to validate it. Therefore, this section explores further the methodologies and techniques used in each phase and how they inform the subsequent phases (methods and techniques). Figure 4.3 displays the phases considered in the design toolkit development. Although, it shows a continuum character with a series of phases that have a clear start and end, the current process required an iterative set of actions to collect data and to analyse it.

Figure 4.3 Phases of the development of the design toolkit



4.4.1 Phase 1: Exploratory study

This first phase considers two main procedures: (1) review the literature and produce a prototype of the design toolkit, and (2) explore the context of study and redefine the prototype with the data collected and feedback. The review of the literature allowed the researcher to develop a theoretical and conceptual framework. Both were used as a means to explain the principal factors and variables that need to be studied and the possible relations between them, allowing selecting the relations that have more sense to the study (Rodriguez, et al, 1999). Consequently, the researcher used the information to understand the particular domain of study and to direct the data collection and its analysis. It was utilised to produce the first prototype of the design toolkit through the understanding of the Mexican context, teir small TBEs, their organisation structure and management style, and design and its value and roles in the business context.

The next part was to redefine the design toolkit using semi-structured interviews, and closed and open-ended questionnaires. According to Bryman (1989), questionnaires and structured interviews are used as potential data collection instruments in organisational research. Both methods enable the researcher to operationalise concepts as they question people about diverse aspects of their work environment. The idea of operationalisation entails the provision of indicators that can stand for the concept in question (Bryman, 1989). This leads to produce a series of divisions or statements that need to be measured through indexes or scales to obtain an overall score.

Semi-structured interviews were used because this technique manages to address both the need for comparable responses and the obtainment of information about a determined problem (Newman and McNeil, 1998). Wisker (2001) argues that semi-structured interviews bring the opportunity to set a series of questions to be asked, and at the same time allow space for some divergence with the interviewer. This type of interview helps to obtain individual's subjective experiences and facilitates the access to events and activities that could not be directly observed as they occurred in the past. In order to facilitate the data collection, the researcher developed an interview guide to direct the interview consistent with the purpose of the study. Although, it is important to emphasise that there is a diversity of opinions about the leeway a researcher may use with the interview guide (Baena, 1995; Fontana and Frey, 2005; Patton, 1980; Ridenour and Newman, 2008). Consequently, the structure of this interview used the classification of Patton (1980) to develop the questions under six issues, demographic/biographic; sensorial; experience/behaviour; feelings; knowledge; and opinion/value issues. In this case, the researcher considered three issues to develop the questions, biographic information; experience/behaviour information; and knowledge. A biographic question was prepared to understand characteristics of the person interviewed.

Subsequently, experience/behaviour questions were introduced to understand what the interviewee does or has done in certain period, as interviewees describe experiences, behaviours, actions and activities that would be visible if the observer were present. Finally, knowledge questions were formulated to gain information about facts and ideas that the interviewer is researching. Likewise, they are key to create a feeling of trust and allow the interviewee to open to the interviewer when themes that are more relevant arise during the interview (Appendix 2.A). Unfortunately, interviews need to be planned and managed. This can be time consuming and expensive, and can impose geographical limitations (Gillham, 2000). With personal interviews, there is often a bias as the interviewee may have a tendency to please or impress, create a false personal image or end the interview quickly.

After the semi-structured interviews were finalised, transcribed and analysed, the researcher contacted again the interviewees to answer a closed and open-ended questionnaire (Appendix 2.B). A combination of closed questions and open questions were chosen to obtain easy and quick answers and to attain a clear idea of the respondents' thinking about their social system. Oppenheim (2000) argues that the advantages of close questionnaires go beyond the length of time and the amount of information that can be collected with a reduced amount of money. It allows the respondents to be more focused on the questions without worrying about the format (Wisker, 2001) and lets the researcher to quantify the answers provided by the interviewees (Oppenheim, 2000). Contrary, open-ended questions lead to get a spontaneous sketch in the respondents' own language and containing their own ideas (Oppenheim, 2000). The closed and open-ended questionnaires contained 26 questions, which had nine questions concerning with strategy; eight questions related to the new product development process, eight questions focused on the project, and one last question in which the respondent can comment any issue that was not considered in the questionnaire. The limitations of questionnaires rely on the difficulty to frame questionnaires and it often requires many rewrites before an acceptable questionnaire is developed. Similarly, responses may not be complete and may not be entirely spontaneous or independent of other respondents' replies. Finally, the questionnaires were responded by a personal meeting where the researcher asked directly to the respondent.

The last action of this phase was a workshop to validate the content and structure of the prototype developed during the exploratory study. The workshop was prepared in two phases as this allowed to reduce the time that the entrepreneurs/owners need to invest on it. First, the researcher emailed a summary of the rationale of the workshop and a booklet with information about the design toolkit in order to facilitate the objectives and actions of the workshop. Second, on the day of the workshop, the researcher indicated to the entrepreneurs/owners to be candid with their thoughts about the design toolkit during its revision. Thus, the researcher was able to write notes to later transcribe them to make the changes required to improve the instrument for the next stage. This small study confirmed the basic viability of the approach as well as informing the content and structure of the audit. Furthermore, it was produced an item pool of variables (questions), and then through assessments the scale of measurement of the design toolkit, 'diagnostic framework', was redefined.

4.4.2 Phase 2: Instrument development

This phase is concerned with the development, testing and refinement of the design toolkit on its pilot version. Hence, it encompasses two main actions: use action-research approach (Moultrie, et al., 2006; Platts, 1993) in three live businesses and three workshops with Mexican academics. Action-research was considered relevant for this phase, as it is a form of inquiry conducted by researchers who wish to inform and improve: their practice, their understanding and decision-making in their practice, and the effect of their practice on the research. The researcher can adopt an exploratory perspective in front of any initial definition of the own situation that he or she can hold. It is research on action with the goal of making that action more effective (French and Bell, 1990), as it is measured by the difference in effectiveness of the subsequent actions taken. Therefore, this approach can help the researcher to explore the context (small Mexican TBEs) to focuses on fact-finding practical problem-solving (improve the design toolkit) in a social situation with a view to improve the quality of actions within it (performance of small Mexican TBEs), involving the collaboration and cooperation of researchers, practitioners and laymen (Burns, 2000). Consequently, this clear purpose helped to do not consider ethnography as it focuses just in descriptive/interpretative matters, values, ideas, practices of cultural groups, grounded theory as it consider issues related to process such as experiences through time or changes experienced in different stages and phases, and ethnomethodology as it focuses in issues related to the verbal interaction and dialog.

According to Kemmis (in Hammersley, 2007), this type of research is engaged for practitioners about their own practices. It takes its cues from the perception of practitioners within particular local practice contexts. Hence, it bounds episodes of research according to the boundaries of the local context (Watkins, 1991). This implies that interventions are the experimental manipulation and problem solving is the goal ensuring that the contribution to knowledge relies in the area of research on intervention. Disadvantages rely on the fact that results are crystallised in the active role that assume the subjects that are participants in the research, the expertise and knowledge of the researcher to reflecting about them, breaking in this way with the separatist dichotomy of theory/practice. Thus, the researcher has to have the capability to contemplate the problem from the point of view of those that are implicated within the problem, and then allow a free dialog among people involved, especially the relation between external (researchers) and internal members, in order validate it. Consequently, Peter and Robinson (1984) examined the characteristics of action-research through reviewing the works of eleven action researchers. They identified that the following characteristics were recurrent among researchers in the description of action-research: problem focused, collaboratively conducted and participatory, action oriented, an organic or cyclical process, and scientific. Thus, this research adopted the previous common characteristics along with Lewin's (1946) work in that emphasised four basic characteristic of action-research:

1. It is situational: diagnose a problem in a specific context and attempt to solve it in that context;
2. It is collaborative: researcher and practitioners work together;
3. It is participatory: team members take part directly in implementing the research; and
4. It is self-evaluative: modifications are continuously evaluated within the ongoing situation to improve practice.

Action-research has been gaining interest among researchers, and thus its scope and approach has been extended. It has been discussed the different types of approaches in which action-research can be undertaken in any field of study. Chein, et al. (1948) suggest four types:

1. Diagnostic: in which the researcher/scientist diagnoses a problem and make recommendations for change;
2. Participant: in which the actors learn to take actions and to conduct research;
3. Empirical: in which the actors document action for research and reflection;
4. Experimental: in which there is controlled research on different action alternatives

Kemmis (in Hammersley, 2007) advocates the use of action-research as a way of doing critical social science. Thus, he mentioned three variants in action-research that illustrates the way in which the differing definitional emphasis lead to differential approaches. These three variants, (1) action research -data informs action, (2) action learning -learning improves action, and (3) action science -meta learning transform action, are based on organisational development approaches aimed at bringing organisational change. Consequently, the view of action-reach of Kemmis was adopted for this research, as it focuses on the development of data from the facts of the context that will lead to unfreezing the dynamic equilibrium present in people, groups and organisations. In order to structure this cycle of reflective action, the following four steps can be used: 1) collect/experience, observing and reflecting on the consequence of action in a situation; 2) act/understanding, forming and reforming understanding of a situation as a result of experience; 3) planning, planning actions to influence the situation based on newly founded or reformend understanding; and 4) action: acting or trying out the plan in the situation. Therefore, the researcher will be able to reflect problems in groups which typically include members of the organisation, to collect data around the problem encountered, to analyse the group and to obtain feedback from it, to group designed intervention that attempt to solve the problem, and to undertake an iterative process of intervention followed by reflections.

According to Rodriguez, et al. (1999), the validity of the information or theories that action-research generates depends not so much on scientific test of truth, as on their usefulness in helping people to function more intelligently and skilfully. This permits the researcher to focus on specific problems in a defined context and not on obtaining scientific knowledge that can be generalised. Nevertheless, this has raised many criticisms for producing research with little action or action with little research (Foster, 1972; Sanford, 1981), lacking the rigour of true scientific research (Cohen and Manion, 1985) and lacking in internal and external control (Merrian and Simpson, 1984). Thus, Rappoport (1970) suggests that action-research must resolve three dilemmas, the resolution of either side of which will exacerbate the other: the dilemmas of goal, ethics and initiatives. The goals of action and research appears irreconcilable but must be balanced through adequate time for the research, access to data and appropriate subjects. The researcher needs to consider ethical issues including confidentiality, collusion with the host organisation and competing organisations seeking access to the research or the researcher. Similarly, the researcher has to have the expertise to undertake the effort of consider at the same time research and development and maintain their integrity it is a complex and difficult task. The researcher and participants that work along during the research and development of knowledge and its utilization must take care of both aspects of the knowledge process. In summary, action-research was selected to improve practical judgements in concrete situations (small Mexican TBEs). It was used as a total process in which a problem situation (development of the design toolkit) is diagnosed, remedial action planned and implemented, and its effects monitored to ascertain if improvements are robust.

Multiple data sources were used in each case, including semi-structured interviews with general managers, project managers or designers, workshop reviews, verbal feedback from all participants, observations, documentation, archival record and physical artefacts. This is in order to enable the refinement of the content and structure to establish feasibility and usability of the design toolkit. The techniques used to collect data for this method were semi-structured interviews, workshop reviews, verbal feedback, observation, documentation, archival record and physical artefacts. Observation is a technique that allows the researcher to notice facts as they are raised and to record them following a physical or mechanical procedure (Rodriguez, et al., 1999). This implies that it provides a representation of the reality of a phenomenon. Thus, to address the objective of this phase, it was adopted a descriptive system (Evertson and Green, 1989). This type of observation enables open observations, in which the identification of the problem can be performed in an explicit way referring to specific behaviours, events or process. The total length of the observation is condition for three variables: (1) the problem or question that is pretended to give an answer (section 3.3), (2) the circumstances that surround the observed phenomenon, and (3) the personal criterion of the researcher. Therefore, this research aims to cover the multiple aspects of the behaviour of the personnel within the case studies, as it pretends to reflect all the complexity and extension of the phenomenon and process experienced. The observations were documented using field notes to facilitate their posterior study and reflection about the problem.

Documentation, archival records and physical artefacts are part of the six sources of evidence used in case study methods (Yin, 2003). These sources of evidence were considered as highly complementary with observation, verbal feedback and workshop review to provide a well-documented fieldwork. Documentation comprises all type of documents that are internal or external to the organisation. According to Yin (2003), they are used to verify data, to corroborate information from other sources, and to make inference from documents as they can turn out to be false leads. Archival records are more precise and quantitative type of documentation because they map all the records that the firm has such as service records, organisational records, maps and charts, list of name, personnel records, among others. Finally, physical artefacts concern with all the objects that have being made by the company and there is physical probe of their existence.

The use of all these source of evidence helped to redefine themes and subthemes and to consider specific items to shape the design toolkit. It also improved the content and structure of the audit, including errors of information omission and use of common language. However, it was needed to assess again the viability of the instrument prior to its implementation in the three main case studies (phase 3-4). Hence, it produced a workshop review with three Mexican academics in order to establish feasibility, usability and utility in the instrument, and indeed to provide an academic rigour to the design toolkit. They also reviewed the scale and development of the design toolkit in order to validate it. Each academic was subjected to a workshop, in which they expressed their insights using verbal feedback. Field notes were used once again to collect the verbal feedbacks of participants.

4.4.3 Phase 3: Validation

This phase deals with the validation of the design toolkit. This implies that it was exposed to the subject of study to validate findings from the development phase. Three case studies were selected to participate throughout all this phase, as it has duration of 11 months in which they were subjected to a pre-measurement, modification and post-measurement phases. The first action undertaken was to have an introductory session to provide information about the study to the staff of the cases studies. Then, the researcher was able to distribute booklets with a summary of the design toolkit among respondents in order to facilitate the assessment. Then, in the assessment day the researcher provided each respondent a design toolkit workbook to respond to it. Each workbook was collected on the same day in which it was applied, all answers were decoded and analysed by case study. The outcomes obtained were supported through case study analysis in the three cases. Thus, it was required to utilise multiple data source such as: workshop reviews, observations, and assessment of physical artefacts, archival records and documentation, to collect evidence. During the pre-experiment stage, the design toolkit continually changed as it was produced within a software version. Therefore, five international academics were contacted to review the software version of the design toolkit in order to be validated.

Case study was used as a method because it allows investigators to retain the holistic and meaningful characteristics of real-life events such as organisational and managerial processes, internal relations or maturation of industries (Yin, 2003). This method is the most suitable when the phenomenon under study is not readily distinguishable from its context such as a project or program in an evaluation study. This approach is often used to make practical improvements. Consequently, this approach was appropriate for the purpose of this phase, which was to examine multiple cases to obtain as a product facts (factual prove). It persuades the development and content of certain facts in a representative framework of a more general context. Hence, Yin (1994) suggests the inclusion of the context as a major part of the study creates distinctive technical challenges. First, the richness of the context means that the study will likely to have more variables than data points. Second, the richness means that the study cannot rely on a single data collection but will likely need to use multiple source of evidence. Third, even if all the relevant variables are quantitative, distinctive strategies will be needed for analysis. Thus, it can be argued that a case study involves a process of inquiry that is characterised for detailed, comprehensive, systematic and in deep examination of the object of interest. The case study method has four steps: 1) determine the current situation; 2) gather information about the past and present key variables; 3) test the information collected in order to be analysed. The culmination of this step was to take actions to remedy the problem; and 4) to take remedial action in order to check that the remedy implemented actually work out in practice. Therefore, case study enables rich information to be gathered form which potentially useful data can be generated.

Although, it is inefficient in researching situations which are already well structured and where the important variables have been identified. They lack utility when attempting to reach rigorous conclusions or determining precise relationships between variables. The understanding of these issues led to discard other methods such as phenomenology that focuses on issues related to meaning (explain the essence of the experience of actors), grounded theory that bases on process related issues, ethnography that relies on descriptive issues, and biography that concentrates on subjective issues. Thus, case study was used as a method that requires a collection and record of data about a case or cases, and the preparation of a report or presentation of the case (Stenhouse, 1990:644). Hence, the researcher used different source of evidence to collect and record data to validate the design toolkit, plus to complement the pre-experiment phase. The main outcome of this phase was to produce a design toolkit with summative (Likert) scales that offered a result about the condition of the firm and its design abilities and capabilities. The results were contrasted with the outcomes of case studies research to compare whether the results were compatible or not.

4.5 Methodological development

4.5.1 Phase 1: Exploratory study

From January 2008 to August 2008, the researcher reviewed literature concerning five large themes: contextual overview of Latin America and Mexico; definition of small TBEs and their context; organisational structure and management style; new product development process; design as an asset in business; and design management. Indeed, the researcher reviewed a large number of design (among other fields of study such as innovation, management, etc.) audits, checklist and assessments in order to unveil the themes that are relevant for the study (Table 4.1). As well as, this revision helped to highlight the themes that have not been covered and are required for the context of study. Therefore, an analysis was undertaken to produce the first prototype of the design toolkit. From this analysis the researcher was able to design a semi-structured interview and to consider the themes for the closed and open-ended questionnaire. In June 2008, the first prototype of the design toolkit was developed and reviewed by the supervisors. Feedback was provided and the researcher was able to make the modifications and review further literature on innovation, strategic management and management style. By July 2008, the researcher obtained approval on the PhD research proposal presented. Consequently, it was possible to contact the National Council of Science and Technology of Mexico (CONACYT). This organisation was the liaison between the researcher and small Mexican TBEs in new technological industries. It is important to mention that this organisation is responsible, at the national level, to provide support to Mexican TBEs through different programmes.

Table 4.1 Summary of design audits

Design audits	Advantages	Disadvantages
Design Atlas Inns, 2002 (p. 104)	- Assess five distinct actions: planning for design, process for design, resources for design, people for design & culture for design; - Provide businesses with a complete tool to assess design capabilities, provide insights, & to perform actions according to the results; - In-house or external designers can undertake the audit;	- The tabular results offers four strict positions in where design assets are placed; - Directed to designers & thus, they are responsible for the assessment, analysis & implementation; - Designers require a wide awareness of design thinking, design management & organizations issues;
British standard BS 7000 (p 109)	- A checklist to assess the process to develop products; - Works as a guide to managing product design, & as mean to understand the formative stage of the manufacturing process within a product design;	- Developed for firms that have a formal manufacturing process, as it sets tasks for senior managers, project managers, design manager & personnel; - Firms need to fulfil five prerequisite to adapt the model, as it demands awareness about business environment & design;
Cooper and Press, 1999 (p 97)	- A design management audit; - Address environmental factors, corporate culture, management of design & physical manifestation of design; - Can assess one factor or all the factors;	- Designers need great expertise to apply design effectively & efficiently throughout its activities or specific levels; - Deep understanding of the organization; - Applicable in large corporations of developed nations;
Moultrie et al., 2006	- Assess design performance on SMEs, specifically the process & outcomes; - Comprise two main appraisals: "process audit" based on process maturity principles that target design related activities in NPD; & "product audit" enable assess perceptions towards product characteristics;	- Design team evaluates its process design in a workshop setting, with a view to targeting improvements; - Focus on SMEs of UK; - Does not address strategic & managerial concerns neither the product development (external to design);
Total design Hollins and Hollins, 1991 (p 111)	- Considers service design; - Process relies on a multidisciplinary team that input constantly the project development; - Attend the necessities of different industries & size of companies;	- The team that assess the process needs to have a design vision or thinking. If not, a designer has to undertake the review; - Deep knowledge & understanding between strategic & process aims to align outcomes with the firm's vision;
Design Management Europe, 2009	- Assess 5 areas that define the performance of design management within the firm: awareness, planning, resources, process & expertise; - Provide automatic feedback either as an overall result or as a dimension; - Provide tips & case studies to improve the results obtained;	- Need to hire a designer from DME to further analyse data, translate results & implement actions within the firm; -Focus on the context of European SMEs; -Advance awareness & investment of design
Borja de Mozota, 2003 (p. 92)	- A checklist to assess design actions at the corporative, tactical & operational level; - Explain the reasons why results can vary from tangible to intangible aspects or to price factors to no-price factors;	- Require designers with expertise & knowledge to understand & assess the different levels; - Design awareness from owner & CEO; - Focus on large & medium-sized firms;

The researcher sent a letter to the department of Innovation in Businesses of CONACYT to request help in the facilitation to contact small Mexican TBEs. This letter had a number of requisites to participate in the first phase, such as: (1) being an entrepreneur of small TBEs in Mexico; (2) being a private organisation; (3) utilise design within the operations of their enterprises; (4) being active in the development of products/services; (5) develop innovation (incremental or radical) continuously; and (6) being established in new technological industries. As a result, five owners of companies were contacted, but there was no response from them all. Then, CONACYT provided another two contacts that were willing to participate in the study. During the month of September and early October 2008, semi-structured interviews, closed and open-ended questionnaires, and workshops were conducted with two owners of small Mexican TBEs.

The first entrepreneur that agreed on participating had more than 15 years of professional experience and his background was industrial design. Meanwhile, the second participant had 38 years of professional experience, and his background is on architecture and additionally has a MA degree in management. Both participants were asked to answer a semi-structured interview (Appendix 2.A) that had six overall questions, concerned with biographic information (question 1), experience/behaviour (questions 2, 3 and 4) and knowledge (question 5 and 6). Indeed, the researcher increased the number of questions as the interview was progressing. When the interviews started, the researcher gave the interviewee an informed consent form to sign before they engage in the research. In this form were acknowledge the participants rights, a detailed information about the identification of the researcher, institution sponsor, purpose of the research, guarantee of confidentiality and assurance that they can withdraw at any time (Appendix 1). The results obtained were coded and six themes emerged (Table 4.2).

Table 4.2 Six themes arising from the analysis

1. Management of the company	-No management skills from the owner -No specialised personnel hired in management positions -The owner is the manager and participates in all the decision undertaken in all levels
2. Adoption of strategies	-No adoption of formal strategies -Focus on cost and differentiation
3. Company culture	-Good relation between employer and employees -Most employees are passive and reactive to situations encountered by the firm
4. Problems in the introduction of product/service to the market	-Lack of skills and expertise to introduce technological product/service within the market -Lack of financial resources to introduce technological products/services
5. Dependency on programmes or investors	-Need of external investment and/or investors to develop technological projects
6. Difficulties on the development of projects.	-Few personnel with expertise to undertake technological and innovative activities

These results were interesting as they related with the themes explored in the literature review such as small and medium-sized enterprises definition, organisation and management style in small TBEs, new product development process and success factors within the NPD. Similarly, these outcomes helped to develop the closed and open-ended questionnaire (Appendix 2.B). The overall questionnaire had 26 questions pertaining to how firms perform at three levels of actions, corporative, process and project level. The corporate level contained nine questions (four closed and five open-ended), in which were explored themes about strategies, objectives, mission and vision. The process level had eight questions (one closed and seven open-ended) that discussed how the new product/service development process is planned, organised, implemented, monitored and evaluated. Similarly, the project level section considers eight questions (one closed and seven open-ended) that cover all the actions related to the development of a project. Finally, the last question provides the opportunity to comment freely about any issue that was not covered in the questionnaire.

The answers supported and extended the results obtained in the semi-structured interviews. The outcomes from the corporative level highlighted that there are two sets of mission, vision and objectives within the business. One is directed to external investors and prospect customers and the other set is subjected to internal activities and day-to-day activities. For example, Interviewee 1 mentioned

> *'the mission, well the mission, I do not have it right now, but well… I need to read it to tell you, but it is in overall to provide design services that benefit the humanity, the innovation and that the enterprise use it as it works in Mexico' (September 2008).*

The mission and vision are seen as paper requirements that only concern to the owner/manager and it is not necessarily to be known by every employee. At the process and project level, the organisations have neither an established new product development process nor a formal project process. Owners argued that businesses cannot adopt a structured organisation because external and internal factors demand that they keep their flexibility. The activities undertaken in a technological project/process mainly depend on the financial resources that businesses obtained from their sponsors or clients. This implies that owners/managers are responsible for the overall development and management of projects or process in small TBEs. Finally, the question concerned with recommendations, both managers agreed that the questions were not related to the conditions of small Mexican TBEs, as they do not use this type of terminology and they do not formalise their businesses. One of the interviewees cited

> *'Your questions are directed to large or medium-sized enterprises that have years training people. I believe that your interview is rigid because small entrepreneurs do not use the terminology that you used, and we do not plan anything, and it is because we depend of different variables, do I explain myself…' (September 2008).*

These results enabled the redesign of the design toolkit into a more realistic assessment that reflects the specific reality of the Mexican business context. In addition, it was also important to explore the requirements that diverse public and private organisations ask in order to offer support to small Mexican TBEs. This implies that any organisation that requires access to financial support from any external body (Public or Private organisation) need to present some basic requisites such as: (1) business proposal, (2) business plan, (3) model of technological transference, (4) expenses of the organisation, (5) feasible study, (6) chronology of the project phases (including the pre-commercial stage), and (7) pilot scale (size of the trial). Thus, the combination of both data sets permits to redefine the prototype of the design toolkit. This regarded five main assessments: the firm; the corporative level; the tactical level; the operational level; and culture for design (Appendix 2.D).

By the end of September 2008, the researcher sent to the two entrepreneurs a workshop agenda (Appendix 2.C) and a summary of the design toolkit (Appendix 2.D) to introduce the activities that would be undertaken on the workshop. In addition, it defined the place, day and time for the workshop, which was undertaken one week later. Feedback obtained highlights the follow aspects: reduction of design issues, elimination of technical terms, and elimination of rigid statements about the firm in the five levels of assessment. Consequently, the researcher modified the design toolkit by reducing the amount of technical terms, the design participation and the number of questions. It also witnessed changes on the levels of assessment as it was required to provide the user with more practical divisions.

4.5.2 Phase 2: Instrument development

From October 2008 to February 2009, the researcher undertook action research in three pilot case studies to develop, test and refine the basic viability of the design toolkit and improve its content and structure. Also, the researcher conducted three workshops with three Mexican academics to assess the viability, content and structure of the design toolkit to establish feasibility, usability, utility and academic rigour. Similarly to the previous phase, CONACYT supplied businesses contacts to the researcher under the requirements established (Table 4.3).

Table 4.3 List of requirements

List of requirements	Sub-variables
Being a technology-based enterprise	Use scientific and technology activities; innovative activities; aim to introduce (technological) innovations within the market
Small sized enterprise	Number of employees from 0 to 50
Mexican enterprise	Owned by Mexicans; National Intellectual Property (IP); Mexican workforce in its majority
Private organisation	
Use design within its activities	At the strategic, tactical or operational level; industrial design, graphic design, engineering design etc;
Active in the new product/services development (Product; service; process)	
Develop innovation continuously	Radical (new to the market or new to the world); and incremental
Established in the business for more than three years	
Establish in new technological industries	Biotechnology; ecology; electronic; energy; new materials; and telecommunications

CONACYT provided a list of five companies, which were contacted by the researcher in order to confirm that the pilot case studies fulfil the requirements. Unfortunately, after visiting the five businesses, it was assessed that two companies were not TBEs. Therefore, the researcher provided a profile of the three pilot case studies selected (Table 4.4). It is important to mention that this stage was delayed because the insertion of the researcher into the pilot case studies took longer than expected. Two owners hindered the study because they wanted to be present in the analysis. Hence, there was a gap on the lapse of time between the action-research analysis of one case study and other. This problem affected the design of the phase leading the researcher to alternate action-research studies and workshops with Mexican academics. This decision enabled the researcher to complete the phase on time.

Table 4.4 Background profiles of the 3 pilot case studies

Pilot 1	Pilot 2	Pilot 3
In-house members: 4 engineers and 2 manager **Designers:** Externally hired **Project:** software-medical field **Number of projects:** First project in which concerns with the development of a new product. It is mostly dedicated to the development of external projects (services)	**In-house members:** 2 engineers, one general assistant and 2 doctors **Designers:** Externally hired **Project:** software-medical field **Number of projects:** First project in the life of the firm and focused in the new product development	**In-house members:** 1 manager, 3 engineers, 5 designers and 5 general assistants **Designers:** In-house **Project:** electronic-material in the automotive industry **Number of projects:** First project in which is involved all the new product development process

During the study, the researcher used multiple data sources to produce evidence that lead to improving the design toolkit. The first action was to have an introductory session with all the members of the organisation to introduce the researcher, the research and explain its core objectives. After each employee was explained about the study, the researcher engaged in semi-structured interviews with project leaders, which in two cases were the general manager (Appendix 2.E). The next step was to observe and document how the companies conduct on their activities, as well as to review their archival record and physical artefacts (Appendix 2.F). These actions contributed to understanding the organisation, and enabling the researcher to prepare a workshop to introduce the design toolkit within business activities. Each employee was provided with a summary of the design toolkit few days before the workshop in order to introduce them to it (Appendix 2.G). In the workshop, every employee had a workbook of the design toolkit; they were specified about reviewing the diagnostic framework section. After they examined the workbook (two hours), it was possible to start the discussion session. The researcher played the role of moderator and divided the session by themes to get as much feedback about the structure and content of the design toolkit. Outcomes of this session helped to modify the toolkit, as it was required to introduce it in the day-to day activities of the action-research cases and to document field notes in an ethnographic diary (Appendix 2.F).

Once staff (action-research pilot case study) agreed that the tool was understandable and appropriate for small Mexican TBEs, the researcher arranged a workshop (Appendix 2.F) with an academic to assess the improved design toolkit. The profile of requirements that academics needed to fulfil to participate in the study were: (1) being active lecturers; (2) being acknowledge of design management; (3) have a postgraduate title; (4) background and (5) current degree must concern with design or management; and have done research concern on design in small-sized Mexican enterprises. Five academics were contacted and just three were interested to participate in the workshop. Table 4.5 presents a brief description of the academics' background.

Table 4.5 Description of the Mexican academics

First academic	Second academic	Third academic
Background: undergraduate in economics & postgraduate in industrial design **Expertise:** value chain of design within the different industry sectors **Research:** explore the use of design within Mexican small sized enterprises	**Background:** undergraduate in industrial design & postgraduate in industrial design **Expertise:** benefits of design management in Mexico State in Micro, Small and Medium sized enterprises **Research:** explore design management in Mexican Micro, SMEs	**Background:** undergraduate in graphic design, master degree in industrial design & PhD in design **Expertise:** benefits of industrial design in Mexican Small and Medium sized enterprises **Research:** explore the benefits of industrial design in Mexican SMEs

This phase was represented by the interchangeable repetition of action-research introductions and workshops with Mexican academics. Table 4.6 summarises the modifications done during this phase. The most significant changes on the design toolkit were related to modifications concerning with the structure of some questions; reduction in the number of question; modification in the language used; consideration of quantitative parameters; improvement in the interface between the different sections of design toolkit; and reduction on its complexity.

Table 4.6 Modification of instrument development phase

	Case 1	Case 2	Case 3	Academic 1	Academic 2	Academic 3
Insights	- Strategy is not the force that drives the company; - Clear definition of roles & levels among staff; - Flexibility on the operation of activities; - Informality in process /project management; - Product development depends heavily in external financial support; - Non-designer do not understand design benefits; -Develop external activities to obtain financial resources;	- Each employees is trained to manage their own activities; - No management of activities; -The product development depends heavily in external financial support; -Designers hired to improve product appearance; - Designers do not have abilities to undertake technological projects;	-Designers with experience in large firms know how to prepare project/design brief; - No management of activities, as employees are occasional depending on the project; - The success of a projects is determined by the use of a project brief to establish clear parameters of work as clients are not used to give requirements of the project;	- Design is part of a large chain of value; - Consider that the improvement of the firm is not just affected by design variables	- Consider quantitative parameters to evaluate the performance of the firms & improve design within the business context; -Design in Mexico is not understood neither for designers nor entrepreneurs;	- Design is a complex area that need to be focused in just one area because if not its study can be loose; - Design in small enterprises just can help on industrial design;
Feedback	- Tool has to contextualise the use of design into the firm; - The formality of the instrument provokes that people feel uncomfortable & get tired of answer it;	- Integrate design in the everyday activities of the firm; - Establish an indicator to know whether the firm requires design;	- It is focused for specialised firm or design consultancy; - Owners do not concern on strategy & process; - Design is seen as specialised area that designers & owners are not able to introduce;	- Questions need to be well written; - Reduce number of questions as it lead to bias; - Reduce design terminology as most users are not designers	- Consider a user friendly interface between the diagnostic framework, results & design toolbox; - Use quantitative parameters in order to generate interest in the owners;	- Reduce number of questions as it lead to bias; - The tool is too complex & the structure is too cumbersome;
Modifications	- Adjustment on the structure of the audit; - Reduce design role & balance it with other areas; - Eliminate questions & provide an instrument that helps to understand the firm capability, & design abilities & capabilities; - Change grammar & introduce yes/no question; -Reduce complexity on the structure of subthemes.	- Modification of the structure in order to contextualise the use of design within the different levels; - Change the name of the different levels of assessment for: auditing the company, strategy, process, projects. product/service and culture	- Change the grammatical structure of the questions and the measurement scale; - Rewrite questions from three sections, strategy, process and project	- Rewrite the whole instrument, as the questions are not specific & accurate; - Eliminate academic terms & questions; - Reduce complexity of the tool; - Introduce parameters to evaluate the different activities of the company; - Provide more flexibility in the tool;	- Definition of the terms used; - Improve the instrument interface; - Introduction of quantitative parameters to evaluate the performance of the firm;	- Change the style of the diagnostic framework to facilitate the reading of information; - Reduce questions to do not provoke tediousness among respondents;

4.5.3 Phase 3: Validation

The last phase took was from February 2009 to January 2010. The design toolkit was validated using pre-measurement and post-measurement actions in three small Mexican TBEs and workshops with five international academics. The most significant change relates to the transformation of the design toolkit from a paper-based workbook to a software-base version. The first action was to select the three case studies that would participate in the study. The requirements used were similar to the considered in the pilot case studies (see Table 4.2). After selecting the three case studies, the researcher proceeded to visit each one in person. In order to assess whether the case studies met all the requirements, to present the objectives of the research, and to assure confidentiality to the owner/entrepreneur during and after the study.

After confirmation that the cases fulfilled the requirements and were interested to participate, the researcher held a presentation session in each of the case studies. In the presentation were introduced the objectives of the study and the researcher acknowledged each participant about their rights; provided detailed information about her identification and institution sponsor; the purpose of the research; guarantee of confidentiality to the participant; and assurance that the participant can withdraw at any time. In addition, the researcher signed a confidential contract to protect information that is considered commercial in confidence including all type of images, growth and future plans, financial indicators, details in process, products, services and technologies, attitudes and behaviours. The researcher adopted the conditions established in the confidential contract of each business in the study given the nature of the information collected.

After the researcher was introduced to the case studies, it was selected with the personnel that would participate answering the design toolkit. In this task, it was important to identify and select people from different levels to bring parity to the study. The day in which it was arranged the implementation of the design toolkit, it was ensured to give a copy of the workbook to each participant. The researcher was readily available to the respondents to provide help in any aspect or problem faced in the use of the workbook. The results obtained from the design toolkit were analysed with numerical item scores to assess the reliability of the scale. Employees that participated on the study were asked to provide verbal feedback about their experience in a workshop after two days of the evaluation. Then, it was considered the importance to change the design toolkit into a software version. Therefore, it was subjected to four workshop reviews with international experts in design (management) in order to ensure its usability, content and construct. Finally, the software version was introduced in the post-measurement phase and subjected to one workshop more.

The improvements obtained from the implementation of the design toolkit and revisions with academics were minor, especially on the wording of questions. Three main issues that could affect the performance of the toolkit were repeatedly raised by the academics: (1) number of questions, (2) usability in the software version, and (3) interface between the assessment, results and recommendations. These issues were solved through more implementations with students and employees of the case studies.

4.6 Results

Before introducing the analysis of the results, it is important to highlight some issues and tensions encountered in the study. First, there is an unknown number of small Mexican TBEs in new technological industries. This implies that the universe of these types of firms can be reported as seven (excluding the 24 micro enterprises) according to the study presented by Corona in 1997. If the research adopted this number of enterprises, then the study could be significant and representative. Secondly, the number of personnel involved in the design toolkit was not large, as two of the case studies had five in-house employees. Finally, the number of in-house employees fluctuated during the study. This phenomenon is related to the effects that business experienced due to the economic recession. Once outlined this information, it is possible to introduce the analysis of results.

The number of design toolkits applied was 20, as the implementations of the pre-measurement and post-measurement phases were counted. It is important to emphasise that personnel did not answer all the levels, as some of them were not involved in the level of evaluation or the business did not have that area of assessment. Thus, Table 4.7 presents the distribution of assessment.

Table 4.7 Personnel involved per level in answering the design toolkit

Levels	Personnel involved in the pre-measurement	Personnel involved in the post-measurement
Company	7	7
Strategy	7	7
Process	8	7
Project	5	5
Product/service	8	8
Culture	9	11

The design toolkit, specifically the section 'diagnostic framework', used as a measure construct an interval level response format of 1-to-4 rating Likert scale, summative scale (Balnaves and Caputi, 2001; Hussey and Hussey, 1997; Oppenheim, 2000). In this measurement construction, 1 represents not at all or little satisfactory, 2 to a limited extent or regular, 3 to some extent or good, and 4 to great extent or very good. This decision was adopted because the primary concern of the study is the uni-dimensionality of the scale, thus, the results can be evaluated and analysed using Likert scales. This facilitates the grouping of results according the themes that aim to describe the company condition and its design abilities and capabilities. The results obtained from the design toolkit were analysed in the statistic package SPSS in order to assess the reliability of the scale. Reliability and item scale are important because they are used to construct reliable measurements scales, to improve existing ones and to evaluate the reliability of scales already in use. Both are needed to assess the sum of scales that are made of multiple individual measurements. The assessment of scale reliability is based on the correlation between the individual items or measurements that make up the scale, relative to the variance of the items. Hence, four criteria were used to evaluate the reliability of this scale: 1) item variance, 2) item means, 3) item-scale correlation and 4) Coefficient Alpha (Appendix 2.I).

Table 4.8 shows the result of the corrected item-total correlation from the pre-measurement and post-measurement phase. This summary shows that 43 items were rewritten from the pre-measurement phase to reduce the number of items that had low scores. Similarly, 23 items were eliminated from the study, as they were not relevant. By the second evaluation the number of rewritten items were reduced to 36 and 14 items eliminated as in both evaluations were evaluated low. The level of evaluation that best performs was product/service level with three low level items. Whereas, the company level performed poorly with the major number of low levels items with respect to the total number of items that had each level. In what respect to the reliability coefficient (Cronbach α), it is possible to observe high reliability coefficients in most of the sections of the instrument, except from culture with .873 and process with .885. According to the results obtained from the item-scale correlation and Cronbach's alpha, the design and scale of the design toolkit is reliable.

Table 4.8 Summary of the variables modified and eliminated of the total-correlation

	Pre-measure study change		**Post-measure study change**	
Level of evaluation	**Variables rewritten from the Item-Total Correlation**	**Variables eliminated from the Item-Total Correlation**	**Variables rewritten from the Item-Total Correlation**	**Variables eliminated from the Item-Total Correlation**
Company	V2; V9; V12; V14; V24; V26; V45; V46	V3; V4; V11; V23; V27; V31	V42; V48; V53; V55	V3; V4; V12; V24; V26; V45: V46
Cronbach's alpha	**.933**		**.921**	
Strategy	V2; V3; V10; V21; V22; V24; V36; V40; V41; V48; V52; V54; V58; V60	V62; V63; V65; V66	V1; V4; V6; V7; V15; V16; V19	V2; V10; V48; V58
Cronbach's alpha	**.904**		**.906**	
Process	V1; V2; V3; V5; V8; V14; V22; V24; V26; V31; V32; V40; V41; V42	V35; V45; V67; V76; V77	V3; V4; V10; V20; V25; V29; V34; V38; V54; V60; V64	V8; V68; V78
Cronbach's alpha	**.885**		**.967**	
Project	V42; V43	V43; V50; V51; V52; V54; V56; V57	V9; V10; V12; V19; V25; V28; V29; V30	
Cronbach's alpha	**.971**		**.980**	
Product / service	V1; V6; V8		V3; V8; V9	
Cronbach's alpha	**.927**		**.945**	
Culture	V4; V13	V2	V1; V6; V20	
Cronbach's alpha	**.873**		**.922**	

Three major methodological concerns were considered during the research, (1) impact of the researcher, (2) causality and (3) generalisability. The first relates to the influence of the researcher in the outcomes obtained due to her personal knowledge, skills or characteristics. Thus, feedback was key to reducing the potential bias on interpreting the impact of the design toolkit. The next aspect considered was causality and the researcher relied again on feedback provided by the personnel about usability and usefulness of the design toolkit. In addition, triangulation of multiple inputs enables the researcher to address the issues of causality as far as it is reasonably possible. It is because in the development of a new instrument, it is difficult to attribute any observed effect to the procedural intervention itself (Maslen and Lewis, 1994). The last issue relates to generalisation because this study used action research and case study methodologies (Warmintong, 1980; Yin, 2003). It is important to emphasise that both methodologies were used on a small number of companies and their results were validated through actions and subsequent effects on a specific context under review. The design toolkit was created to raise awareness of design issues in small Mexican TBEs in new technological industries. Therefore, it is expected that these type of businesses exhibit different performance within the level assessed, as results are related to different contexts, sector of new technological industries, culture and size. Nevertheless, a potential limitation of this work is that it may face difficulties to demonstrate the external validity or generalisability of the procedure (Moultrie, et al., 2006; Yin, 2003). The inclusion of a final validation phase for the design toolkit relates to being exposed to a wider industrial feedback, but this goes some way towards the objectives of this study.

4.7 Conclusions

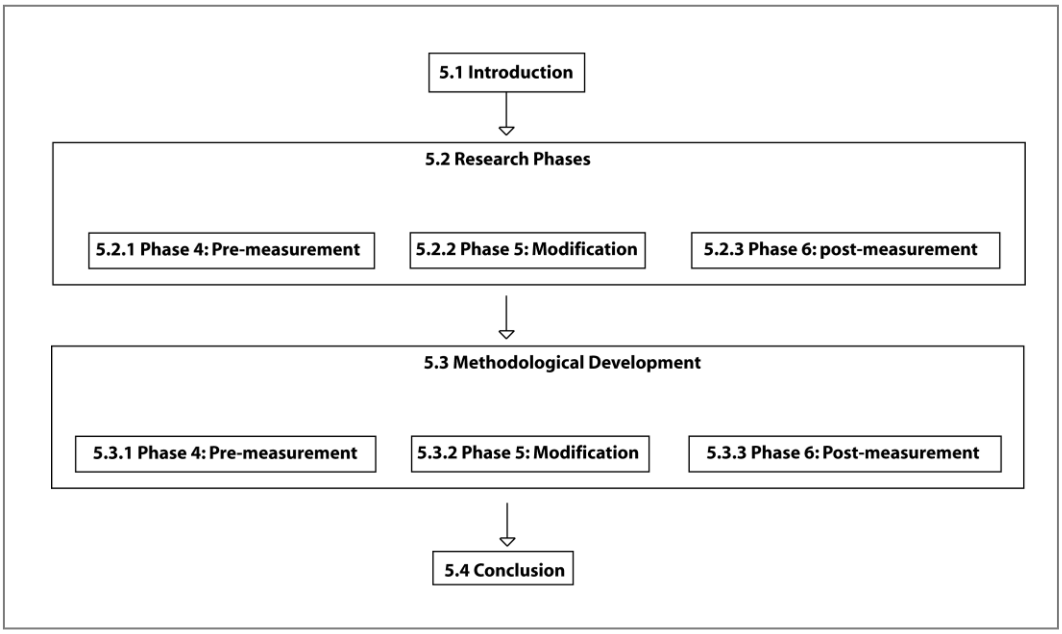
This chapter reviewed the phases concerned with the development of the design toolkit, as its purpose was to present its validity and reliability. Consequently, the chapter presented the objectives and premises of the design toolkit to later define the terms ‘condition of a firm’ and ‘design abilities and capabilities’. Then, it explored the methods used for each of the phases that comprehend this stage. Finally, it described the methodological development assumed in the research process and the results obtained. It is important to emphasise that under QUAL⇒quan design strategy, the strength relies on the development of a model, in this case the design toolkit, as it is tested in the next phase. This implies that the next chapter, pre-experiment, relies on the use of the design toolkit to collect the necessary data to understand the condition of the firm and its abilities and abilities of design. This data is going to provide the researcher with the knowledge to develop specific treatments that lead to explore whether design management can improve the performance of small Mexican TBEs. Consequently, chapter 5 will outline the phases and methodologies considered in the pre-experiment stage. As well as, it is going to describe the implementation and actions reported in the three case studies.

CHAPTER 5.0 PRE-EXPERIMENT

5.1 Introduction

Chapter 4 described the phases to develop a valid and reliable design toolkit. In turn, this chapter explores the implementation of a pre-experiment in which three case studies are assessed with the design toolkit. This enables the researcher to have an account about the condition of the case studies, to develop specific modifications on the cases and to follow up on the results to evaluate whether design management has an impact on the business performance. Thus, it is necessary that the chapter provide a holistic overview of each case study to understand from different perspectives their condition. It is also relevant to discuss an account of the procedures selected and the data obtained from this section, as these results are going to inform the next chapter. Figure 5.1 outlines the themes considered in this chapter.

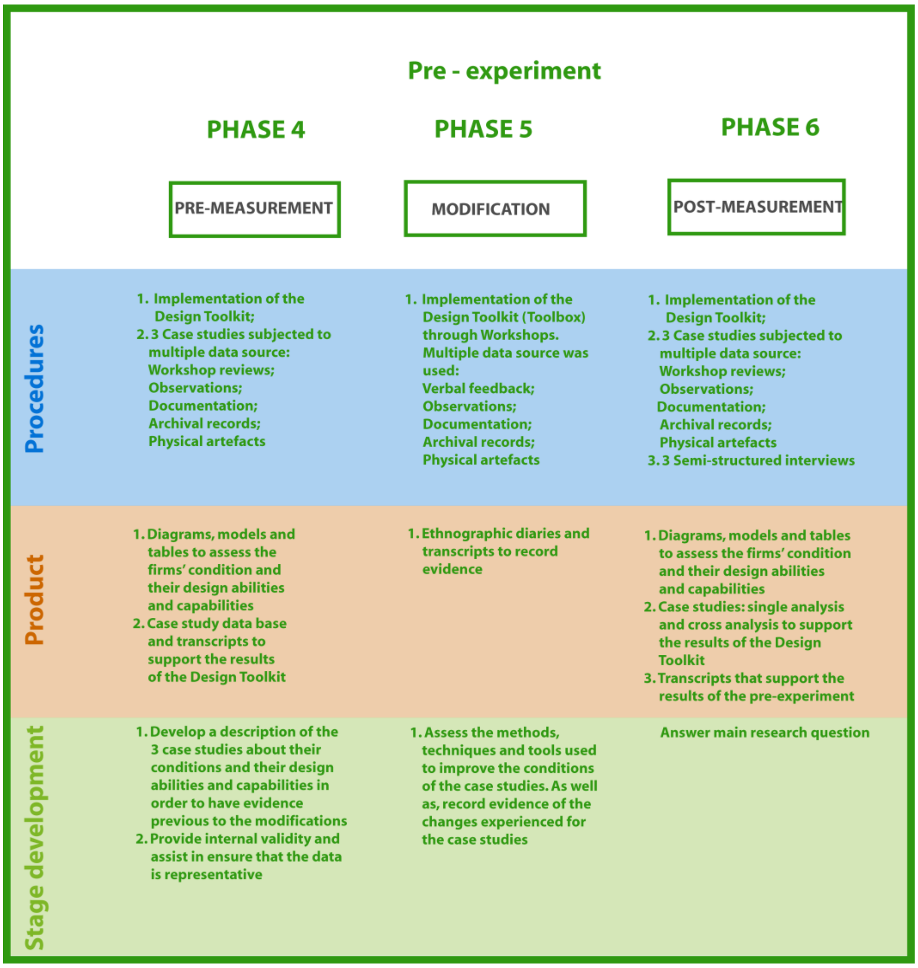
Figure 5.1 Outline of the chapter



5.2 Research phases

This stage represents the continuation of the 'QUAL⇒quan' design that aims to test the design toolkit developed in the previous stage. Consequently, this phase intends to answer two research questions: *'How can small Mexican technology-based enterprises in new technological industries use, implement and integrate design management within their activities?'* and *'Do small Mexican technology-based enterprises in new technological industries improve their performance using design management within their activities?'*. Thus, the researcher needs to analyse the case studies' condition to create specific interventions adequate to their demands. As each intervention is specific for every case, it is necessary that the researcher introduces modifications during a period of six to seven months and observes the changes occurred within that period. Then, it is possible to analyse again the case studies and compare if the actions implemented in the modification phase are related to the results. Figure 5.2 exhibits the phases considered in the pre-experiment stage. It shows that the phases are subsequent as each phase is dependent of the outcomes obtained from previous phases. This design allows a combination of methods and data obtained to support evidence produced throughout the study.

Figure 5.2 Phases on the pre-experiment



The 'pre-experiment stage' comprehends three main phases, pre-measurement, modification and post-measurement phase. The 'pre-measurement phase' (phase 4) covers the assessment of the three case studies condition and their design abilities and capabilities. It aims to explore the case studies holistically within their context of study to unveil issues about their condition, values and behaviours that can affect the next phase. Then, the researcher can use the set of results obtained to shape the 'modifications' (phase 5) that need to be implemented in the case studies. It is expected that each firm is going to produce different outcomes due to their different circumstance. Finally, the 'post-measurement phase' (phase 6) requires introducing again the design toolkit to assess the case studies' condition and to compare the outcomes obtained from the two evaluations. This analysis will provide evidence that enables the researcher to answer the main research question. Thus, this section further explores the methods and techniques used in each phase and their relevance on supplying data to the subsequent chapters.

5.2.1 Phase 4: Pre-measurement

This phase features two main actions; first, implement the design toolkit to produce an account of the firm's condition and its design abilities and capabilities; and second, explore through case studies the firm's condition within the context of study. Two methods were used, survey (design toolkit) and case study, to provide a description that enables the researcher to produce outcomes for the next stage. As previously discussed in the last two chapters, the design toolkit was developed to assess the condition of small Mexican TBEs in new technological industries. This implies that it is effective when it is implemented under this specific type of enterprises and industrial context. Similarly, the evidence obtained from each case study can differ, as they are unique in their own terms. Once these two points were clear, it could be explained further the methods.

Questionnaires (survey) are a popular mean of collecting data, but they are difficult to design, as they require skills in understanding levels of measurement, using simple language and administration (Balnaves and Caputi, 2001). It is suggested that researchers define operational definitions (section 4.3), as these should be reflected in the variables (questions) of the questionnaire. According to Creswell and Plano-Clark (2007), it is recommended to consider two main aspects on its development:

1. Use qualitative data to yield specific ideas from individuals to produce variables, to generate codes that can be designated as variables measured by multiple items, and to develop themes that can represent the larger scale of the instrument (section 4.4.1);
2. Develop an instrument with sound psychometric properties. As the best instruments are rigorously developed using good procedures of scale development. For example, these are some procedure for scale development: (a) determine what you want to measure (section 4.4.1); (b) generate an item pool, using short items, an appropriate reading level and questions that ask a single question (section 4.4.1); (c) determine scale of measurement for the items and the physical construction of the instrument (section 4.4.1); (d) item pool reviewed by experts (section 4.4.2); (e) inclusion of validated items from other scales or instruments (section 4.4.2); (f) administer the instrument to a sample for validation (section 4.4.2); (g) evaluate the items (section 4.4.2); and (h) optimize scale length on item performance and reliability checks (section 4.4.3)

The questions within the questionnaire need to reflect the appropriate levels of measurement necessary for further statistical analysis. The researcher needs to decide which level of measurement is going to be used (nominal, ordinal, interval or ratio), as it reflects the nature of the phenomenon studied. Questionnaires can be used as a method in their own right. Its advantages rely on its low cost and no requirement of prior arrangement. They allow plenty of time for the respondent to formulate their responses and avoid any interviewer bias. Disadvantages concern with the design questions and literacy problems. The researcher has no control over who completes the questionnaire and it is not possible to give assistance if required. Responses may not be complete and may not be entirely spontaneous or independent of other respondents' replies.

In this phase, the design toolkit (workbook format) has two sections, 'diagnostic framework' and 'design toolbox' (Appendix 3.A). The 'diagnostic framework' section focuses on identifying the firm's condition and its design abilities and capabilities. It considers six sections (company, strategy, process, project, product/service and culture) that can be evaluated as a solely entity or as independent sections (Table 5.1). Each division, except from product/service and culture, has four main sub themes (planning, organising, documentation and implementation, and evaluation) that concern on the actions embarked by the company in a day-to-day basis. Each level of assessment, except from company, had a section that concerns with the evaluation of design abilities and capabilities that it has available. In addition, at the end of each level of evaluation, excluding culture, it is considered a set of quantitative measures to establish parameters that can help to prove quantitatively whether the firm is improving or not. In order to understand further the diagnostic framework section, it is provided a summary in Table 5.1 about the divisions of levels of assessment, their number of variables and aims.

Table 5.1 Division of assessment levels in the diagnostic framework

Levels of assessment	Number of variables (questions)	Aim
Auditing the company	65 questions	Explore the management style of the firm and its organisational structure, and innovation taxonomy
Auditing the strategy	70 questions	Analyse the factors that lead the firm to adopt and implement certain type of strategy; **Design** is centred in the management of corporative activities and the alignment of inter-organisational decision-making
Auditing the process	77 questions	Evaluates those visible and (in) tangibles actions that direct to achieve the posed strategy; **Design** evaluates those actions that help to make the process efficient and effective through the coordination of tasks and information
Auditing the project	57 questions	Reviews all the individual or collaborative enterprises that are carefully planned and designed to achieve a particular aim (tangible result) **Design** evaluates those actions that help to improve activities and to obtain better results when the outcomes are assessed against requisites such as satisfaction of market needs, costs, technological achievements, economical objectives, technical quality, among others
Auditing the product/service	18 questions	**Design** evaluates the levels of value delivered in the outcome. This covers the add value offered to the final user and/or consumer in the product/service as a response to their needs and desires
Auditing the culture	22 questions	Examines the form in which the firm configure and maintain its day-to-day activities; **Design** considers the work environment and attitudes of employees to design

The 'diagnostic framework' questions uses as a measure construct an interval level response format of 1-to-4 rating Likert scale, summative scale (Balnaves and Caputi, 2001; Hussey and Hussey, 1997; Oppenheim, 2000). In this measurement construction, 1 represents not at all or little satisfactory, 2 to a limited extent or regular, 3 to some extent or good, and 4 to great extent or very good. This decision was adopted because the primary concern of the study is the uni-dimensionality of the scale, thus, the results can be evaluated and analysed using Likert scales. Then, it is possible to group the answers according to the company condition and its design abilities and capabilities. After the design toolkit workbooks were collected, the answers were analysed and grouped by section to position them in diagrams, models and tables developed specially for this study. After the results were presented to the members of the company, it introduced the second section the design toolkit, the 'design toolbox'.

Once implemented and results obtained, it was important to use case study research as a complementary method. In order to collect sufficient evidence that enables the researcher to prove or disprove the results obtained from the design toolkit and to provide a specific modification. Case study is the preferred research method to explore a phenomenon on its natural context and to use a multiple source of sub-methods to collect evidence. Gillham (2000) argued that case study seeks a range of different kinds of evidence, evidence which is there in the case setting and which has to be abstracted and collated to obtain possible answers to the research question. The purpose of this method is to test and illustrate the results obtained from the questionnaire to deal, then with the case. Nevertheless, it does not mean that nature and essence of the case study is neglected in this study because it is also necessary to describe what is happening in this particular situation. It is the only method that helps to explore the situation experienced for the case studies, to rise evidence that allow to diagnose the case, to identify its source and to set what can be done about it (Gomm, et al., 2000). This implies that the analysis of the case studies go beyond description and explanation, as it offers support to the design toolkit to include evaluation and prescription.

Case study research in organisational studies has been increasingly interested in present studies that provide valid and generalisable results. In its earliest stages, case studies focused on the detailed investigation of one or two organisations (Blau, 1955; Goulder, 1954). However, many discussions about its validity and generalizability led to adopt the study of larger samples. According to Bryman (1989), many investigations have used large samples of organisations to enhance the generalisability of the study allowing comparisons that help to identify much more readily special features of cases. Subsequently, case studies tend to emphasise the context of study in order to provide the readers with an insight that they know what is like to be in the organisation being studied, and this perspective provides a frame of reference for both researcher and reader to interpret events. Nevertheless, case study research in organisational studies still encountering discord with respect to the prevailing view that it is not possible to generalise the results of research deriving from just one case or two cases (Bryman, 1989; Donmoyer, 1990; Lincoln and Guba, 1985; Stake, 1975). Thus, multiple case studies have become a conscious attempt to increase the range of types of organisations investigated and try to mitigate this point (Sutton, 1987; Yin, 1994). Yin (1994) argues that a case study should be evaluated in terms of the adequacy of the theoretical inferences that are generated. The aim is not to infer the findings from a sample population, but to engender patterns and linkages of theoretical importance. Hence, the theory should be tested in comparable contexts to see whether it fits another cases, if it does not, it is likely that the condition under which the theory operates will need to be specified more precisely, replication logic (Yin, 1994). Case study research that examines more than one site often comprises its own replication logic, as it occurs in this study.

Other considerations in the use of case study method were to obtain methodological trustworthiness, construct validity, internal validity, external validity and reliability. According to Healy and Perry (2000), methodological trustworthiness refers to the extent to which the research can be audited by using a case study database and by the use of quotations in the report. Thus, it was adopted in this research a case study database and quotes. These were utilised in the writing and analysis of the data generated. Construct validity pertains to how well information about the constructs can be measured. Therefore, it can be enhanced by establishing clearly specified operational procedures. The validity in this research was achieved by using prior theory research and revisions with key informants on the case drafts. This last action allowed the researcher to improve the evidence obtained from both the design toolkit and case studies to develop the modifications. Internal validity concerns with establishing causal relationships when certain conditions are shown to lead to other conditions, as distinguished from false relationships. Thus, internal validity addresses the credibility or truth value of the project findings. In this research it was achieved by using multiple sources of evidence. Then, external validity focused on the need to find out where and in what context the projects findings can be generalised. The attention here is on analytic and no statistical generalisation and will require generalising some broader theory and not broader population. Finally, to establish reliability it was necessary to demonstrate the operations of the research can be repeated with the same results.

5.2.2 Phase 5: Modification

This phase focuses on the analysis of the evidence obtained in the pre-measurement phase to develop specific modifications for each of the three case studies. Consequently, the researcher produced a series of interventions and follow up actions during a period of six to seven months until the post-measurement phase was undertaken. Different techniques were used to document this phase and to produce confident evidence. Workshops, verbal feedback, observation, documentation, archival records and physical artefacts were used to implement actions and to record evidence of the changes suffered in the case studies (Appendix 3.B). These actions allowed the researcher to achieve internal validity and external validity, as they assisted to look for discrepant evidence and to ensure that the data was representative.

As discussed in section 5.2.1, the design toolkit considered a section, ‘design toolbox’, in which a series of methods, techniques and tools are introduced in order to produce implementation within the business. The aim of the ‘design toolbox’ is to position these tools, techniques and methods within four business actions (planning, organising, implementing and monitoring, and evaluation) to provide support in the decision-making of the owner, project manager, designers or/and personnel. These methods, techniques and tools were positioned according to two dimensions, areas of involvement and relevance in the short, medium and long term. The first dimension recognises the different areas (design, engineering, marketing and management) that are involved in the actions undertaken in the day-to-day basis of the business. The second dimension positions the different tools, techniques and methods according to their relevance with the firms’ strategies (short, medium and long-term). The researcher used this design toolbox to introduce the changes to improve the abilities and capabilities of employees and consequently, the overall performance of the firm.

5.2.3 Phase 6: Post-measurement

This phase concerns with the post-measurement of the three case studies that are part of the pre-experiment study. It is required to use, once again, the design toolkit (software version) and case study method to assess the condition of the case studies. Likewise, it is contemplated the use of a semi-structured interview to support the results obtained from the pre-experiment stage. The design toolkit is the first method used to obtain data about the condition of the firm, and its design abilities and capabilities. As discussed in section 4.5.3, the design toolkit was modified from a workbook (paper based) to a software version. Its structure changed as the new version regards three sections, 'diagnostic framework', 'results' and 'design toolbox'. 'Diagnostic framework', similarly to its previous version, examined six sections (company, strategy, process, project, product/service and culture) that can be evaluated as a solely entity or as independent sections (Appendix 3.C). Another modification concerned with the number of questions that each phase contains (Table 5.2).

Table 5.2 Changes on the number of questions in the diagnostic framework

Levels of assessment	Number of questions diagnostic framework (paper based)	Number of questions diagnostic framework (software version)
Auditing the company	65 questions	57 questions
Auditing the strategy	70 questions	66 questions
Auditing the process	77 questions	79 questions
Auditing the project	57 questions	47 questions
Auditing the product/service	18 questions	18 questions
Auditing the culture	22 questions	21 questions

After the design toolkit is implemented and results collected, it is possible to introduce case study method to support the evidence produced. The aim of case study is to support the information obtained from the instrument. Consequently, after both sets of data are analysed, it is possible to assess and to contrast the results obtained in the pre-measurement phase and the post-measure phase. T-test and descriptive study are the procedures used to explore whether the results differ between them significantly with respect to their measurements and to ascertain the incidence and values in which are manifested one or more variables. The results of the study were presented to the employees of the case studies. Then, the researcher subjected the personnel responsible (two owners and a design manager) of implementing actions within the firms to a semi-structured interview. This interview has 10 questions that concerned on understanding the experiences lived during the study (Appendix 3.D). The data obtained from the interviews was transcribed and analysed by themes and quotes in order to raise evidence that support the results of the pre-experiment. Overall, the utilization of different methods represented an advantage for the researcher, as can be drawn overall results and interpretations of the study. This means that it was possible to discuss themes that emerged in the context of study, its results, and finally to assess its effectiveness.

5.3 Methodological development

5.3.1 Phase 4: Pre-measurement

From February 2009 to April 2009, the researcher implemented the design toolkit and undertook three case studies. Thus, the first action was to select the three case studies that were able to fulfil the requirements displayed in Table 5.3.

Table 5.3 List of requirements

List of requirements	Sub-variables
Being a technology-based enterprise	Use scientific and technology activities; innovative activities; aim to introduce (technological) innovations within the market
Small sized enterprise	Number of employees from 0 to 50
Mexican enterprise	Owned by Mexicans; National Intellectual Property (IP); Mexican workforce in its majority
Private organisation	
Use design within its activities	At the strategic, tactical or operational level; industrial design, graphic design, engineering design etc;
Active in the new product/services development (Product; service; process)	
Develop innovation continuously	Radical (new to the market or new to the world); and incremental
Established in the business for more than three years	
Establish in new technological industries	Biotechnology; ecology; electronic; energy; new materials; and telecommunications

The researcher contacted the owners of the companies in order to visit them and to explain the rationale of the study. Once the owners accepted to meet the researcher, it was possible to verify that the cases fulfil with the prerequisites and to accept them as part of the study. Prior to start the study, the researcher had an introductory session with the owner and participants to familiarise them with the aims of the study. In addition, they were provided with information about the participants' rights; identification of the researcher and institution sponsor; purpose of the research; guarantee of confidentiality to participants; and assurance that the participant can withdraw at any time. Each individual company signed a confidential contract to protect information that is considered commercial in confidence. This includes all type of images, growth and future plans, financial indicators, details in process, products, services and technologies, attitudes and behaviours.

Subsequently, the researcher selected the personnel involved in answering the design toolkit. The employees selected were from different areas in order to have balance in the study. The researcher applied one design toolkit at time to provide help in any inquiry or problem faced by the personnel. After each employee completed the design toolkit, the researcher collected all the workbooks and introduced case study to explore the condition of the firm. The evidence produced from the case study method was contrasted with the outcomes obtained from the design toolkit to provide a description of the firms' condition and their design abilities and capabilities.

a) Case Study One

The organisation was established in 2004 as a technology-based enterprise in the development of software in the state of Hidalgo, Pachuca City (Fig. 5.3). Even though, the business is centred on the software industry, it offers a wide range of services related to consultancy in business management. In the last years, the organisation has been directing its efforts and expertise to generate projects related to virtual reality. This desire triggered the generation of its latest technological project, which is a product that enables mute-deaf people to communicate with people. Thus, the organisation needs to produce a new software and hardware. Indeed, this project has generated many expectations within the business, as it is the first product/service on its category in the market. This technological development aims to approach a target market (mute-deaf people) that has been neglected and it needs to be integrated to the society to leverage their quality of life.

Figure 5.3 Location of the case study one

Its origin goes back to 2003 with the MA thesis of one of the stakeholders (project leader). In that period, the student required financial resources to develop his MA degree project (the current technological project) and thus, he established contact with the person who is the current general manager of the business. The idea of the thesis soon became a whole business proposition to produce technological projects, and to provide consultancy and training on technological developments. In 2004, it was required to create the business and integrate new stakeholders to help on shaping the expertise necessary to offer services. Then, another member (operative manager) joined the team to extend the proposition of the business and to help in the development of the project. By 2006, the firm completed its first software and it became recognised as a RENIECYT business. This helped them to obtain financial funds from CONACYT to develop technological projects. In the same year, the business extended its portfolio provoking an alteration on its strategy and expertise (Table 5.4). In early 2007, the business began officially to develop its current major project, a product for mute-deaf people. Although, it is important to emphasise that the project started from 2004, but for the lack of resources and expertise, it was required to delay its development. It is also important to mention that even though the business is a TBE, it bases its development in services that are not directly related to scientific and technological projects. This is due to two main reasons: 1) it required financial resources to continue with its technological developments, and 2) its first technological development was not profitable to enables it to survive producing scientific and technological knowledge. Therefore, the company aims to invest major resources to obtain a product that generates enough profits that let it dedicates to the production of technological products/services.

Table 5.4 Portfolio of case study one

Product/services	Technological products/services
Consultancy: project management, marketing analysis, intellectual property, technological development; **Services**: research studies; **Training**: project development, strategic planning, service quality;	**Current technological project**: Integral system in oral and hearing rehabilitation, and virtual laboratories; **Services**: integral system of planning (software);

In this stage, the case study has 6 internal employees and 10 external employees. The reason to have this distribution in the business is because in words of the general manager *'the structure of the company has to be compact and flexible because our industry demanded. Likewise, the firm has not the resources to hire full time these external employees. Obviously, we try to be efficient with our personnel and financial resources' (February 2009)*. Even though, the number of employees is reduced, there are three defined levels in opinion of the employees with exception from the owner. The top level is occupied by the owner (provide the funding), the next level is held by the operational manager (second stakeholder and partner) and the project leader (developer of the technology and third stakeholder), and finally the third level was constituted by the rest of the staff (Fig. 5.4).

Figure 5.4 Organisational chart of the company

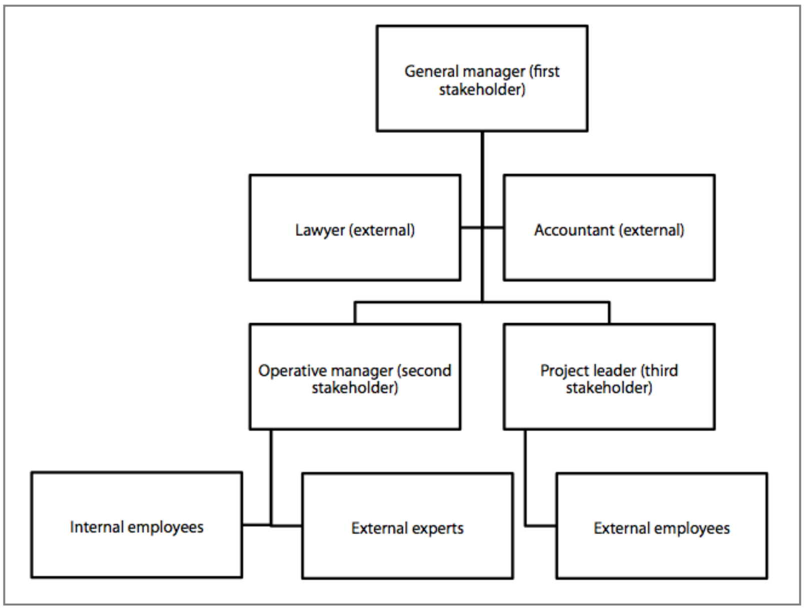


Figure 5.4 outlines, the structure of the organisation and the horizontal communication making activities bureaucratic. One of the stakeholders argued:

> *'that this separation of levels provoke lost of time and information. It feels that the firm is separated in two different businesses because the decision-making of the two low levels is more less efficient. The trouble comes when the mid-level needs to contact the owner'* (March 2009).

At this stage, it is important to point out that the general manager does not work in the organisation, as he has a job as a Public Servant. The time he dedicates to the business is at minimum and it represents one of the reasons on the delay of actions in the management of activities and financial resources. Therefore, electronic means of communication has become essential for the business to undertake day-to-day activities. However, the main problem is that the information is not recorded or documented, thus causing loss of information and misunderstandings between the different levels and external employees. Another recurrent mean of communication used to convey information is word of mouth, but often also leads to misunderstanding and problems amongst employees, as they are involved in several projects concurrently.

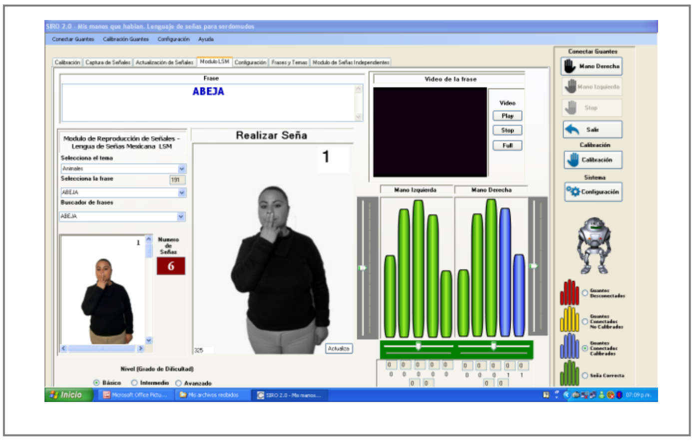
A relevant issue arising from the case study concerns on the way in which the firm commits to scientific and technological activities. Literature on technology-based enterprises mentions that this type of business invests the majority of its resources (human and financial) and time to develop scientific and technological developments. However, this case concentrates its efforts to projects that are related neither to its technological projects nor to its core competences. All employees, except the project leader (innovator), are involved in projects related to consultancy, training and market research, even when they are not experts in these types of activities. The return of investment and profits obtained from these services are invested on its majority to improve the organisation infrastructure. In what respect to technological and scientific activities are solely undertaken by the project leader. Although, when deadlines in the delivering of technological projects are tight, few engineers are assigned to the project. It was documented that technological projects are just developed when financial resource come from third parts such as angel investors, funds, grants and/or prizes. One stakeholder suggests that:

> *'the firm is frightened to invest all the resources, especially human resources, to transform the business into a serious technology-based enterprise. It seems that they do not want to have as a core business the development of technological products/services in the software industry. I think that this is the reason why the business does not invest too much money to promote our technological product/service developments and these products/services in turn are consigned to oblivion' (February 2009).*

Another interesting finding concerns the oppressive work environment in which in-house employees feel threatened because they cannot provide suggestions or comment about issues within the enterprise. They believe that expressing a comment can cost their jobs and consequently, they perceive that they are not part of the organisation. They do not feel committed neither proactive to the firms vision. Furthermore, employees notice that their expertise is wasted, as they could do activities that are more complicated and/or help more in the technological development. Employees would like to specialise more in technological activities rather than on managerial activities. They would like to contribute on improving the scientific and technological area of the organisation, so then it would be possible to offer a wide range of technological services and products. In order to further understand the complexity of the firm, it is important to discuss the roles played by employees. The role of the general manager is to find clients and projects in which the firm can participate. He is responsible to take major decision-making on financial resolutions. This means that employees that required financial resources need to first approach the operational manager, and then the former will approach the general manager to obtain the resources. The operational manager is responsible to provide an efficient communication between the different levels. Likewise, she is responsible to direct all projects in which the firm is involved. In what respect to the technological projects, the operational manager plays an important role in all the management and juridical operations. Contrary, the project leader centres on the technical development of scientific and technological products/services. Finally, employees take part in different roles, as they adopt different tasks depending on the project in which they are involved. Although, they are at times incorporated to technological projects, and these few times concern minor activities like help in evaluations, recording videos and documentation.

In this phase, the technological project was in the prototype phase. This was composed by two main elements: a software and hardware represented by a pair of gloves with an integrated Bluetooth (Fig 5.5). The gloves are the mean to convey signals that feed the pre-installed software in a computer. The software translates the signs in a word or sentence that later emits a voice from the computer to produce communication with others. The software recognises 4, 200 phrases in the sign language and it allows personalising it, as it possible to add as many signs as it is needed for the end-user. Even, it is possible to produce a new whole vocabulary, although, this modification is subject to the internal memory of the computer. The project leader was tasked to record the sentences that integrate the software and to capture the movements of the hand into a programming language in the software. These actions aim to establish a standard pattern of movements that allow prospective users to experience a usable and effective software and hardware. This phase of the project required: to hire an expert on signal language, to test the product/service with prospect users, and to involve in-house employees to assess outcomes. The project leader was able to evaluate the technical problems faced on the hardware and software. The operational manager acted as the provider of solutions to equipment and material that were necessary for the project.

Figure 5.5 Demo of the software developed



It was interesting to discover that employees consider the new technological development as a project rather than a process of new product/service development. They visualise in this way because they do not have experience and need to have more certainty in their activities. Their ultimate aim is to finish the prototype and ensure that it can be developed. Thus, they do not know any information about the cost, time and place of production of the hardware. In what respect to the software, it is believe that is an easy task to reproduce a copy from the original file. This suggested that the cost of the project has increased sharply because the purchase decision was based on project thinking rather than an investment for the creation of core competencies for the business. An example of this type of decisions concerns to the purchasing of equipment that would be infrequently used again or to bring two or three different options of the same raw material from imported suppliers.

It is important to highlight that the technological project was developed in entirety by the project leader. This means that if the project leader left the company, the business would not longer be a TBE, as they depend on him to produce technological innovations. This issue reveals that the project leader has been the only instigator in respect to knowledge generation. In addition, he has all the documentation and records about the project and some of these are in the business laboratory, but others are in the laboratory of the University in where he works. The operational manager has information about the project, but it only concerns with financial and juridical data.

Design activities and actions within the business are centred to the services offered as opposed to technological projects. Designers are external and they work as freelance for the business. Their background is related to graphic design, thus they develop all the advertising, stationary, artwork and presentations for the company. Although, they are not experts on web design they created the web page for the firm and they are in process to redesign it due to its poor overall quality. Likewise, they are in charge of the brand identity of the firm (Fig. 5.6). Neither designers nor the business uses a design brief to develop the projects that the firm require. The operational manager argues that

> *'design is an area that we use constantly because they bring a nice appearance to our projects. Our clients like the results that we provide them, so I guess we need to keep investing on design activities. For me, these designers are good because we can communicate through electronic means and develop a design that is required for our client' (March 2009).*

During the study, it was perceived that internal employees were starting to use graphic design software to develop brochures, posters and invitations. When they were asked in an informal talk about the issue, they said

> *'it is not difficult to use design software, and we enjoy do this type of work. We are doing the work of the designers in order to save some money, and we*

do not see a great difference between our outcomes and their outcomes' (March, 2009).

Figure 5.6 Brand identity of the case study one

Finally, the technological product/service (Fig. 5.7) has been targeting governmental departments, specialised institutes, training centres, no governmental organisations, and private and public institutions of higher education. It is estimated that public or private organisations can acquire the equipment with a cost that fluctuates around $ 270, 000 USD. This equipment considers a laboratory with 16 computers, 16 pair of gloves, an intelligent blackboard, a Phantom robot, and a 3D projector. If it is acquired for personal use, the cost of the product/service fluctuates around $13, 000 USD. This price comprehends a pair of gloves, a personal computer, training and personal service the 365 days of the year. The organisation estimates that 360,000 people can be benefited with this project.

Figure 5.7 Prototype of the software and hardware

b) Case Study Two

This business was established in 2004 in Mexico City (Fig 5.8), as technology-based enterprise specialised on the development of medical equipment. The developer of the technology (owner) recognised the necessity to produce nationally medical equipment, as the current health condition of the Mexican population has been deteriorating. In addition, few hospitals and clinics in Mexico had specialised equipment to detect and prevent certain illnesses, especially those directed to visual diseases such as glaucoma, sclerosis and senile macula degeneration. The lack of equipment is because it is too expensive, as they are imported and there are not local specialised technicians that are able to fix technical problems. Consequently, the owner decided to start-up producing medical equipment specialised on visual diseases. Its technological product concerns on the production of the first national 'visual field analyser', as the actual options are neither adequate to doctors nor to patients. The project was welcomed by different public and private organisations, as the number of Mexicans with visual problems had risen as complications of diseases such as hypertension, diabetes and obesity.

Figure 5.8 Location of the case study two

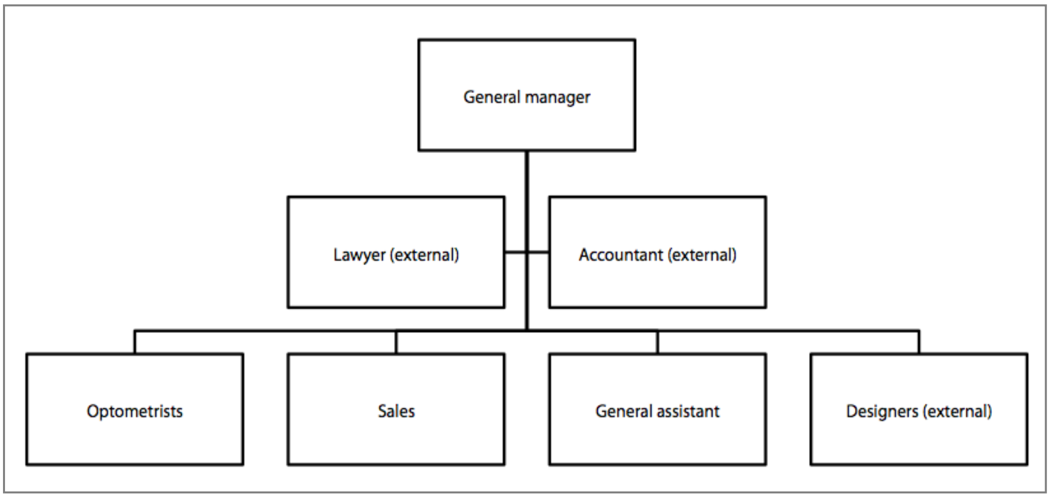
The principle aim of the business is to develop products that can be readily affordable for Mexican specialist on ophthalmology and optometry. It also considers the necessity to fulfil the special conditions of Mexican patients and doctors, including no extra investment on after sale care and service. Thus, the researcher spent many years doing field study on clinics, hospitals and Universities to understand the relationship between the intervention and the interface in the software and hardware. Once understood, the function of the equipment, they produced the first prototype to subject it to as many trials as possible. By 2006, the firm was granted as a RENIECYT business and obtained financial support from CONACYT. After one year, the company managed to develop an alpha prototype, but the estimated cost was exceeded because the engineer hired to design the product chose expensive materials and complex procedures of production. Finally, the prototype was analysed and subjected to various tests to discover that it needed modifications on its architecture to reduce costs and improve its effectiveness. However, the lack of financial resources delayed activities and led the owner to offer services that were not related to the product or to the technological developments (Table 5.5). After two years, the company was able to hire external industrial designers to redesign the product to reduce the cost of production.

Table 5.5 Portfolio of case study two

Product/services	Technological products/services
Services: Acoustic equipment, health campaigns, and surgery hours;	**Current technological project**: Visual field analyser

The company comprises of 10 employees; 5 internal and 5 external. The structure of the firm is simple as it is composed of two layers (Fig 5.9). The structure operates horizontally because employees work closely and freely in all the projects. Employees have specialism in engineering, optometry, sales, accounting, law and design. The owner is an engineer specialised in computing science and communication and he is responsible for developing the software algorithm. He undertakes different roles in the business, as he is in charge of managing the organisation, taking financial and operational decisions, and leading either technological or non-technological projects. Meanwhile, optometrists are accountable for evaluating the interface between the software and hardware. They participated throughout the project to produce a user-centred product. The sales expert is liable for contacting key people within the public and private sector such as hospitals, specialised clinics, educational institutions and small optometrist practice offices. The general assistant carries out diverse activities that are related to the operation and assembly of the visual field analyser. Finally, the accountant, lawyer and designers are external consultants that work for recognised organisations, as the owner is required to approach people that guarantee keeping the information confidential.

Figure 5.9 Organisational chart of the company



An interesting finding of the business is disciplined documentation of outcomes produced on the technological project, software algorithm and product, to protect them juridically. However, it does not document any information produced at the operational level such as cost or records about the product. For example, the have to undergo changes on the physical artefact, but they do not have any mock-up, prototype or rendering of the modifications, as all the information is on the hands of designers. This affects on the considerations about producing and introducing the product in to the market. The owner commented on this respect that

> *'in this type of business there is not a possibility to plan because your actions depend on the financial resources that you have. For example, there are times that you have financial resources to work six months continuously without concerning with other things than the project. There are other times in where there are no resources and you have to stop working in the project for months. Then, there is no reason to plan future actions as tomorrow represents a great uncertainty, at least, for us' (March 2009).*

The principal means of communication used by the company is word of mouth, as there is no need to have complex systems of communication because the team is compact. The firm has at least two meetings per month to discuss actions and update people about advances in the work. These meetings provide feedback that gives opportunity to suggest ideas about how to improve certain actions or strategies, especially for sales. The working relationship among of employees is cordial and respectful, as they always try to support the work and efforts of other colleagues. They are committed to the firm, and they are always attempt to contribute and promote new ideas and actions.

During this phase, the case study was moving from the prototype phase to production. Employees were focused on improving the product to reduce costs and to leverage its quality. However, the redesign of the product was just undertaken by external industrial design consultants. Thus, the rest of the team concentrates on the promotion of the product through health campaigns, exhibits in conferences and fairs, and visits to specialists. These efforts were not only directed to increase the number of prospective clients, but also to contact angel investors and other organisations that want to inject financial resources to the production phase. Furthermore, employees were involved in other projects to keep running the business. One of the major problems encountered by the company is the transition to production, as it is the first product developed. Thus, problems regarding to cost, time and place of production are being continually reviewed. Similarly, options about channels of supply for the product are being explored. Employees recognise that their expertise is on services, thus they try to translate those experiences into efficient actions in the new product development process. The general manager comments that:

> *'is going to be as hard as the other phases because we do not have the experience and expertise. But, as we did early, we are going to learn through experience. However, at this point there is not allowance for failure or mistakes as it is going to be just one opportunity. In the medical field, there are not chance for mistakes because everything has to be perfect, product and services have to have high standards, quality and above all they have to be reliable' (March, 2009)*.

Design activities are mainly centred to the product development, as the owner identified the need of experts that help the firm to reduce costs. It was also acknowledged the importance of product aesthetics because it conveys values and ideas about quality, safety and reliability. The owner believes that a good product can give the opportunity to access a competitive and exclusive market; meanwhile the firm gains reputation. In a meeting with the external designers, it was observed and later supported through informal conversations, that they do not use a formal design brief or provide a record or updates about the product advances. Their analysis and research is based on secondary data research, especially in what concerns with anthropometry and ergonomics reference (from Spain). Another interesting finding was related to the poor involvement of the designers with the project, as they do not know how the visual field analyser works or how it is used from the perspective of the doctor or patient. They have not engaged in any field study to assess their ideas, concepts and designs, as their deliveries to the owner have been sketches and renders of the product and the forecast of the final product cost. The firm has considered design to build a corporate identity and the brand identity. However, they developed both in a workshop with an engineer that was helping them in the development of the second prototype. The current stationary and promotional products have been developed by the owner and employees, as they do not have resources to hire more designers (Fig. 5.10). Finally, the owner believes that it is more relevant to invest in product design because it can lead to success rather than on activities that produce intangible outcomes such as brand identity.

Figure 5.10 Brand identity of the case study two

Finally, the firm has been promoting its product to attract investors or/and prospect clients (Fig. 5.11). It was presented in different means of communications to enhance its benefits such as: it performs exams 30% faster than other products in the market; it does not need to be calibrated; it is lighter and portable; and its cost is 75% less expensive than the cost of the leaders in the market (fluctuates around $ 6, 000 USD). The company describes its product as follow:

- Programme: central 15º (macula) 24º, general 30 º screening;
- Intensity of background light 31.5 ASB;
- Dome: 300 mm of diameter;
- Control from an external PC;
- Interface: USB;

- Measurement range 30º;
- Stimuli II Goldman;
- Stimuli colour white;
- Time of presentation of the stimuli .2 seconds;
- Print in any printer connected to the computer;

Figure 5.11 Prototype of the visual field analyser

c) Case Study Three

This business was established in 1999, and it was registered as technology-based enterprise in the development of new energy sources, batteries. The developer (owner) of this technology envisioned that the development of new energy sources could have a wider and deeper impact if it was integrated with another industry such as the automotive industry. He visualized an opportunity to offer not just a new energy source, but also to design, manufacture and produce lightweight and public transport vehicles with a hybrid-electric propulsion system. The owner recognised a niche market that has not been satisfied and there is a necessity to solve chronic pollution problems generated in large cities like Mexico City. Both premises gave life to the idea to produce a hybrid-electric vehicle using three different energy sources: a model of batteries, an internal combustion motor and electronic energy storage system. This promising idea helped the business to obtain financial resources from national and international organisations and angel investors. Diverse means of communication have promoted the business mentioning *'this* *business is promising because is the first and only Mexican hybrid vehicle manufacturer' Katz* (Gordon, 2006). This firm had its central office and a warehouse in Mexico City and it was building its first manufacturing plant in Aguascalientes City, which is 444 km from the headquarter (Fig. 5.12).

Figure 5.12 Location of the case study three

The business started-up as a result of the development of a cleaner technology by a chemical engineer. This idea became soon a proposition for a profitable business (Toledo, 2006). Due to the lack of larger financial resources, the firm has been using existent means of production and technology in different ways to achieve its purpose (Mintzberg, et al., 1998). Although, this problem become worst because the few resources available were misused for the lack of expertise and experience in business and project management. Therefore, the entrepreneur formalised the company and developed a business plan to obtain financial support from national and external organisations, investors and alliances. In 2000, the case study was awarded first place in New Ventures Investor Forum (New Ventures, 2001). The follow year, it attained an intensive investment by CONACYT through the program RENIECYT that aims to support the development of new technological innovations (Olín, 2006). Since then, the firm has centred on securing financial support from international and national companies that want to invest on the project (SIEI, 2007).

Under pressure by its different sponsors, the general manager promised on April 2007 that the first pilot production of 100 hybrids vehicles would be produced in that year (Fig. 5.13). The owner acknowledged that *'after all these years the real work of the firm can be summed up in to obtain money and develop technology'* (Reforma, 2006). Both statements show that the business has been mainly concerned on raising financial resources rather than directs its efforts to solve problems on the manufacturing of the product. The situation of the firm became critical in mid-June, as it was not able to obtain financial support to develop the technological project. Thus, it started to offer services in its area of expertise, and it began also to build alliances with other business to get either equipment or expertise in other areas. Unfortunately, the promise made by the owner was not fulfilled. Instead, it managed to obtain an agreement with the government of Aguascalientes State to build the manufacturing plant in 2009. It is important to emphasise that the organisation's main problem relies on the scarce number of specialist that can deal with the project's complexity and management. Therefore, it is understandable that after 11 years the firm has not been able to achieve its goals.

Figure 5.13 News about the product in a Mexican newspaper

Arman primeros híbridos

Con tecnología mexicana, se lanzan al mercado las primeras 80 unidades que consumen energía eléctrica y un poco de gasolina, pensadas para circular en tráfico intenso

Arranca producción y venta de ecológicos

Traen también las grandes firmas sus autos con tecnologías limpias

No es producto de la imaginación, la empresa Vehizero, situada al sur del Distrito Federal, ha desarrollado en México dos modelos de vehículos con estas características, que funcionan con un sistema híbrido de alimentación de energía, es decir, cuentan con un módulo de baterías y un pequeño motor de combustión interna de gasolina, a un precio igual o menor al de sus similares tradicionales.

Mexicano y ecológico

En el primer semestre del próximo año, luego de 15 años de investigación y varios millones de dólares invertidos, estarán listas las primeras unidades de carga ligera y taxis con consumo de energía híbrida.

Source: Reforma (2006)

The organisation has been working on three projects (Table 5.6). The main project regards on the development of a lightweight vehicle and the other subprojects are vehicles directed to the public transport sector. The case study targets a specialised niche market that has two broad markets: urban delivery and transport sector in Mexico. The lightweight vehicle targets large companies that use fleet of vans to transport products or to deliver services to SMEs, c-stores and small markets. It also considers SMEs that deliver products or services in urban areas. This product represents 80% of the company's prospective sales. Its other project, transport vehicle, is focused on trade unions of taxis in large cities and it constitutes 20% of the prospective sales. The owner is also interested to develop specialised tourism transport with the support of Mexico City Governments. Nevertheless, the firm needs large amounts of money to launch lightweight vehicle into the market, and then, it can develop the other two sub-projects.

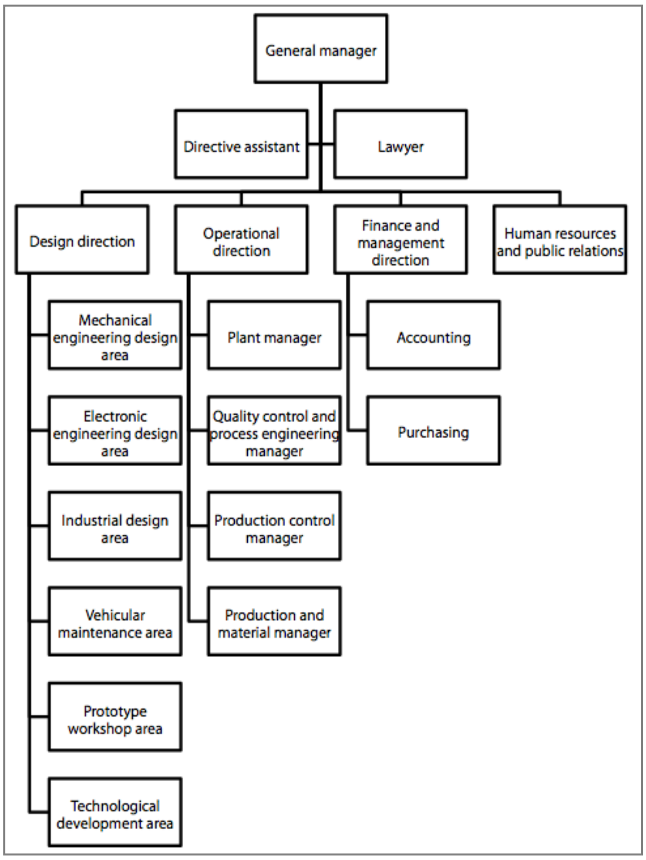
Table 5.6 Portfolio of case study three

Product/services	Technological products/services
Services: new energy source development, and electronic development;	**Current technological project**: Lightweight vehicles, taxis and tourism vehicles

In March 2009, the case study had 49 employees, although this number grew to 68 in-house employees and three external consultants. From these total, 13 employees are part of the original team that started the project. The structure of the firm was sophisticated, as it considered four executive directors on the major areas: design direction, operation direction, finance and management direction, and human resources and public relation. Figure 5.14 shows the organisational chart provided by the firm that presents a formal management structure. The largest area is design direction as it comprehends another six sub-areas, mechanical engineering design, electronic engineering design, industrial design, vehicular maintenance, prototype workshop and technological development. It has seven industrial designers that are responsible to provide help on prototyping and to improve the physical development and aesthetic look of the product. During data collection, it was observed a large informality in this area, as the social situation in which employees embark activities was generally characterised by behavioural spontaneity, casualness and interpersonal familiarity. This behaviour was common as employees were testing the prototype, as well as they were based in a warehouse far from the directive part of the business. The general manager encourages this type of situation arguing:

> *'In my opinion, even though the firm has formal divisions, I consider the structure as flat because everyone takes decisions for the good of the project. Everyone is important for the development of it and the few divisions that we have is just to give a little bit of organisation. Therefore, we can say that the company is divided in the management part that conveys ideas to the second layer. The second layer is conformed by the engineers, designers and mechanics'* (*March 2009*).

Figure 5.14 Organisational chart of the company



Employees believe that there are three major levels of hierarchies in the business, but they ignore in which position they are potioned. An employee mentioned that

> *'the first division is the administrative area in which the senior manager, secretary, auditor, accountant and finance people work. The second division is constituted by three areas, design area, mechanical engineering and electronic engineering. Finally, the last layer is composed by the workforce who carries activities of the assembly and production phases. Although, I am not sure because there is not a formal organisation chart into the company that shows how it is structured'* (March 2009).

They claimed that the new changes experienced have provoked bureaucracy within their operations, especially on those related to finance and management area, and human resources and public relation area. The data collected displays that the firm had adopted two internal management styles: (1) a formal structure that directs the activities of finance and management area, and human resources and public relation area, and (2) an informal structure that use the design direction to undertake activities. This is due to personnel responsible of the top levels have experience in large business with structured areas and regular entrance of financial resources. Therefore, they do not know how to introduce their knowledge on a project in which there is not structure, references or ideas about how to shape the business. This task becomes even more difficult when the firm depends on the success of its project to survive. This means that the firm changes along with the project, as both are part a solely entity.

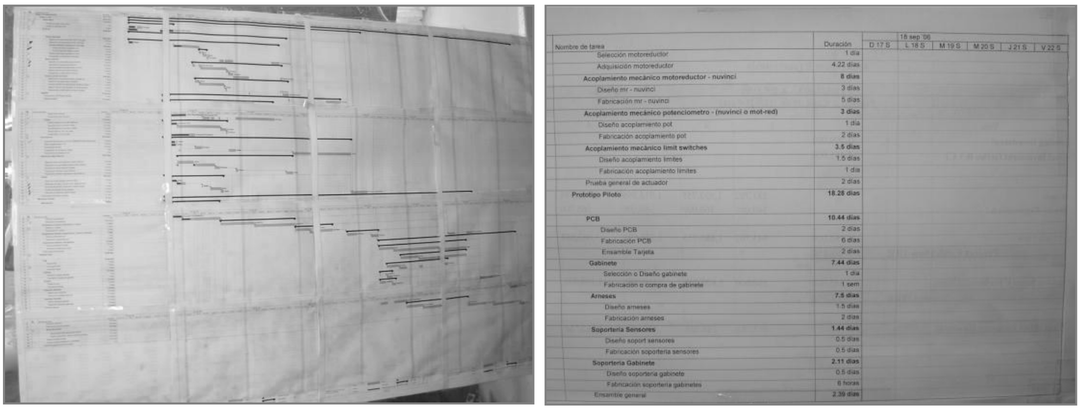
To understand further the firm, it is important to discuss the overall roles of the areas. The general manager is in charge of contacting angel investors that want to invest on the business. The finance and management direction is responsible of creating a database with the financial information that was not managed or even put into an account during the last six years. As well as, they are updating information about costs, suppliers, investors and human resources, and trying to formalise the process of purchasing to have control. The human resources area is undertaking the task of contracting personnel and recording information of the employees. The design area is responsible for solving the problem of standardisation among all the design areas such documents nomenclature; specification of plans, drawings and renders; definition of the phase of development; and the document version. Finally, the operation direction is designing the assembly line of production in the plant of Aguascalientes City.

The organisation had a NPD process with three well-delineated phases: (1) the formulation stage comprehends the general idea of the project; (2) development stage includes the implementation of actions that has as an outcome; and (3) manufacturing phase involves on the production of the product. The formulation stage addresses all basic considerations that are required to create a product idea. The idea of the project started on the mind of the general manager and it was developed further with a small research. This research entitles him to support his idea through finding a market opportunity that later was explained to their counterparts (engineer and stakeholders). Thus, they were required to hire personnel to produce a business plan and a product concept to attract attention. In what respect to documentation, the firm has documented product concepts, Gantt charts and concept developments (Fig 5.15); although, there is no evidence of the use of a project brief. This, in turns, has lead to extend the time, cost and risk of the project (Ulrich and Eppinger, 2003).

Figure 5.15 Product concepts

The development phase aimed to implement the necessary actions to develop a prototype. The project was explained to all employees involved to coordinate and to reduce activities (Eder, 1998). It was recognised that during the project development different inputs from diverse multidisciplinary cross-section were required to merge. Employees agreed that they had been experiencing this stage as a fuzzy, informal, intuitive, creative and spontaneous process. It is fuzzy because the lack of requirements and experience provokes that the work between areas clashed and repeated continuously during the project. Many employees recognised that *'the lack of specifications provokes that the team looses time and money due to activities have to be repeated' (March 2009)*. Thus, they need to improvise most of the time in the product development. Nevertheless, its downside concerns with the communication, documentation and control of information that few times is recorded provoking informality in the project management. It also provoked a series of misunderstandings that delayed the project development. Consequently, the project manager has developed a Gantt chart to set milestones and roles to employees (Fig. 5.16). Similarly, he is updating employees through constant meetings to notify issues relevant to the project such as new external projects; the lack of resources; the introduction of new investment; and modifications on the product development. It is intuitive because staffs do not have any tool that helps them to evaluate the evolution of the project. Employees feel more creative and spontaneous to solve problems because there is lack of resources, equipment and expertise.

Figure 5.16 Gantt chart used to manage the process



Another problem documented relates to the low consideration of intellectual activities, as the project manager just plans physical activities, especially those that lead to completion of the prototype. According to one project manager, *'the plan and the management of it just consider those physical activities that are of main importance into the process development. So, intellectual activities are not counted due to they are judge as not important and low in impact within the process' (March 2009)*. Hence, employees are encouraged to ensure that their activities are going to finish on time and on budget. Nevertheless, the low consideration of intellectual activities has suggested that employees do not finish on time their personnel projects affecting with it other areas. Some employees agreed that *'projects need to be flexible as there are activities that cannot be undertaken because the company does not have the skills, capabilities or equipment to do it' (Engineer, March 2009)*. Consequently, it was normal for the team to experience deviations on the project, in aspects such as materials, product scope and range, cost range of the product, etc. Finally, the project manager started evaluating outcomes of the project through the performance of the prototype.

Design plays an important role in new product development, as industrial designers are in charge to fulfil technical standards, ergonomics and aesthetics of the product. Furthermore, designers need to provide support to other areas, as they are responsible on the development of models for the bodywork and internal pieces of the vehicle. Many changes have been experienced lately on the design area because an industrial designer expert in the automotive industry was hired to fulfil further requirements such as physical features, safety, standards and legislations, feasibility, maintainability and disposability.

He was also responsible to reduce cost in the final product because the current cost was higher than the programmed. The organisation is also investing on design as a mean of communication between the firm and prospect consumers through the business website. This design activity is undertaken by external designers and the person responsible for the project is the owner. Although, two industrial designers were tasked to evaluate the outcomes of the website project because they have more experience and knowledge about design. Nevertheless, employees argued that they do not have the expertise to know whether the outcome was the most suitable for the company, as they are just able to comment on the appearance of the website.

The firm had not arrived to the production stage, as they were focused on the development of alpha prototypes. The case study was developing its first 25 alpha prototypes to distribute them to their sponsors (Fig. 5.17). This action represented also a pledge to its sponsors, stakeholders, investor and future customers to wait longer for the manufactured vehicles, as it was important to reduce costs and to run further tests on the vehicles. It was promised to deliver a product with more benefits than the simple values that other hybrid vehicles offer.

Figure 5.17 Alpha prototypes

The lightweight vehicles will have an approximate cost of $13, 300 USD. The final users are going to experience benefits related to:

- Deduction of 100% on taxes from the year of purchase;

- They are exempt from the Mexican vehicle programme today's does not run 'hoy no circula';
- The vehicle needs environmental verification after the sixth year of being purchased;
- The insurance is lower than average;
- Reduction in the emission of contaminants;
- Reduction of 50% in maintenance expenditure; and
- Reduction on the cost of gas

However, these are not all of the benefits, as the product in itself has different advantages. The firm has used some of the following means of communication to promote its product: newspapers; TV news; fair trade exhibitions; science exhibitions; entrepreneur seminars; Government programs; school programs; and specialised means of communication in green products. Finally, the company promotes its vehicles (Fig. 5.18) as follow:

- Save energy expenditure from 50% to 80%;
- Electric engine: 26.5 HP nominal 70 HP maximum
- Internal combustion engine: 4 HP, 1 Cylinder 4 times;
- Manual transmission of 5 velocities to the front and reverse;
- Energy source: electric and gas;
- Maximum velocity of 100 Km/hr;
- Capacity of load: 1000 Kg
- Available surface of load: 2520 x 1800 mm.

Figure 5.18 Hybrid lightweight vehicles

5.3.2 Phase 5: Modification

From beginning of April 2009 until October 2009, the researcher introduced a series of actions within the case studies. These actions were designed in agreement with the employees of the case studies, after the results obtained from the design toolkit were explained. In the feedback session, the researcher explained the results using visual images and employees' comments (anonymous) collected during the study to support the results. Thus, the owner can have a complete description of the company's condition, including specific information of its different levels of development. Similarly, employees were able to understand the condition of the business and the types of activities in which the owner and other high level employees are involved. The presentation helped to define where the company wanted to go and how they aimed to achieve it. Diagrams, models and tables were used to explain complex themes in simple terms allowing entrepreneurs to understand the effects of their decisions.

The next stage was to introduce the third section of the design toolkit, the design toolbox. The toolbox map identified a different range of methods, techniques and tools from four areas of development design, engineering, management and marketing (Appendix 3.D). These tools were placed under two axes that represent the main actions (planning, organising, documentation and implementation, and evaluation) carried out in any management of a project, process and/or company. As well as, the position of these actions depended on the relevance that they have in the short, medium and long-term within the business. Therefore, this map helps them to link the previous results with what was required in each major action activities on the management of the company, process and/or project. Then, specific actions where implemented for each case. Workshops were used as a means to introduce tools, techniques and methods within company activities. The researcher used presentations, case studies and templates (where required) of the theme explained. Obviously, it was required that employees participated continuously during the workshops and after because their commitment was to adopt these techniques to their everyday activities.

a) Case Study One

The results obtained from case study one (section 6.5) lead to take actions in the short and medium-term, as they wanted to use them in the current technological project. During seven months, 11 workshops were held to introduce the use of methods, tools and techniques that would help the firm to improve its results and activities (Table 5.7).

Table 5.7 Actions introduced in case study one

Planning	Organising	Implementation and monitoring	Evaluation
Project planning; Cost/benefit diagram; Decision tree analysis; Corporative identity; Brand identity; Planning cycle	Action plan; Critical path analysis;	Task analysis; Project brief; Design brief; Gantt chart; Logical framework approach; Product development process; Request for proposal documents	Business requirement analysis; Marketing plan; Benchmarking; Alpha/beta analysis; Post implementation review; Product analysis; Web page analysis; Project budget; Service analysis

In this case, the general manager was not present neither in the delivery of results nor the workshops. The person in charge of the study was the operational manager. All the in-house employees participated in the workshops, except for two workshops in where the project leader had to leave. As the researcher returned to the United Kingdom, some of the workshops were carried out using videoconference software. The other workshops were provided in the installations of the company. It was interesting that two engineers were not participative in the first three sessions, until the fifth workshop, they became very participative, and sometimes they lead the suggestions, comments and ideas. It was also significant that during the process of implementation, employees were able to envision future opportunities of business through the identification of core values and strengths that they had not perceived before. The data generated from the workshops were kept by the case study, as it contained high confidential information for future projects.

b) Case Study Two

Case study two obtained results (section 6.5) that enabled the enterprise to redefine its objectives and how they aim to achieve them. This firm decided to implement actions in the short and medium-term, as its product/service was almost finished. It requires activities that enable them to improve its product at the stage it was currently performing. In seven months, the researcher presented 15 workshops and prepared four field studies. The methods, tools and techniques implemented are displayed in Table 5.8.

Table 5.8 Actions introduced in case study two

Planning	Organising	Implementation and monitoring	Evaluation
Business plan; Project planning; Cost/benefit diagram; Decision tree analysis; Corporative identity; Brand identity; Planning cycle; Presentation	Body storming; Brain storming; Visual storming; Action plan; Critical path analysis; Product architecture; Distribution; Advertising	Task analysis; Project brief; Design brief; Gantt chart; Logical framework approach; Product development process; Request for proposal documents; Market research; User behaviour	Business requirement analysis; Marketing plan; Benchmarking; Alpha/beta analysis; Post implementation review; Product analysis; Web page analysis; Project budget; Service analysis

In the case, most of the employees participated in the workshops, except from salesman and general assistant. The general manager was responsible to implement the actions within the business and to provide the dates, locations and information to employees. It is important to highlight that he was the most participative contributor during the workshops. He promoted different activities to extend the knowledge learned. In fact, all employees were participative and committed to the treatment. The researcher returned for a period of three months to United Kingdom. Thus, some of the workshops were undertaken using videoconference software and others were in the researcher's study (Mexico City). It was also used a web forum site (wiki site) to store information, left comments and update information. Since the first workshop, the employees participated and commented about the tools, techniques and methods recently introduced. They always prepared for the next session a list of questions, cases, information and a presentation about how they implement the tools in their activities.

When the researcher was in Mexico, she prepared a field study, where the aim was to observe how the visual field analyser works in the context of study and observe the interaction between the product, doctor and patients. In this session, field notes and photographs were taken with the consent of doctors and patients. Another activity arranged by the owner was a competition in a University with student of the last semester of industrial design to produce solutions to one piece that was increasing the final cost of the product and its total weight. The researcher was invited to participate as a judge to decide which idea was the most suitable solution. During these six months, the company developed a series of families of products and services that can be part of the business portfolio. They also produced new projects related to their expertise and they generated new technological developments.

c) Case Study Three

Case study three was challenging due to the large number of employees. The presentation of results was just for the executive level and project leaders of each division. The presentation took more than half a day, as it was discussed the actions that would be undertaken in the overall company, per level and area. As the case study was extensive and there was not enough time to undertake all the required actions, it was decided by consent to focus on the new product development process. The actions considered were focused on the short and medium-term improvements, although, these would permeate in the long-term actions. There were required 20 workshops to introduce the methods, techniques and tools among project managers and employees (Table 5.9).

Table 5.9 Actions introduced in the case study three

Planning	Organising	Implementation and monitoring	Evaluation
Project planning; Cause/effect diagram; Cost/benefit diagram; Decision tree analysis; Planning cycle; Life cycle analysis; Risk plan	Project initiation; QFD; Estimating time accurately; Action plan; Critical path analysis; Product architecture; Distribution; System engineering; Task analysis	Task analysis; Project brief; Design brief; Gantt chart; Logical framework approach; Product development process; Request for proposal documents; Selecting criteria; Sustainable product development; System testing; Product feature permutation	Alpha/beta analysis; Post implementation review; Product analysis; Project budget; Value analysis; Problem abstraction; Material and process selection; Ranking and weighting; Morphological chart; Failure modes and effect analysis

The implementation of actions was difficult because most of the project leaders were too busy, therefore it was impossible to have a meeting with all of them at the same time. This became more complicated when the researcher had to go to United Kingdom because the workshops had to be undertaken by videoconference. The researcher engaged a major action, as it was introduced the use of a web forum site (wiki site) in where all the information was uploaded and all employees could have access at any time and in any place. Thus, the way in which the presentations were developed had to be modified to allow the project managers to be able to understand the information and to implement it within their activities (Appendix 3.C). The most participative area was industrial design, as the project manager involved more designers in the workshops and they were doing the implementations within their activities. The other areas were not interested as the majority of project leaders did not have implementations and they just assisted to two or three workshops. The general manager was not interested in the workshops, as he was focused on obtaining financial investment. Although, he encouraged employees to participate (as an invitation), as these workshops would bring benefits to their activities. The workshops session improved when the researcher returned to Mexico City, although, few project managers assisted. As some employees move to the manufacturing plant in Aguascalientes City, and others quit the job due to financial difficulties. The number of employees dropped drastically due to the financial crisis of the firm. At the end of the intervention, the wiki site did not have many comments, discussion, and reviews from the employees.

5.3.3 Phase 6: Post-measurement

From November 2009 to January 2010, the researcher conducted the second evaluation within the three case studies. The evaluation was quicker due to the design toolkit was in a software format, which allowed efficiency on the collection of data and on its analysis. The researcher had to access the case studies to collect data that support or reject the information got from the design toolkit. After the researcher collected the data and analysed it, it was arranged a meeting to preset results from the post-measurement study and the whole study.

a) Case Study One

The results of the post-measurement (section 6.7) illustrated that the case study formalised its organisational structure and management style. This was due to formalised activities and roles of employees and planned corporative activities and financial and human resources. Although, the major problems of the case study remain on communication between the general manager and employees and documentation of activities. In addition, the company modified its strategy from leadership to cost, as their clients and prospect customer are not willing to pay extensive amounts of resources for its products and/or services. It was also interesting to observe that innovative activities were drastically reduced as the technological project was completed. Furthermore, it was documented that the case study developed design strategies along with general strategies. In what concern on the activities established during the intervention, some were applied within the business activities, other was omitted for the lack of time.

After 8 month the first evaluation, the enterprise had experienced different changes on its structure, activities and the technological project. First, the number of employees was reduced due to the financial crisis provoked a reduction on the number of projects that firm provided. Secondly, the product leader left the business to study for a PhD, which in turn represented the end of technological and scientific developments and projects. Finally, the technological project prototype was completed and presented to prospect customers. However, there was not promotion or advertising of it. Until today, there had not been any contact or approach to purchase the technological product. Nevertheless, the business was able to increase the number of services offered.

b) Case Study Two

The results of case two illustrated improvement on the areas in where the implementations were made, design at the strategic level, evaluation in the NPD and culture for design (section 6.7). The company formalised key aspects within the business such as management of resources, plan and organisation of financial resources, communication and documentation, and evaluation of activities. However, the case study had to close its office as they did not have resources to maintain it, but employees still working virtually. The technological project was interrupted and consequently, the delivery of results from designers was delayed. During the data collection and on the last interview, it was emphasised the new way of thinking of the general manager and employees. They embraced design in every activity that they develop, especially in the way in which they manage projects and deliver outcomes to their clients. Even, the optometrist had modified the way in which they attend the patients and accommodate their office surgery. The owner had changed old ideas about strategy, and management of the company and its activities. Now they see it as a complete entity that affects the results of all levels and vice versa.

The company is focused on developing its expertise on software development and it is producing programs for different companies in the medical field. Likewise, they are generating new technological developments meanwhile they get enough resources to pay to the designers and get finally their product. Indeed, they required a large financial investment as the production in going to take place externally, and they need to produce as much as possible pieces to reduce the cost. They are planning to invest resources to create a strong brand identity rather than spend it on advertising.

c) Case Study Three

The result of the case demonstrated very clearly the conditions that the firm was experiencing (section 6.7). This case was the most affected by the financial crisis and the poor management of its internal financial resources. The company had to stop the construction of the manufacturing plant and the development of the prototypes. The number of employees was reduced to one third of the employees that were hired in the first pre-measurement evaluation. The majority of project leaders left the company effecting a lost of expertise and knowledge, as few documented all the information produced during the modification of the prototype.

However, the enterprise had important improvements as it hired a specialist in project management. A system of communication was developed, as well as a standard on the documentation of activities was established. Now, the employees need to adopt new guidelines to deliver reports and any documentation regarding with the process and project. The strategy of the company concerns on reducing costs in operational activities, thus the resources not invested can be directed to improve the product.

5.4 Conclusions

This chapter described the phases concerned with the pre-experiment stage. It also outlined and justified the different methods used at the different phases and the actions undertaken to do it. Then, it was introduced a description of the case studies during the different phases of the pre-experiment. Similarly, it provided detailed information about the transition of the case studies during the pre-experiment. This chapter set precise and concise evidence that allows the reader to being acknowledged about the procedures undertaken and outcomes obtained during the research. Finally, chapter 6 focuses on analysing the data obtained from the pre-measurement and post-measurement phase to answer the research problem.

CHAPTER 6.0 DATA ANALYSIS

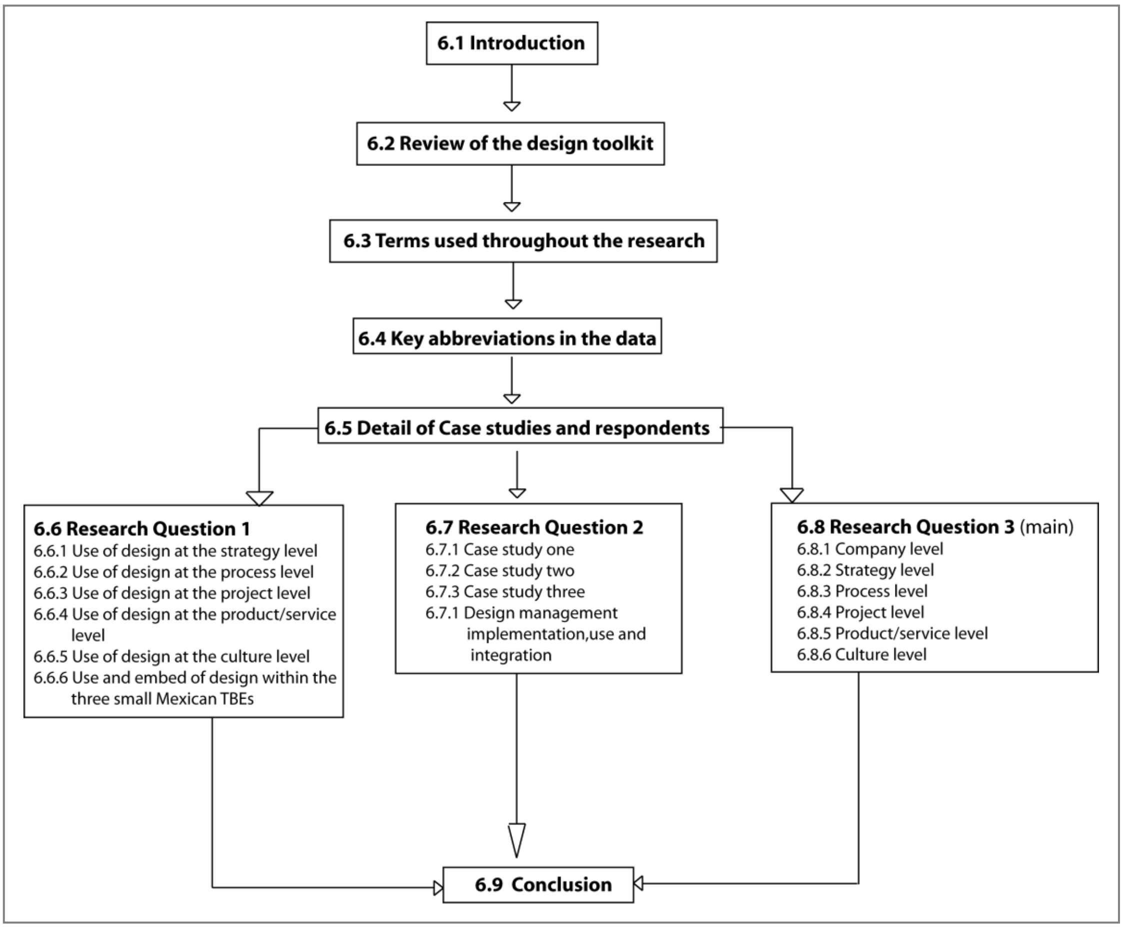
6.1 Introduction

Chapter 5 provided a detailed description of the phases, methods and outcomes obtained in the pre-experimental stage. Contrary, the objective of this chapter is to analyse the data collected from the case studies to yield answers for the three research questions posed. Thus, it is necessary to produce an initial analysis that produces a structure on the subject of study to answer the first question: *'How do small Mexican technology-based enterprises in new technological industries use and embed design in their business activities?'*. The researcher will be able to present a series of modifications with the analysed data to answer the second research question: *'How can small Mexican technology-based enterprises in new technological industries use, implement and integrate design management within their activities?'*. Finally, the data collected from the pre-measurement and post-measurement phase is analysed to compare both data sets. This information aims to answer the main research question, that is: *'Do small Mexican technology-based enterprises in new technology industries improve their performance using design management within their activities?'.* This refers that the researcher requires addressing related questions in order to have supporting data to answer the main research question.

This chapter is structured to answer the third and main research question (Fig. 6.1). First, it considers a review of the design toolkit developed to assess the company condition and its design abilities and capabilities (section 6.2). The following section reviews the terms used throughout the research (section 6.3), and then it provides a brief description about how data is display in this chapter (section 6.4). Afterwards, the researcher presents a concise account of the cases and their respondents (section 6.5), as this information is the cornerstone to understand the following three sections. Section 6.6 examines the first research question, which aims to provide awareness about the consideration of design within the three small Mexican TBEs. The next section examines the second research question (section 6.7) that aims to analyse the overall assessment of the firms' condition to produce a series of modifications. Finally, the last and main research question (section

6.8) is answered through the analysis of the pre-measurement and post-measurement evaluation. This chapter ends with the conclusion (section 6.9)

Figure 6.1 Outline of the chapter



6.2 Review of the design toolkit

This part describes the design toolkit used to assess the three small Mexican TBEs in new technological industries in this research. It was developed to perform three main actions: to evaluate the company's condition and design abilities and capabilities; to provide results along with a set of recommendations; and to present a set of tools, techniques and methods that enable the firm to improve its design abilities and capabilities. Therefore, this section is divided in three major parts; (1) design framework, (2) results and (3) design toolbox; to explain further the structure of design toolkit (Fig. 6.2).

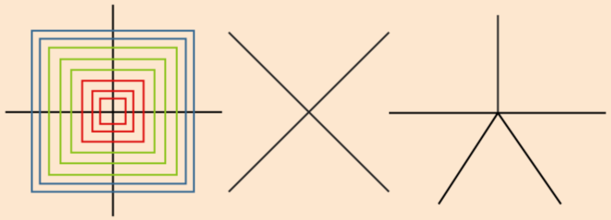
Figure 6.2 Structure of the design toolkit

First section: Diagnostic framework

Aim: Assess the company's condition and its design abilities and capabilities. It considers six sections:

1. Company
2. Strategy
3. Process
4. Project
5. Product/service
6. Culture

Second section: Results



Aim: Show the outcomes obtained from the diagnostic framework in a comprehensive manner that enables understanding of the condition of the firm

Third section: Design toolbox

Aim: Present a series of methods, tools and techniques to improve the capabilities of employees and with it the overall performance of the company

The first section of the design toolkit comprehends the ‘diagnostic framework’. Its aim is to undertake an assessment of the company’s condition and its design abilities and capabilities in the three small Mexican TBEs in new technological industries. Hence, six sections are considered, (1) company, (2) strategy, (3) process, (4) project, (5) product/service and (6) culture, to produce a description of the firm’s condition and its design abilities and capabilities. These sections can be evaluated as a sole entity to provide an overall overview or as independent sections to obtain the situation of a specific level such as process, project or product/service. Each division, except from product/service and culture, is evaluated under four main actions, (1) planning, (2) organising, (3) documentation and implementation, and (4) evaluation, which are considered in a day-to-day basis in any company. The assessment of design abilities and capabilities is undertaken out at all levels, except at the company level. Furthermore, quantitative parameters are considered at the end of each level of evaluation, excluding culture. In order to understand further the ‘diagnostic framework’ the different levels are explained.

Auditing the company explores the management style of the firm, its organisational structure and taxonomy of innovation. This information determines the form in which the firm operates. Auditing the strategy analyses those factors that lead the firm to adopt and implement certain type of strategy. At this level, design is centred in the management of corporative activities and the alignment of inter-organisational decision-making. In the case of auditing the process, it evaluates those visible, tangibles and intangible actions that are directed to achieve the planned strategy. Consequently, design helps to make the process efficient and effective through the coordination of tasks and information. Auditing the project reviews all the individuals or collaborative enterprises that are carefully planned and designed to achieve a particular aim (tangible result). Design helps to improve these activities and to obtain better results when they are evaluated against the satisfaction of market needs, costs, technological achievements, economical objectives, and technical quality. Auditing the product/service evaluates the levels of value delivered in the outcome to the final users in the product/service as a response to their needs and desires. Finally, auditing the culture examines the form in which the firm configures and maintains its day-to-day activities.

The second section, 'results', shows the outcomes obtained from the diagnostic framework in a comprehensive manner that let the owner or employees to understand the situation of the firm (Table 6.1). Thus, results from the company section concern on position the business according to its management style and organisational structure and its taxonomy of technology-based enterprises. The results from the strategy section explain which type of generic strategy and design strategy is adopted by the firm. The outcomes of the process and project level position the firm under the performance that it has on the four actions of development that drive the business and design (Table 6.1). Product/service positions the outcomes according to the values delivered to the end user. Finally, culture explores the attitudes and behaviours prevailing within the company.

Table 6.1 Results provided from each level of assessment

Level of assessment	Outcomes
Company level	**Management style and organisational structure** positions the firm under: Efficient bureaucratic firm; unstructured unadventurous firm; pseudo entrepreneurial firm; or effective entrepreneurial firm; **Taxonomy of technology-based enterprises** positions the firm under: Firms based in science and technology; firms based in intensive resources; firms based in being a specialised supplier; or firms dominated by the supplier
Strategy level	**Types of generic strategy** establish the firm under: Leadership in differentiation; focus on differentiation; leadership cost; or focus on cost; **Design** strategies are based on: Brand; market and cost
Process level Project level	The **performance of the business** is assessed under: planning; organising; implementation and monitoring; and evaluation; **Design** assess the abilities and capabilities of the designers under the process and project
Product/service level	**Design** positions the product/service under the value delivered to the end-users: superior, augmented, current and basic level
Culture	Assess the attitudes and behaviours that prevail in the business **Design** considers the attitudes and behaviours that employees have for design

The third section is represented by the 'design toolbox'. It presents a series of tools, techniques and methods to improve the capabilities of employees and with it the overall performance of the company. This set of tools, techniques and methods are positioned under four axes that represent four main actions, 1) planning, 2) organising, 3) documentation and implementation and 4) evaluation, which are necessary to manage and maintain a business working. To make efficient their utilisation, it is necessary to place them under two dimensions, areas of involvement and relevance in the short, medium and long-term. The first dimension recognises the different areas, design, engineering, marketing and management, which are involved during the day-to-day action of the company. The second dimension positions the different tools with respect to their relevance within the firm's strategy in the short, medium and long-term.

6.3 Terms used throughout the research

Condition of the company refers to the prevailing situation influencing the performance or outcome of a process. This includes those factors that can influence different levels and areas of the firm.

Design abilities allude to the capacity of the personnel to do design activities and tasks.

Design capabilities refer to the extent someone has power or abilities to perform effectively and efficiently specific design activities and tasks.

Performance concerns with how successful the action or process of undertaking or accomplishing an action, task, function or operation is performed.

Strategic level concentrates on the management of the corporative level activities and the coordination of inter-organisational decision-making activities. It conceives the corporative level as a 'production line' that aims to achieve its goals and objectives (Best, 2006). This refers that its main concern is to understand the demand from the market in order to acquire the necessary requirements to assess better the translation of ideas into a product/service to achieve this state, managers need to deploy effectively the resources available within the business.

Tactical level focuses on the product development process. Its aim is to make the process effective and efficient through the coordination of tasks and information. Employees have a wide range of tools and methods to precisely control, store, present and distribute the information generated among the team members of the process.

Operational level considers all the procedures related on the management and control of routine functions and actions of a business. It is important to regard tangibles (physical) and intangible (human) resources.

6.4 Key abbreviations in the data

This section provides detailed information about the content analysis used in the pre-experiment stage. Thus, a brief overview of the different types of analyses, scale employed and abbreviations used in this chapter is presented.

Analysis type. A detailed and intensive content analysis was undertaken from interview responses, workshops, observation, verbal feedback, documentation, archival records and physical artefacts. The outcomes obtained from the design toolkit were supported with the case study outcomes. The use of different methods allows producing evidence that permits to answer each research question of this study (Creswell and Plano-Clark, 2007; Miles and Huberman, 1994).

The design toolkit responses are provided in the form of numbered scaled responses to attitudes. Owners and employees' responses gave an attitude about the degrees of importance relating to the company condition and its design abilities and capabilities. The numbered scaled responses were used in this research to indicate the approximate measure of importance for each variable. The second type of response was the verbal answers to questions posed to the interviewees. These questions aim to offer an in-depth explanation of what actually occurs in practice in relation to company performance. Similarly, feedback, workshops, informal interviews, and observations were used to support the data obtained from the design toolkit.

As discussed in chapter 3 (section 3.6), it was apparent a high degree of reluctance from the pilot case studies and case studies to record and to document any information that is relevant for the firm. This situation remains despite reinforcing guarantees of anonymity and confidentiality for the case studies. Hence, the researcher was subjected in each pilot and main case study to sign confidentiality contracts. To obtain as much consistency in the analytical methodology for the purpose of replication, interviews were recorded or in the cases in which it was not possible to record, extensive notes were taken. In what respect to the documentation of observations, archival records and physical artefacts were recorded in ethnographic diaries. The data collected was transcribed to give the information back to the respondents to review it and make sure which information can be used for the researcher's thesis. All the documents and information transcribed and collected were kept in the pilot case studies and case studies offices.

The outcomes obtained from the multiple data source techniques were used as quotations through this section to illustrate the respondents' own experiences and opinions and to assist in supporting the evidence. Ergo, the researcher developed a set of abbreviations to present the quotes and identify the case (number), respondent (letter), section (letter) and issues (letter). Table 6.2 shows in detail the keywords used for the data analysis. The cases were presented in chronological order as they were evaluated by the researcher (Yin, 1994). All transcript material was coded according to the issues covered and the research questions considered.

Table 6.2 Keywords used for the data analysis

<table>
<tr><th>Case</th><th>Respondents</th><th>Section</th><th colspan="2">Issues</th></tr>
<tr><td rowspan="6">Case study one - Case 1
Case study two - Case 2
Case study three - Case 3</td><td rowspan="6">General Manager-GM
Stakeholder-SH
Project Manager-PM
Engineer-ENG
Designer-DES
Employees-EM
External Employees-EXEM</td><td rowspan="6">Company-COM
Strategy-STRA
Process-PRO
Project-Pro
Product/service-PRO/SER
Culture-CUL</td><td>Planning-Plan</td><td>Strategy
Standard
Planning</td></tr>
<tr><td>Organising-Org</td><td>Structure
Personnel
Management</td></tr>
<tr><td>Implementation & Monitoring-Imp & Mon</td><td>Documentation & monitoring
Training & learning</td></tr>
<tr><td>Evaluation-Eva</td><td rowspan="3"></td></tr>
<tr><td>Innovation-Inno</td></tr>
<tr><td>Design-Des</td></tr>
</table>

Scales employed. Numbered scale responses were used to gather respondent's indication about the relative relevance of issues and factors based in their experience, belief and opinion. This numbered scale was pre-coded to provide a series of results according to the answers computed. These results were analysed and supported with the multiple data source techniques from the case study analysis. Finally, the numbered scale responses were used to determine the extent of agreement on the importance applied to each variable (question) (Table 6.3).

Table 6.3 Numbered scale responses

Scale	Response 1	Response 2	Scale assessment Representation
1	Not at All	Little satisfactory	1-25%
2	To a Limited Extent	Regular	26-50%
3	To Some Extent	Good	51-80%
4	To Great Extent	Very Good	81-100%

Single analysis and cross analysis. For this study it was important to explore single cases because it was necessary to understand each particular situation. Cross-case analysis was also considered to produce a clutter of the minutiae that highlight key issues (and even pattern) in the data. Therefore, when a factor or issue was found to be important to an individual or small number of cases, it was highlighted as a specific finding or issue between cases.

The information yield in this section is key to set basis for the follow sections of the data analysis. Ergo, the next section provides a brief summary of the case studies to produce an overview and to identify apparent patterns. Then, the following section answers the first question that relates to the use and embed of design within small Mexican TBEs in new technological industries. This information is presented along with the condition of the company to produce the modifications required for each case study. This question considers the identification and discussion of patterns and themes across the analysis. Subsequently, the pre-measurement data and the post-measurement data is analysed to highlight those factors that show a change.

Themes analysed. As discussed in section 6.2, the design toolkit has a section, ‘diagnostic framework’ that aims to assess the condition of the company and its design abilities and capabilities. The outcomes obtained then are displayed in a series of diagrams, models and tables that assess the different levels (Table 6.1). Therefore, it is important to describe each term used in each of the sections

Table 6.4 Description of the terms used in each level of assessment

Level of assessment	Outcomes
Company level	**Management style and organisational structure** positions the firm under: 1. ***Efficient bureaucratic firm:*** They are commonly found in placid environments in where the need to innovate cannot be perceived as high. Their structure aspires to provide order & uniformity in the organisation's activities. Their structures are made to facilitate the fulfilment of routines & predictable demands of conservative managers; 2. ***Unstructured unadventurous firm:*** They are frequently found in environments that change rapidly. Their markets are focused on compete through improvements in current technologies. Their structure allows them to respond quickly to the opportunities and challenges of their environment, therefore it is common that they define their operations in a day-to-day basis; 3. ***Pseudo entrepreneurial firm:*** They are commonly found in placid environments. They are devoted to entrepreneur activities, but their structures do not totally support these activities as their structure is stable. Their organisational structure is formal with clear roles & responsibilities, & the decision power is centred in the general manager; *4.* ***Effective entrepreneurial firm:*** They are commonly found in dynamic and hostile environments; therefore, they tend to transform the industry. Their organic structure allows them to respond to market & industry demands. Their internal activities depend on good communication & a reduced number of bureaucratic barriers to innovate; **Taxonomy of technology-based enterprises** positions the firm under: 1. ***Firms based in science and technology:*** They have the highest level of innovation in product/service; thus, they invest a large quantity of financial resources & time to those activities. The owner/manager tends to have an inclination to innovative activities, they use as a sources of innovation universities & research institutes, as well as the target market; 2. ***Firms based in intensive resources:*** They have a relative high level in innovation, in both product/service & process. For this reason, they assign financial resources & time to innovative activities. However, they tend to limit the resources to the personnel, & use external material & technologies; 3. ***Firms based in being a specialised supplier:*** They focus on the innovation process. They use few sources of consultation because they emphasise customer' needs in their innovations. They use their specialised labour in the generation of innovation; although, they depend on time and financial resources; 4. ***Firms dominated by the supplier:*** Assign their effort to innovate within their processes. They aim is to generate innovations from suppliers' proposal. Their openness within other institutions is the form in which businesses solve their problems. Their participation is associated as they depend on other firms to innovate
Strategy level	**Types of generic strategy** establish the firm under: 1. ***Leadership in differentiation:*** They focused their product development in enhanced product quality, precision, quality control and response time. Therefore, the products and services that offer are unique, these products/services are related to design, brand, image, technology, suppliers, distribution and after sale service; 2. ***Focus on differentiation:*** They focus on niche markets, thus, their development process relies on precision, quality control and response time. They develop their products/services with the aim to create a loyalty among customers and produce major profits than the competency. 3. ***Leadership cost:*** Their product development it is based in the facility to manufacture, efficient logistic and reduced number of materials. Their process development relies on the learning curve of employees and scale economies to reduce their cost. They have to have sustained access to capital, close supervision of work with controls in the cost, incentives based on quantitative controls, designs that are easy to manufacture, and have considerable advantage in raw materials, components, employees expertise, etc.;

(Continued)

Level of assessment	Outcomes
Strategy level	4. ***Focus on cost:*** They centre their product development in minimising the quality of the product or service, and its development aims to minimise costs. They need to have great efficiency, reduce cost to the minimum, and hire experts in engineering; therefore, this strategy is viable to large size enterprises; **Design** strategies are based on: 1. ***Brand:*** It utilises extensively design and marketing. Design focuses in the corporative identity and brand, packing, delivering of experience to the end users through superior and augmented products/services; 2. ***Market:*** The firm use jointly marketing, management, engineering and design. It focuses in exploiting the market through the development of a product or service that meet the current needs and desires of the market; 3. ***Cost:*** It uses management and engineering in order to reduce costs in the new product or service development process. Therefore, the final product/service can be able to compete through low cost in the market;
Process level Project level	The **performance of the business** is assessed under: ***Planning*** is the act or process to make, act or doing something developed in advance; ***Organising*** arranges or prepares to efficiently coordinate the activities of a person or a group of people; ***Implementation*** puts a decision, plan, agreement, etc., into effect. ***Monitoring*** observes an checks the progress and quality of something over a period of time; keep under systematic review; ***Evaluation*** forms an idea of the amount, number, or value of the actions undertook or considered by the firm during a certain period of time; ***Design*** assess the abilities and capabilities of the designers under the process and project
Product/service level	**Design** positions the product/service under the value delivered to the end-users: ***Superior level*** The emotional product, which integrates attributes such as emotional appeal, emotional response, appearance, and brand identity; ***Augmented level*** The global product, which integrates non-physical attributes. It usually consists on added value factors for which people may pay or may not a premium price. Therefore, it is important consider extra services such as free delivery, after-sale maintenance, installation, and warranty; ***Current level*** The market product that is tangible and display physical attributes. It entails packaging, instruction of use, quality, style and brand; ***Basic level*** The technical product that is described by its core physical characteristics;

Once explained the terms that are part of the section of results, it is possible to address the meaning of the colours used in the diagrams (Table 6.5).

Table 6.5 Use of colours in the diagrams

Colour lines	Action assessed	Sub-actions assessed
Red	Planning	Strategy Standards Planning
Green	Organising	Structure Organisation Management
Blue	Implementation and Monitoring	Documentation and implementation Training and learning
Non-colour	Evaluation	Evaluation

6.5 Detail of case studies and respondents

The three cases were selected under a strict set of requirements to achieve theoretical and literal replication (Table 6.6). Even though, the cases were selected under similar requirements; they differ from one case to another because they adopted different actions to achieve their aims. Thus, each case has its own structure and way of development.

Table 6.6 List of requirements

List of requirements	Sub-variables
Being a technology-based enterprise	Use scientific and technology activities; innovative activities; aim to introduce (technological) innovations within the market
Small sized enterprise	Number of employees from 0 to 50
Mexican enterprise	Owned by Mexicans; National Intellectual Property; Mexican workforce
Private organisation	
Use design within its activities	At the strategic, tactical or operational level; industrial design, graphic design, engineering design etc;
Active in the development of new product/services	Product; service; process
Develop innovation continuously	Radical (new to the market or new to the world); and incremental
Established in the business for more than three years	
Establish in new technological industries	Biotechnology; ecology; electronic; energy; new materials; and telecommunications

The researcher assigned code numbers to the case studies to maintain their anonymity. Each case study was subject to nine to ten months of interventions. They were subjected to three phases of study, in which the researcher first implemented the design toolkit and explored internally the case studies with multiple data source techniques. Then, implemented modifications and observed the changes suffered by the firm and employees. Finally, the case was subjected to another assessment with the design toolkit to contrast the results obtained from the first evaluation with the second evaluation. During the examination of the cases, employees from different levels were involved in answering the design toolkit. Employees were encouraged to respond to those sections in which they have been involved (experience and knowledge) within the business (Table 6.7). The respondents held different positions within the organisation such as general manager, project manager, designers, general assistants, and secretaries amongst others. Targeting this wide range of employees was of great benefit as it brought parity to the evaluation and it arose internal issues that were not evident. Then, it is possible to obtain with the data collected a clear description of the corporate strategy, operational and tactical developments.

Table 6.7 Summary of the employees that evaluated the firm in specific sections

Levels of evaluation	Case 1		Case 2		Case 3	
	Pre-measurement	Post-measurement	Pre-measurement	Post-measurement	Pre-measurement	Post-measurement
Company	3	3	2	2	2	2
Strategy	3	3	2	2	2	2
Process	None		2	2	6	5
Project	2	2	None		3	3
Product/service	3	3	2	2	3	3
Culture	2	4	2	2	5	5

Detailed information of each of the three case studies has been kept in a case study database including interviews, documents, field notes, photographs and photocopies of archival documentation. This database is kept by the owners of each case study, for confidential reasons, and they decide which information can be used for the researcher in the thesis analysis. Therefore, it is necessary to provide a brief background of the three case studies to set the basis for the later analysis of the research questions (section 6.5, 6.6 and 6.7). According to Carson et al., (2000), within-analysis sets the background information and content setting for the analysis of the research questions. The results obtained from the case studies were analysed using different techniques, as the outcomes considered quantitative data and qualitative data. Quantitative data is addressed using tables, descriptive diagrams and T-test tables. Whereas, qualitative data uses a matrix of information and quotes (comments) from individual respondents to pattern match phenomena identified (Yin, 1994).

Multiple source of evidence. To apply the different types of analysis to the research data it was also necessary to use multiple sources of evidence. According to Yin (1994), the use of multiple sources of evidence in case studies far exceeds that in other research strategies, such as survey, experiments or histories. In order to introduce the data collected from the case studies, it is necessary to adopt the following requirements. To comply with the request of participating organisations for confidentiality and anonymity associated with all sources of evidence and to satisfy ethical considerations (section 3.6). The cases are referred to, as case 1, 2 and 3, and only the respondents' functional titles have been revealed. Table 6.8 contains the details of the case studies and respondents.

Table 6.8 Background of the case studies

Number of case	Time of intervention	Industry sector	Years of the business	Financial support	Respondents	Number of Employees	Turnover ($)
Case 1	11 months	Software-Virtual reality	6 years	Governmental support; Personal loans	General manager; Operational manager; Project manager; Employees	16 employees	Semi-Private (Fluctuates around $ 110, 493 USD)
Case 2	10 ½ months	Software-Medical	6 years	Governmental support; Family loans	General manager; Employees;	10 employees	Semi-Private (Services fluctuates around $ 3, 251 USD)
Case 3	11 months	Eco-Technology	11 years	Governmental support; Angel investors; Stakeholders; Bank loans; Personal loans; Family loans	General manager; Stakeholders; Project managers; Employees;	49 employees (Before) 71 employees	Private

Case Study One (case 1), was established in 2004 as a technology-based enterprise in the development of software. The business centred its operations on two types of actions, offer services and develop technological product/services (review Table 5.3). The services offered are directed in three delineated areas of expertise: consultancy, services and training. In what respect to the technological development of products/services, it is concerned with the development of software for managing projects and virtual reality. The firm relies on the offering of services to maintain the business running and develop technological developments. Unfortunately, the company has not being able to exploit and introduce its technological products/services development within the market. The firm has hired 6 internal employees and 10 external employees, among them free-lance designers, that focus on the service activities. Contrary, the project leader is the only one involved in the development of technological projects. The operations of the business were initially financed from personal resources until it was obtained financial support from governmental organisations (CONACYT) to develop technological developments. It is relevant to mention that until now the company still using financial resources from Governments to develop technological developments. Finally, its last technological project (integral systems in oral and hearing rehabilitation) is still in the prototype phase after six years of development.

Case Study Two (case 2), was created in 2004 in Mexico City and it was listed as a technology-based enterprise for the development of new software and products in the medical field. The enterprise centres its operations in two types of actions: offer services and develop technological products/services (review Table 5.4). It depends on the development of external projects to maintain the business running and to keep progressing on the technological project. The company employed 10 people, 5 internal and 5 external, among them designers that are externally hired from a design consultancy. The external employees are involved on the technological development of the product either on the legal part or in the operational activities. Meanwhile, the five internal employees are improving the technological project, developing new projects and finding financial resources. By the time of the pre-measurement phase, the organisation was developing the final prototype of the visual field analyser. The firm was trying to obtain financial resources from governmental organisations, angel investors and inviting new stakeholders. Likewise, it concentrated on the development of strategies to introduce the product within the market, especially in the recruitment of sales people within the medical area. After the study was finished, the company continued waiting for the designers to deliver the final design of the visual field analyser. This implies that it has not been able to launch and position its technological developments within the market after six years of development.

Case Study Three (case 3), was founded in 1999 and it was registered as technology-based enterprise in the development of new energy source, batteries. The developer of the technology (owner) implemented its technology into the automotive industry. Thus, the business required developing different technological projects in order to produce the lightweight hybrid vehicle. The business has been centred on the advance of the project; although, occasionally it develops projects concerning on its area of expertise for third enterprises. The firm had in the pre-measurement study 49 (then grew to 71) employees from whom three were external, as well as, it has an internal department of design. The operation of the business was initially financed from personal resources, venture capital and governmental support. Now, the company uses financial resources from angel investors and stakeholders to complete the beta prototype. Likewise, it has an agreement with the state Government to establish the production plant on its territory to generate employment in change for financial resources. Finally, its product in the pre-measurement phase was focused on the prototype phase and in the post-measurement phase it was transiting to production. This implies that the company has not been able to exploit its technological product within the market after 11 years of development.

Table 6.9 provide a summary of the operational context of each case study and the level assessed in the study. It is part of the protocol developed for the data collection. It was used as checklist about what was required to explore within the area of study. Thus, the researcher was able to delineate the boundaries of the study without affecting the new issues that arise. The operational summary considers in each case a number of variables that are key for these types of businesses. The first variable relates to the innovative production of the business that means whether it focuses on product, service or/and process. The next variable concerns with the innovation source that triggered the product/service/process. This source can be scientific and technological development, customer needs and/or suppliers requirements. The technological source of the project development, which in this case can be licensed in or personal endeavour.

Table 6.9 Operational context of each of the case studies

Case	Innovative production	Innovation source	Technological source	Type of innovation	Basis of the product service	Intellectual property	% of the total staff time devoted to technological process	Stage of the new product/service development	Level assessed with the design toolkit
Case 1	Product & service	Scientific & technological; Supplier needs	Personal endeavour	New to the world	Feature and benefit	Copyright	Leader of the project 100%; Operational manager 20%; Internal employees 30% External employees: Designers 10%; Expert in sigh language 80%; The others 0%	Prototype	Company; Strategy; Project; Product/service; Culture
Case 2	Product & service	Scientific & technological; Customer need;	Personal endeavour	Incremental	Feature and benefit	Copyright; Trademark; Patents (in process)	Owner 70%; Optometrist 60%; Sales person 5%; Designers (consultancy) 15%	Prototype	Company; Strategy; Process; Product/service; Culture
Case 3	Product	Scientific & technological; Customer need;	Personal endeavour	New to the market	Feature and benefit	Patents;	All employees (internal and external) 100%	Prototype	Company; Strategy; Process; Project; Product/service; Culture

The type of innovation that has been developed, radical (new to the world or new to the market) or incremental, by the case studies is considered too. It is also mentioned the basis of the product/service, whether it is a feature or benefit. This leads to the next variable, which is centred on the intellectual property that the company posses in their developments (copyright, patent, trademarks, etc). Then, introduced is the percentage of personnel assigned to the technological process and the stages completed in the new product/service development or project. Finally, considered is the level of assessment undertaken for each case study. In summary, this section outlined the background information of the case studies in order to better understand the results of the analysis.

6.6 Research question 1

The first research question looks at '*How do small Mexican technology-based enterprises in new technological industries use and embed design in their business activities?'*. Therefore, it is important to explore the case studies to understand the types of activities in which designers are involved. This implies that it is necessary to examine the different operations that the businesses encompass (strategy, process or project, product/service and culture) to later place them under the three levels of actions considered within the business (strategic level, tactical level and operational level).

Analysis of the use of design. The resulting data were analysed from the respondents' attitudes to the importance on the adoption of design elements within the strategy, process, project, product/service and/or culture, and the extent to which these elements are actually adopted. The rationale for this approach is that on one hand employees or owner recognise the importance of a specific element in the business activity, and on the other hand the extent to which a particular element is actually adopted within the organisation. The data collected from the design toolkit provides detailed information about the adoption of certain practices at the strategy, process, project, product/service and culture level. Then, this information gathered from each case study contributed to obtain key insights about how these practices were considered or/and performed by employees (internal and external). It was identified from the literature (section 2.6.3) that the major number of adopted design elements within the business, greater the likelihood of business success. Hence, the analysis of data not only identifies which elements were adapted but also to the extent to which they were considered by the firm.

The design toolkit aims to consider the attitudes of employees toward the adoption of certain activities within the business. Thus, it was necessary to use case study to support or reject and to extend the information obtained from the design toolkit. The rationale for this was the recognition that employees may have certain predetermined ways of thinking in which they tend to either over evaluate or under evaluate the activities performed in the business. Similarly, there are specific components and features that are less well defined and then it is necessary to observe them from their natural context. Consequently, two types of data, quantitative and qualitative, had to be considered to provide a more complete view about the results and the specific features relating to each individual element. In this way, cross-cluster analysis across each of the components of the framework remains valid due to the ability to draw meaningful inference between clusters and across components.

6.6.1 Use of design at the strategic level

The results of the strategy level are key as they set the purpose of the use of design in the process or project level and its outcomes, being a product or service. Table 6.8 presents the summary of the data analysis derived from the strategy section. Thus, each element is discussed in turn through the follow sections.

a) Strategy

Design strategies are located under three components: cost, brand or market. This implies that the design strategy focused on cost aims to reduce the sum of money required to produce the new product/service in order to compete with low costs in the market. The brand strategy pinpoints the creation of the value proposition of the business, its name, graphic and personality. Finally, the strategy centred on the market refers to the exploitation of the marketplace through the development of a product/service that satisfies the current necessities of a group of consumers or end users. Results from Table 6.10 exhibits that the three case studies (column I) use design strategically to reduce costs to some extent in the outcome developed by the firm. However, when it was explored the actual condition of the cost strategy (column II), it was discovered that just two cases use this to some extent.

Table 6.10 Use of design at a strategic level

Case number	Strategy			Alignment between firm & design strategy	Alignment between product, information & communication	Procedures to select designers	Role of design in the product strategy	Allocation of budget within different design specialities	Design in the information system	Corporate design communication	Awareness about the competition
	Cost	**Brand**	**Market**								
Case 1	3	1	2	1	1	2	2	2	3	X	X
	X	2	1	1	1	2	1	2	X	X	X
Case 2	3	X	3	2	3	2	1	1	3	1	2
	3	X	1	1	2	2	2	2	X	1	2
Case 3	3	2	2	3	3	1	1	2	X	1	2
	3	1	1	1	2	3	2	2	X	1	2
Total number of cases	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**
	2	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**X**	**X**	**2**

The attitudes of importance obtained were numbered with scale responses and these were presented in the table using the **media** attained from the set of evaluations;

The numbered scale responses range from **4 to 1** where:

4 to great extent or very good

3 to some extent or good

2 to a limited extent or regular

1 not at all or little satisfactory

X stands for the elements that were not considered by the firms due to they do not have them within their activities

Column I presents the employees' attitudes toward design (highlighted in blue colour);

Column II represents the actual adoption of design within the firm (data obtained from the case study white colour);

It was interesting to discover that the two cases that adopt cost design strategy aim to introduce their products as superior and augmented within their target market. The case studies recognised that design is also utilised strategically to satisfy the market. Case study 2 regarded to some extent and case 1 and 3 considered it to a limited extent. When the researcher was collecting data from the case studies, it found little evidence about its use. Finally, employees of case 1 believe that they do not use design at all to build a brand, and case 3 applied it to a limited extent. When the researcher entered the case study, the evidence demonstrated that case 1 used it to a limited extent and case number 3 did not employ it at all.

b) Alignment between the firm strategy and design strategy

The next component evaluated was the alignment between the organisational strategy and design strategy. The firm needs to be able to align all its decisions and actions with its main strategy, as this helps it to apply effectively the resources that it has available. Case 3 and 2 rated the alignment between their firm strategies and design strategy to some extent and to little extent of importance, respectively. Nevertheless, when the researcher assessed physical objects, documents, interviews and archival records, it was observed that they regarded the alignment to a limited extent. In the situation of case 1, both evaluations highlighted that it did not consider the alignment of strategies at all, neither on design nor on other departmental areas.

c) Consistency between the product/service strategy, information and communication

Any organisation that is promoting its products/services needs to convey to prospective customers or users the rationale of why they should be interested in their offerings. This implies that the firms needs to be consistent throughout every point of contact (product/service, information and communication) in which the user or consumer interact with it, as it conveys the values that the company offers and stand for. Case 2 and 3 believes that they are consistent to some extent throughout their three means of contact with consumers (Column I). However, the results showed that they are congruous with the three means to a limited extent. Employees of case 1 regarded that the consistency between these three means was not contemplated at all and data supported this statement.

d) Specific procedures to select designers

The selection of designers is an important procedure, as there are chosen the set of skills and type of outcomes that are going to be delivered in the project (process). Design is a wide area in scope (section 2.6.1) because it has different areas of specialisation. Consequently, it suggests the use of a checklist that lead to selecting the appropriate designer for each project or activity. Case 1 and 2 regarded to a limited extent the use of specific procedures when they hire a designer (Column I). Contrary, case 3 mentioned that it did not utilise specific procedures at all to hire designers. However, when the cases were explored, it was illustrated that case 3 employs to some extent guidelines, meanwhile case 2 and case 1 utilised to a limited extent these procedures (Colum II). It was interesting to note that owners of TBEs have informal procedures to hire designers, especially when they are external consultancies. The general manager argued that '*it is important for me to choose not just the most appropriate designers, but as well as the ones that are going to protect my information. Therefore, the first action is to search for the best consultancies using the web. When I choose one, the website has to look really professional, and the second thing that I look at is the years of experience that they have. Obviously, I also look for the type of project that they have developed, and then I analyse whether they can be able to develop my project. Then, I call the consultancies in order to arrange a meeting, I select 2 or 3 businesses in order to know them, know what their skills are and introduce them to the project. When they confirm that is possible to develop the project, the first things that I consider is the confidentiality of the project. Later, I concern about the money that is going to cost the project. This is how I select the designers for my project'* (Case 2/GM/STRA/Des). The procedures employed by the three case studies to select a designer concern mainly in the security of confidentiality for their innovative projects rather than the skills.

e) Consideration of the role of design in the product strategy

This refers to the awareness of design as an asset within the new product development. This means that design is not just considered as a part of a stage, but rather as a part of the complete new product/service development process. Case 1 considers to a limited extent a basic product strategy within the NPD, and case 2 and case 3 do not use it at all. However, the researcher noticed that case 3 uses it to some extent, as designers were involved since the concept development until the end of the new product development. Similarly, case 2 considers it to a limited extent, as it hired a design consultancy to have a more efficient production. Finally, case 1 regarded design as not necessary at all on the product strategy.

f) Allocation of the budget within the different design specialties

As discussed (section 6.6.1 d), there are different design specialities and thus it is necessary to understand in which skills to allocate the budget. Case 1 and 3 are able to allocate in a limited extent the budget into the different design specialities according to their relevance in the project. Whereas, employees of case 2 believe that they are not able at all to allocate budget in the different design specialities. However, it was discovered that the three cases regard to a limited extent the allocation of budget. This is mainly due to case 3 had a complex new product development in where different areas, especially design specialties, need to be involved. According to the owner of case 1, *'we involve designers in certain projects, especially in those in which it is required to deliver graphic outcomes. We think that it is good to invest on design, as it leverages the perception that customers and consumers have about us'* (Case 1/GM/STRA/Des). Owners have a basic awareness about design and they often use designers for specific outcomes.

g) Design in the information system

Design is used as part of the internal information system of the company to communicate strategic, tactical and operational information to all parts required. Case 1 and 2 regarded design to some extent, as a mean to source internal information system of the organisation. Nevertheless, the researcher did not find any evidence that shows that any of the three case studies have an internal information system, and consequently, there was no contribution of design into the system.

h) Design within the corporate communication

Design is used to make efficient and effective the communication between stakeholders, prospective customers, suppliers, consumers, internal employees and external employees. Case 2 and case 3 do not use design at all to communicate the corporate news. This information was confirmed, when the researcher analysed the case studies and documented that they use a basic corporate communication. Both corporate means of communication have a lack of relevant information for their external stakeholders, suppliers and prospect costumers.

i) Awareness about the design of the competition

This element is relevant for those enterprises that compete on differentiation, as the introduction of similar products (physical features) can affect the entrance of their developments within the market place. Case 2 and 3 regarded to a limited extent the review of the designs of the competition. During exploration of the cases, it was confirmed the information provided by the employees. A designer argued that *'we need to review constantly the designs of the competence because in our target market, people tend to be move not just for the cost of the product but as well for the design appealing. This is the main reason that we want to offer the best choice into the market, as it will lead to increase the sales of our product'* (Case 3/DE/STRA/Des). Both cases regarded the need to review the design appearance and aesthetic of the competition. Therefore, they can differentiate their products, as both elements are key in the purchasing decision for their target market.

6.6.2 Use of design at the process level

Design at the process level had two distinct approaches, one concerns the implementation of the product/service strategy, and the other deals with the new product/service development process. The first addresses the strategic use of design; thus, designers need to understand the nature of the new product/service development process. They need to be able to formulate projects proposal; select specialists; to assemble and manage NPD teams; to plan, organise, implement, monitor and evaluate the NPD process; and to prepare cost work and devise a project budget (Topalian, 1994). The second type of design activities refers to the designs experts that are placed at different phases of the process to develop a project along with other areas and deliver an outcome. The outcome will differ from phase to phase because each phase has different aims and levels of difficulties in the NPD process. Table 6.11 presents the design elements that were used to subject the analysis at process level. This assessment regards the general implementation of design in the process activities. The data obtained from the design toolkit was supported with evidence from case study analysis. It is important to note that case 1 did not evaluate the process level, as it did not have one (See Table 6.7).

Table 6.11 Use of design at process level

Elements	Case 2		Case 3	
	Column I	Column II	Column I	Column II
Design implementation in the NPD	√	√	√	√
Designers consider the firm requirement	1	1	1	2
Designers consider the consumer needs	1	2	1	1
Use of design in the generation of concepts	2	X	1	X
Use of design in the evaluation and selection of concepts	3	1	2	2
Use of design in the development phase	3	3	1	4
Use of design in the prototype and model phase	4	4	1	4
Use of design in the production phase	3	2	1	2
Use of design in the distribution of the product/service	1	X	1	X
Use of design in the product launch	4	X	1	X
Consideration of design about the product disposal	2	1	1	X
Consideration of design about the product recycling	2	X	1	X
Designers define procedures in the NPD	X	X	X	X
Designers define standards for design performance	X	X	X	√
Designers define relation between design & total quality	X	X	X	√
Designers define roles and tasks of the business structure	X	X	X	X
List of designers/suppliers that could collaborate in NPD	X	X	√	√
Designers guarantee that the budget is programmed	X	X	X	X
Total of elements considered	**12**	**8**	**12**	**9**

The attitudes obtained were numbered with scale responses & it presented the **media** attained from the evaluation;
The numbered scale responses range from **4 to 1** where: **4 to great extent or very good; 3 to some extent or good; 2 to a limited extent or regular; 1 not at all or little satisfactory; X stands for the elements that were not considered by the firms due to they do not have them within their activities; and √ stands for a positive answer of the firms in the consideration of certain activities**
Column I presents the employees' attitudes toward design (highlighted in blue colour); **Column II** represents the actual adoption of design within the firm (white colour);

a) Consider the firm requirements and consumer needs

Both elements explore whether designers contemplate the firm's requirements or/and the consumer's needs when the NPD process commences. They are important because they direct the team throughout the NPD to deliver expected outcomes. Employees of case study 2 and case 3 agreed that designers do not consider the firm's requirements and customer's needs (Column I). However, evidence collected using documents, archival records and physical artefacts illustrate that case 2 considers to a limited extent the consumer needs (Column II). Contrary, case 3 addressed to a limited extent the firm requirements in the NPD process (Column II). Both organisations directed their strategies to satisfy different aims, thus implying that they are going to obtain different outcomes.

b) Designers involved in the generation, evaluation and selection of concepts

These elements are concerned with the first phase of the NP/SD process, as it aims to produce and assess diverse ideas in order to enable the business to select key concepts that are likely to succeed in the market place. Designers of case 2 are involved to a limited extent to the generation of concepts, and to some extent to the evaluation and selection of concepts (Column I). Nevertheless, evidence revealed that designers are not considered at all in the evaluation and selection of concepts, as they are not involved in the generation of concepts (Column II). Case 3 rated the participation of designers in the concept generation as irrelevant, although they participate to a limited extent in the evaluation and selection of concepts (Column I). The current condition illustrates that case 3 entails designers to a limited extent in the evaluation and selection of concepts (Column II). In the words of a designer it is due to *'when they hire me most of the decisions about the concept was already considered. The design of the concept was done by the owner, even though he is not a designer, and the same happened with the evaluation and selection of the concept. The firm hired me to solve the problems of that concept, as the owner did not know how to translate that concept into a prototype. Thus, it was required that we redesign the concept, in some details, to make it more functional. It represented the moment in which we demonstrated to the owner, stakeholders and other project managers, our expertise as we developed different concepts, obviously under the lines of the previous concept, and then evaluated them'* (Case 3/DE/PRO/Des).

c) Designers involved in the development phase

The development phase covers the transition from concept development to a tangible outcome. Different areas work together in order to transform an idea into a collection of observable or physical outcomes that later enable the company to test it with the consumer. Employees of case 2 rated to some extent the involvement of designers in this phase (column I); this was confirmed with the data collected in the case study (Column II). Contrary, case 3 argues that design was not involved at all in this phase (Column I). Nevertheless, when the researcher approached the case, it was discovered that design was used to a great extent in this phase (Column II). According to an engineer, *'designers are important in the development phase because they are involved in the development of the product structure. Therefore, they depend from us and we depend on them to finish the product. The true is that every member of the organisation and consequently every area is of utmost importance in this stage'* (Case 3/ ENG/PRO/Des).

d) Designers involved in the prototype and model phase

This element covers the evaluation of bi-dimensional or tri-dimensional outcomes attained from the development phase. This phase helps either to explore and assess the outcome or to discard it before goes to the following production stage. Case 2 illustrated that design was involved in great extent at this stage because it led to improve the final details of the product and to evaluate its final cost before the production phase is reached. Contrary, employees of case 3 believed that design was not used at all in the phase of prototyping. However, when both cases were explored within the case study, it was observed that design was utilised to a greater extent in this phase. According to a general manager, *'design is becoming key because it shows us that the product required more changes than we expected. It is amazing to learn how relevant the use of design is at this phase. Now, I see that it was worth the investment'* (Case 2/GM/PRO/Des).

e) Designers involved in the production phase

This phase refers to the action of making or manufacturing from components or raw materials. This phase is where the organisation translates all the activities and developments to produce a series of products/services that can be introduced within the market place for their consumption. Employees of case 2 consider that design is used to some extent in the production phase (column I); however, it is utilised to a limited extent in this phase (column II). Employees of case 3 do not employ at all design in the production process (column I), but in fact, it was documented that they manipulated it to a limited extent within this phase (column II).

f) Designers involved in the distribution phase and product launch

The distribution phase focuses on the action or process of supplying goods to stores and other businesses that sells products/services to consumers. Product launch refers to the moment in which the company introduce a new product/service to the public for the first time. Employees of case 2 regard to a limited extent the use of design within the distribution phase and to great extent in the product launch (Column I). Case 3 do not utilise at all design in the distribution phase and the product launch phase (Column I). Nevertheless, evidence of the case study suggests that both cases do not consider design in these two phases, as their products/services have not achieved this point (Column II). The manager considers that there is no need to invest on design in both phases because *'the product is so good that it is sold by itself without the need of a campaign for launching it. I do not consider relevant to show something extra as the product stand-alone on its presentation in the market. I think that invest on design at that stage is a waste of money that we do not have'* (Case 3/GM/PRO/Des).

g) Designers' attention to product disposal and recycle

The product disposal relates to the human action of getting rid of a tangible outcome (product) that was acquired from a third party. Product recycle is when it converts the waste (product) into reusable material. Designers of case 2 regarded to a limited extent in their solutions the product disposal and product recycle (Column I); however, the evidence shows that they did not consider it at all (Column II). Case 3 assessed the use of design in a limited extent in product disposal and recycle (Column I); although, the evidence shows that they do not consider it (Column II).

h) Design management actions within the NPD

The last section assesses six elements that designers need to consider in the management of design activities in the new product development process. These are: (1) define procedures in the NPD; (2) set standards for design performance; (3) establish a relation between design and total quality; (4) specify roles and tasks of the business; (5) produce a list of designers/suppliers that can collaborate; and (6) guarantee that budget is programmed. Employees of case 3 assured that they manage the list of designers/suppliers that could collaborate in the NPD process (Column I). The researcher uncover that designers consider at least in their area the standards for design performance, defines the relation between design and total quality, and consider a list of designers/supplier that could collaborate in the NPD (Column II). Whereas, designers of case 2 did not consider any element in the management of design activities, as they area externally hired (Column I and II).

6.6.3 Use of design at the project level

Design at the project level involves to setting up all procedures related to the management and control of individual or collaborative design enterprises (with in-house or external designers) that are carefully planned and designed to achieve a particular aim. This implies that designers need to settle requirements for each stage of the project, as well as monitor and record all the activities and outcomes obtained to later evaluate them and deliver an outcome. Table 6.12 illustrates the design elements that were subjected to analysis at project level. The data obtained from the design toolkit was supported with case study analysis. It is relevant to highlight that case 2 did not evaluated the project level (See Table 6.7).

Table 6.12 Use of design at project level

Elements	Case 1		Case 3	
	Column I	Column II	Column I	Column II
Design brief considers the project requirement	3	1	X	3
Design brief considers the general vision of the project	3	1	X	2
Design brief considers the desirable needs of the project	3	2	X	1
Design brief considers the primary audience	2	1	1	1
Design brief considers planning time and activities	X	X	2	2
Design brief considers planning of project budget	X	1	1	X
Design brief considers of deliverables	X	X	1	2
Design brief considers evaluation of the project result	X	X	X	2
Designer deliver a design draft	X	X	X	X
Specific procedures to select designers for the project	X	X	X	X
Define the design competence necessary in the project	X	X	X	X
Designers document and control the project development	X	X	X	X
Designers support the technological transfer	X	X	X	√
Total	**4**	**5**	**5**	**8**

The attitudes obtained were numbered with scale responses & it presented the **media** attained from the evaluation;
The numbered scale responses range from **4 to 1** where: **4 to great extent or very good; 3 to some extent or good; 2 to a limited extent or regular; 1 not at all or little satisfactory; X stands for the elements that were not considered by the firms due to they do not have them within their activities; and √ stands for a positive answer of the firms in the consideration of certain activities**
Column I presents the employees' attitudes toward design (highlighted in blue colour); **Column II** represents the actual adoption of design within the firm (white colour);

a) The use of design brief within a project

This section focuses on different elements that relate to the design brief implementation into the project development. Case 1 takes account to some extent of the follow themes in the design brief: project requirements, general vision of the project and desirable needs of the project. Similarly, they consider a limited extent the primary audience (Column I). Nevertheless, the researcher discovered that employees consider, in a limited extent, the desirable needs of the project and not at all the project requirements, general vision of the project, primary audience and planning of the project budget. The evidence shows that designers do not use a design brief, as the operational manager provides them with the project requirements using a project brief. According to the operational manager, it is developed in the follow manner: *'as the operational manager, I have to provide to all my employees the requirements needed in order to deliver a project successfully. In the case of designers, I just need to tell them what I need from the project, who is the primary audience and when they have to give me the results. About the payment, I know how much I need to pay to the designers for their hours of work in the project. However, when they have to develop projects in which I am not an expert I ask about the price to develop the whole proposition, let say printing, brochures, etc. The true is that I manage the work of designers and they just concern in give me what I need'* (Case 1/OM/Pro/Des).

Case 3 regards to a limited extent the plan of activities and time and not at all the primary audience, plan of the project budget and deliverables (Column I). When the researcher observed the design activities at project level, it was found out that designers use an informal design brief. It considers to some extent the project requirements, and to a limited extent the general vision of the project, planning of time and activities, deliverables and evaluation of results. Finally, the needs of the project and primary audience were not considered at all (Column II).

b) Design management actions within a project

This section reviews the management of activities that designers carried out in project development. As it can be seen from table 6.5, designers do not manage any activity, except for the designer in case 3, in which they support the technological transfer of other areas. Case 1 hired external designers in order to develop specific and small projects in its service offerings. Consequently, they are not encouraged to be involved in technological or complex projects and exploit their design competence with the firm. Case 3 hired designers to focus on design activities and to support other areas encouraging them to participate on the transference of technology. It was discovered that case 3 hired a design manager to improve the consideration of standard elements within the technological project as he has experience working in the automotive industry (large company). Therefore, he aims to translate these experiences within the small TBE to improve the performance of design projects.

6.6.4 Use of design at the product/service level

Design at the product/service level presents the position of the value delivered by the outcome. This means that it covers added-value offered to the final user and/or consumer in the final product/service as a response to their needs and desires. This level reflects the results of the adopted strategy and all activities considered in the organisation for a period. Consequently, Table 6.13 exhibits the results obtained from the elements fulfilled in the product/service level. The data obtained from the design toolkit was supported with case study findings.

a) Basic product/service

Concerns the technical part and the physical characteristics of the product/service. Case 1 evaluated to a greater extent the utility of its product/service, to some extent its cost, to a limited extent its physical attributes, and not at all its functionality (column I). However, when the researcher evaluated the ‘final prototype’, the four elements were regarded in a limited extent (column II). Case 2 took into consideration to some extent the functionality, utility and physical attribute of its product/service, and to a limited extent its cost (column I). The evidence from the physical artefact, archival records and documents provide evidence that shows that case 2 contemplates to some extent the functionality and physical attribute and to a limited extent the utility and cost (column II). Finally, case 3 assesses to great extent the utility and cost of the product and to a limited extent its physical attribute and functionality (column I). Nonetheless, the results obtained from the case study analysis exhibits that it addressed to some extent the utility, and to a limited extent the functionality, physical attribute and cost (column II).

Table 6.13 Use of design at the product/service level

	Elements	Case 1		Case 2		Case 3	
		Column I	Column II	Column I	Column II	Column I	Column II
BASIC PRODUCT	Functionality	1	2	3	3	2	2
	Utility	4	2	3	2	4	3
	Physical attribute	2	2	3	3	2	2
	Cost	3	2	2	2	4	2
ACTUAL PRODUCT	Communication	3	3	2	2	4	3
	User needs	1	2	2	2	2	2
	User-centred	1	2	3	2	2	1
	Technical quality	1	3	3	3	3	3
	Durability	1	X	3	3	1	1
	Aesthetics	X	X	2	1	4	2
AUGMENTED PRODUCT	Instructions	1	X	2	1	X	X
	Warranty	X	X	2	X	1	X
	After sale service	X	X	2	X	X	X
	Graphic and brand identity	1	X	1	1	2	2
SUPERIOR PRODUCT	Interface with user	1	1	1	X	3	2
	Emotional response	X	X	2	X	2	2
	Pleasant appearance	1	X	1	X	2	2
	Profits	2	X	2	X	3	X
	Total	**14**	**9**	**18**	**12**	**16**	**14**

The attitudes obtained were numbered with scale responses & it presented the **media** attained from the evaluation;
The numbered scale responses range from **4 to 1** where: **4 to great extent or very good; 3 to some extent or good; 2 to a limited extent or regular; 1 not at all or little satisfactory; X stands for the elements that were not considered by the firms due to they do not have them within their activities; Column I** presents the employees' attitudes toward design (highlighted in blue colour); **Column II** represents the actual adoption of design within the firm (white colour);

b) Actual product/service

It refers to the product/service level that not just satisfies physical attributes and tangibles features, but also centres into elements that fulfil intrinsic desires of prospect consumers. Case 1 regarded to some extent the communication between the product/service and the user, and it did not consider at all the user needs, user-centred, technical quality and durability of the product/service (column I). In the evaluation undertaken by the researcher (column II), the physical artefact obtained the same results in communication between the product and user and its technical quality of the product. Nevertheless, it considers to a limited extent user needs and user-centred. Case 2 takes into account to some extent of the technical quality, durability and the user-centred of the product, and to a limited extent the user needs, aesthetics, and the communication between product/service and user (column I). Evidence shows that the product/service covers to some extent the technical quality and durability, and to a little extent the communication between the user and product, user needs and user-centred, but not at all its aesthetics (column II). Case 3 considered to greater extent the communication between the product and the user and aesthetics, to some extent the technical quality, to a restricted extent the user needs and user centred, and not at all its durability (column I). In fact, communication and technical quality are considered to some extent, user needs and aesthetics are used to a limited extent, and user-centred and durability are not regarded at all (column II).

c) Augmented product/service

This term refers to the level in which the global product/service integrates no physical attributes for which people can pay a price above the standard. Thus, it is required to provide extra services after the sale. Case 1 does not regard at all the instructions and graphic and brand identity of the product/service (column I). Case study analysis does not provide evidence that supported these claims (column II). Case 2 addresses to restricted extent instructions, warranty and after sales service of the product/service (column I). The evidence shows that the firm does not consider at all instruction and graphic and brand identity (column II). Case 3 considers to a limited extent the graphic and brand identity and not at all the warranty of its product. The assessment of the archival records, documents and the physical artefact confirm that the firm invest in a restrained extent in the graphic and brand identity (column II).

d) Superior product/service

This level alludes to the emotional part of the product/service that integrates attributes such as the interface with users, emotional response and pleasant appearance, and the profits that it accrues. Case 1 considers that its product/service produce to a limited extent profits, and not all the interface with users and pleasant appearance (column I). After analysing the case study, data showed that it did not consider at all the interface with the user, as the product/service has not been finished (column II). Case 2 regards to little extent the emotional response and profits of its product/service, and not at all the interface with the user and pleasant appearance (column I). Nonetheless, the evidence shows that there is no consideration of any element at this level (column II). Finally, case 3 contemplates to some extent the interface with users and profits, and to a restrained extent the emotional response and pleasant appearance of the product (column I). Nevertheless, the data collected shows that it just addresses to a limited extent the interface with users, the emotional response and pleasant appearance of the product (column II).

6.6.5 Use of design at the culture level

Design at this level considers the form in which the firm configure and undertakes its day-to-day activities. It also contemplates the work environment and the attitudes toward design. Hence, Table 6.14 exhibits the results obtained from the elements fulfilled at this level. The data obtained from the design toolkit was supported with case study analysis.

Case 1 supports to some extent the commitment of the general manager to design, the investment of design activities and design leadership as an element to drive innovation, and it gives importance to a limited extent to design to support creativity and experimentation. It does not consider at all the commitment between other areas and design to develop successful projects and efficient solutions (column I). Nevertheless, the evidence shows that the commitment and investment to design is regarded in a restrained extent and design is not used at all to support creativity and experimentation in the operational activities of the firm (column II).

Table 6.14 Use of design at the culture level

Elements	Case 1		Case 2		Case 3	
	Column I	Column II	Column I	Column II	Column I	Column II
Commitment of general manager to design	3	2	3	2	3	3
Investment to design activities	3	2	3	2	3	3
Support creativity, experimentation & design	2	1	3	2	3	2
Importance that employees give to design	2	1	2	2	3	2
Commitment between other areas & design for success works	1	X	2	2	2	3
Commitment between other areas & design for effective solutions	1	X	2	2	3	3
Use of design thinking as element to produce innovation	1	X	2	X	3	X
Use of design leadership as element to drive innovation	3	X	2	X	3	X
Total	**8**	**4**	**8**	**6**	**8**	**6**

The attitudes obtained were numbered with scale responses & it presented the **media** attained from the evaluation;
The numbered scale responses range from **4 to 1** where: **4 to great extent or very good; 3 to some extent or good; 2 to a limited extent or regular; 1 not at all or little satisfactory; X stands for the elements that were not considered by the firms due to they do not have them within their activities;**
Column I presents the employees' attitudes toward design (highlighted in blue colour); **Column II** represents the actual adoption of design within the firm (white colour);

Case 2 experienced to some extent the commitment of the general manager to design, the investment of design activities and the support to creativity, experimentation and design. Employees agree that there are contemplated to little extent the importance of design, the work between areas to deliver successful works and efficient solutions, and the use of design leadership and design thinking as an element to drive and to produce innovation (column I). The evidence obtained from the case showed that design is considered to a limited extent in all the previous elements discussed, except from the use of design thinking and leadership because it is not used it at all (column II). Finally, case 3 considers all the elements to some extent, excluding commitment between other areas and design for success works as it was assessed to little extent (column I). Nevertheless, the researcher found out that the case study used to some extent the commitment of the general manager to design, the investment of design activities, the commitment between other areas and design for successful works and effective solutions. As well as, design was not important for employees and it was used to a limited extent to support creativity and experimentation within operational activities of the firm (column II).

6.6.6 Use and embed of design within the three small Mexican TBEs

After this detailed evaluation, it is possible to assert how design is used and embedded in each case study. Table 6.15 shows the summary of how design is used in the three small Mexican technology-based enterprises in new technological industries. First of all, it was revealing to discover that the case studies consider design at the strategic level. They tend to regard two or more generic design strategies when they decide to invest in design expertise. General managers acknowledge to a restrained extent to design abilities and capabilities and their implementation at a strategic level. Two case studies used design at the process level in order to support other areas in the development phase and prototype and model phase. Designers are able to consider to a limited extent the requirements of the firm and consumer needs during the process. Similarly, they were able to contemplate design standards, define the relation between design and total quality, and list designers and suppliers that can participate in the project. At a project level, two case studies have informal design briefs in which were regarded the general vision of the project; its desirables, planning of time and activities. Design is used in the product/service, as a support to fulfil the basic and actual elements of the firm's outcomes. Finally, the general managers have limited commitment with design activities and consequently, other areas consider its relevance in a restricted extent.

Case 1 uses design to leverage its brand image through the outcomes delivered on its projects. As discussed (section 5.3.1), it uses external employees (designers) to undertake its different projects. The operational manager is aware about different areas of expertise, including design, and then it is possible to select the most suitable set of skills in each project. This enabled the firm to have a basic strategy for selecting design personnel and budgeting for each project. In what respect to project activities, the operational manager provides designers with basic information about the project requirement, the desirable's needs for the design project, a general vision of the project and the primary audience. External designers are in charge to deliver specific outcomes, which would be evaluated under an operational perspective, and not from the project requirements. Designers are passive and reactive on the use of design within the project. This implies that they tend to be directed by other areas or the general manager on the development of design projects. As well as, they are focused on solving the day-to-day problems encountered on the development of design projects.

Table 6.15 Summary of the use of design within small Mexican TBEs in new technological industries

Level	Findings
Strategy	- Design strategies are mixed between two or more strategies, especially directed to cost and market; - There is to some extent acknowledge about the alignment between product, information and communication; - Design is used in a limited extent in the adoption of product strategy; - *Design management abilities and capabilities*: The follow action are considered to a limited extent: how to allocate design resources, how to select designers and revision of designs developed by the competition;
Process	- Design is used in the NPD process to some extent at the development phase, and prototype and model phase; - Design is used in the NPD process in a limited extent in the evaluation and selection of concepts, and production phase; - *Design management abilities and capabilities*: Designers consider in a limited extent the firm requirements and consumer needs in the early stage of the process; Designers of one case study contemplates design standards for performance, the definition on the relation between design and total quality, and the list of designers and suppliers that collaborate in the NPD process;
Project	- The design brief considers to some extent the general vision of the project, its desirable needs, and the planning of time and activities; - It also addresses in a limited extent the project requirements, primary audience and the project deliveries; - *Design management abilities and capabilities*: one case study use design to support the technological transference;
Product/service	- There are considered to some extent the four basic elements of a product/service, functionality, utility, physical attribute, and cost; - Four elements of the actual product level comprehend to some extent the communication between product and user, user needs, user-centred, and technical quality of the product; - It is considered to a limited extent one element of the augmented product, graphic and brand identity; - Three elements of the superior product, interface with the user, emotional response, and pleasant appearance;
Culture	- There is a limited commitment of general manager to design, investment on its activities and support creativity and experimentation; - Employees consider to a limited extent the relevance of design and the commitment between other areas and design for successful works and for effective solutions;

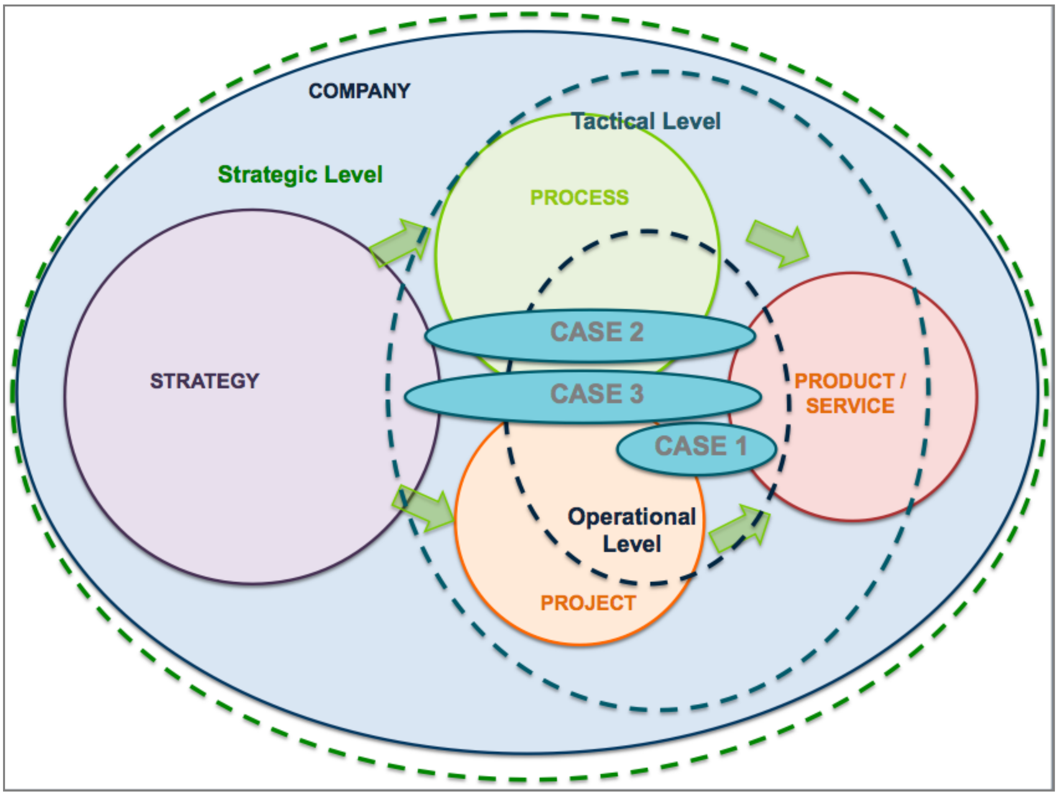
The final prototype of the technological project was evaluated in the product/service assessment. Design was not considered during any stage of the technological project, as employees regarded it as not useful for purpose. Thus, the product/service just fulfil to some extent the basic requirements of the product, and to a limited extent the elements of the actual product level. It is committed to a restricted extent to design, they invest in it but they do not exploit it due to their lack of awareness; thus, the firm embeds it just at the operational level.

Case 2 considers design, as an area of expertise that can help to reduce the cost of the product development and to meet market needs. Employees take into consideration the allocation of budget for different design expertise, and product strategy, as they have set a basic alignment between the product, information and communication. Design is used in a restricted extent to bring awareness about the products of the competition, and thus find actions that led the business to differentiate from others. At the process level, designers were mainly used in activities that are directed to obtain tangible outcomes. Therefore, the company utilises design expertise to great and some extent in the prototype and model making and development phases. It is considered in a restricted extent in the production phase and evaluation of concepts. This is mainly due to the entrepreneur being in charge of the first phases of development. The firm covers to some extent the basic and actual requirements of the product. Nevertheless, the firm failed to provide an augmented and/or superior product to their prospect customers. The general manager is committed to a restricted extent to design to invest on design activities and to support creativity, experimentation and design. Similarly, employees regard to a limited extent the relevance of design, and the commitment between other areas and design to produce successful projects and effective solutions. This infers that design is used as an expertise that is involved in specific stages of NPD, and thus, it is embedded in a limited extent at both tactical and operational levels.

Case 3 contemplates design at a strategic level of action, which helps to deliver a high quality product and at the same time reduces the production cost. The organisation use design in a limited extent at the strategic level to align the product with information and communication, and to provide reports about the products developed by the competence. Due to the complexity of the product, the company required the creation of different internal departments. The case has an in-house department in which employees are considered at the process level. Designers are regarded to some extent in the prototype and model phase, and to a restrained extent into the development phase and evaluation and selection of concept phase.

They are in charge to provide a list of suppliers in design activities that can collaborate at the new product development phase. At the project level, designers consider to a limited extent any information that leads them to obtain tangible outcomes in project development. Hence, designers establish project requirements to attain certain results that can be evaluated against project results. The product was evaluated and it fulfils to some extent the basic and actual requirements levels, and few elements of the augmented and superior product levels. However, as the product is going to compete in a market in which it is required to achieve all the superior requirements. Therefore, the company needs to re-evaluate its current product before it reaches production. The firm regards to some extent the commitment of the general manager to design activities, investment on design and employees and designers to develop successful projects and effective solutions. Thus, the organisation embraces design in a restricted extent at the tactical and operational level. Finally, Figure 6.3 shows the levels in which design is embedded in the three case studies at the three different levels of design action.

Figure 6.3 Levels of use and embed of design



6.7 Research question 2

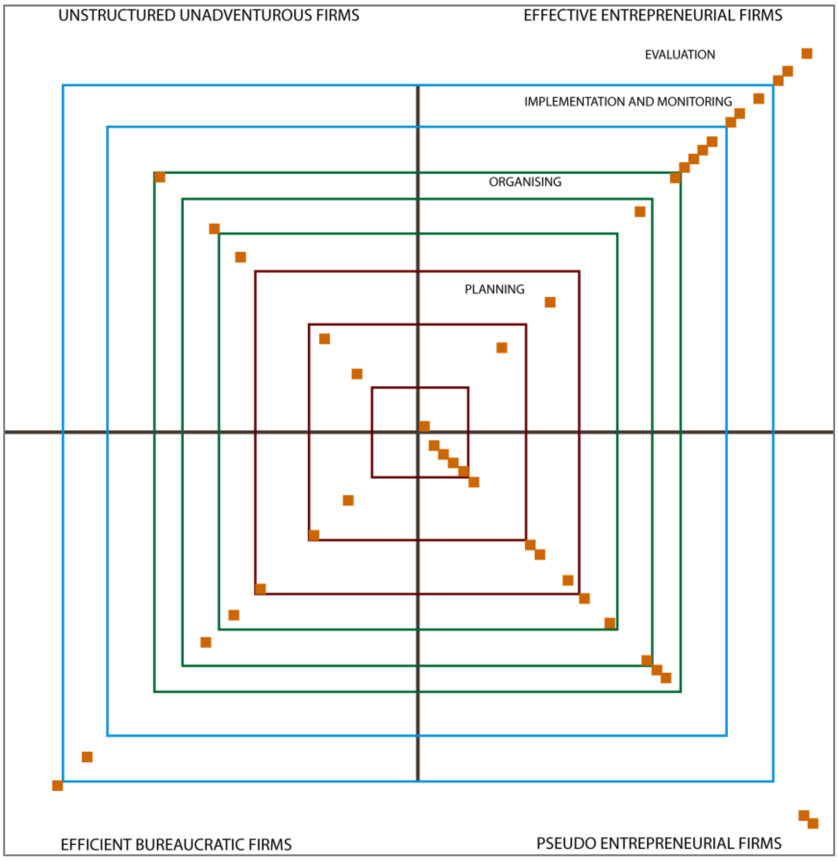
This section aims to uncover the ways in which design management activities can be used, implemented and integrated in three small Mexican TBEs in new technological industries. Thus, it intends to answer the second question: *'how can small Mexican technology-based enterprises in new technological industries use, implement and integrate design management within their activities?'*. In order to answer this question, it is required to understand the current condition of the company. This information provides insights to the researcher to produce a series of design management implementations. Therefore, this section is going to offer a detailed summary of the conditions of the case studies to later describe the design management actions considered.

6.7.1 Case Study One

Company level

This case study explores four large areas: company, strategy, project and product/service. Figure 6.4 provides a detailed summary of the decisions and actions implemented within the business planning (red squares), organising (green squares), implementation and monitoring (blue squares) and evaluation. As it can be seen, the case 1 tends to adopt a pseudo entrepreneurial and effective entrepreneurial management style. It is interesting to observe that the organisation tend to rely its planning and organising activities on semi-formal activities, when its implementation and monitoring, and evaluation focuses on flexibility and informality. This implies that it has a well-defined strategy; although, it has been developing alongside with its objectives and business plan. This phenomenon occurs due to the business is transiting from a young venture to a structured organisation. Thus, the business tends to document and implement in a basic manner its objectives and business plan. It contemplates informally (ideas) future products/services development on its strategy. The organisation considers the planning, organisation, direction and control of activities; however, these are not applied all the times with the same intensity. Its activities are enterprising, but these types of actions are not compatible with its organisational structure, as it has a formal structure with defined roles. Its structure tends to be bureaucratic as it is based in a stable and predictable environment that presents few challenges and threats. Finally, the case study focuses its efforts in obtaining the intellectual property for its developments (planning section).

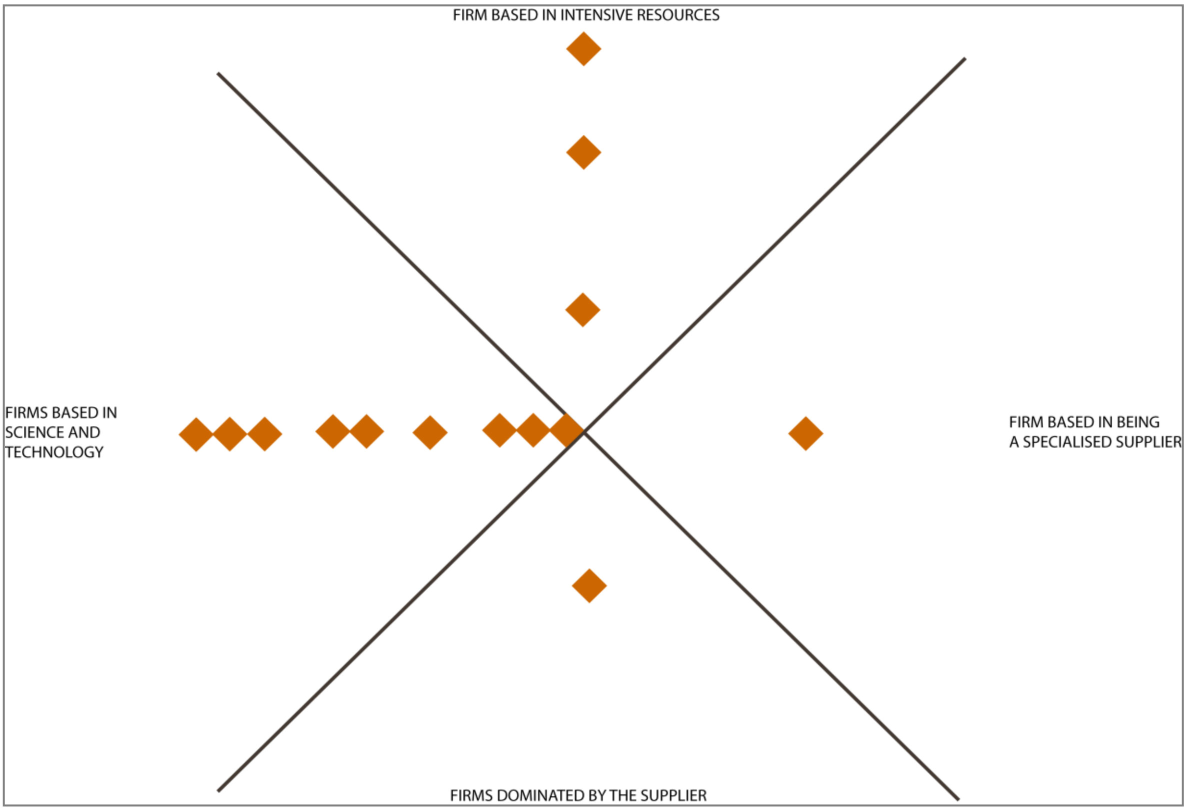
Figure 6.4 Results of the organisational structure and management style



The firm tends to organise its activities under pseudo entrepreneurial actions. This infers that the organisation depends on financial funding to arrange projects and personnel, and to take decisions. The business experiences a centralisation of decision-making of actions from top management, provoking an effect on the contributions of employees. They tend to be passive with their contribution to the organisation, even when the firm encourages a pleasant work environment to increase the levels of production (organising section). In what respect to the implementation and monitoring level, the firm adopts actions and activities of effective entrepreneurial firms. Thus, the structure of the company is not complex, and provides good communication between the external and internal employees and the different areas. However, the system of communication is not designed efficiently, and it does not follow any documentation. The firm has been able to hire adequate personnel into each of its projects leading with it to promote the generation of knowledge and self-learning throughout the projects (implementation and monitoring section). Finally, the evaluation level tends to adopt behaviours of efficient entrepreneurial firms, as it tends to do not evaluate outcomes. This leads to missing rich information and feedback to improve the performance of employees and the business.

Figure 6.5 depicts the tendency of the case study to adopt a taxonomy based on scientific and technological developments and some characteristics of business based in intensive resources. This implies that its strategy is directed to the generation of innovation within its development process and in the results of this development, and not to depend on other organisations or their parties to produce innovative solutions. The firm focus on producing innovation either in its processes or in its products/services. Consequently, it invests resources to have the expertise and equipment required to generate innovative outcomes. Even though, the firm aims to completely develop its innovation, it depends on suppliers to complement or adapt its innovation, as they do not have the expertise to produce these types of developments. It also tends to collaborate with universities and research institutions to produce innovation.

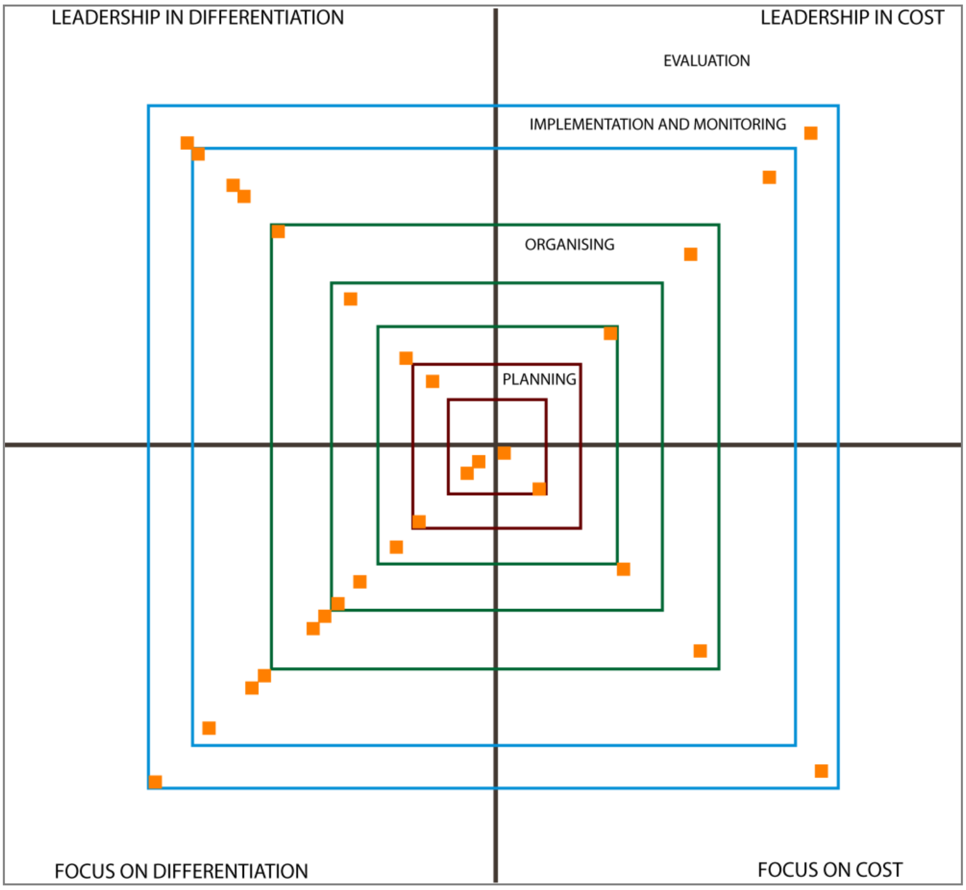
Figure 6.5 Results of the taxonomy of technology-based enterprises



Strategic level

Figure 6.6 exhibits a description of the activities implemented by the firm in order to achieve a desired aim through the selection of a generic strategy. As it can be seen, the organisation tends to adopt activities that lead it to produce outcomes that differentiate from the competition. Nevertheless, it also considers in key actions strategies directed to reduce costs, which in turn affects its proposal to offer standing products or services. For example, the company plans activities considering similarly differentiation and cost strategies. This tendency is reduced in the organisation of activities because the firm directs its activities to differentiation strategies, although, some aspects still emphasising cost strategies. Nevertheless, the differentiation tactics are more accentuate in the implementation and monitoring of activities.

Figure 6.6 Results of the generic strategies

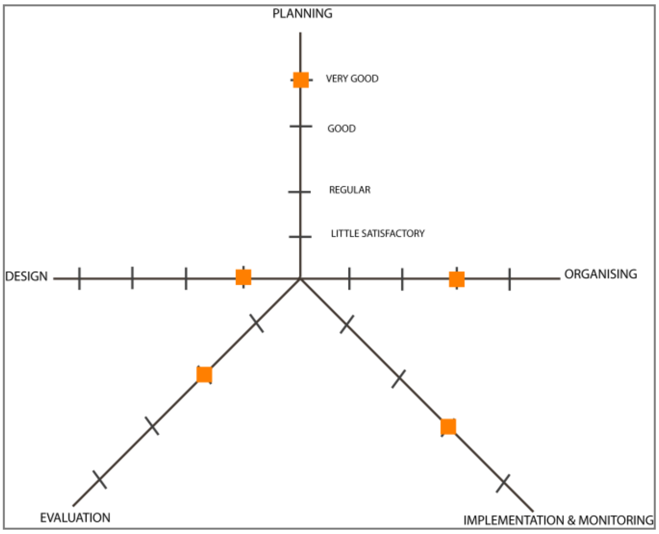


It can be suggested that the case is inclined to adopt a differentiation strategy focusing on market niches. Nevertheless, the adoption of cost tactics in some key actions provokes a deficient performance on its strategic implementation. An example that illustrates this merge of strategies relates to the over control of the operational manager in the supervision of activities undertaken in the business in order to reduce costs. Meanwhile, employees are encouraged to participate in producing new possibilities to generate new families of products/services. The firm tends to plan physical activities and underestimate intellectual activities. It uses as a preferred mean of communication, electronic media and then verbal means; although, the information produced is not documented provoking a lost of insights, time and cost. The firm does not have a record of its projects producing a waste of opportunities to self-learning from mistakes and/or positive results. It does not invest in training for their staff, as it hires external personnel to undertake certain specialised activities. Finally, it assesses the characteristics of the market and market trends when it is aiming to launch a new product/service.

Project level

Figure 6.7 shows that the firm has a positive performance in the development of projects. It has a very good performance in the planning of activities and a good execution in the organising, and implementation and monitoring of activities. Nevertheless, the evaluation of activities performs regular compared to its three previous assessments. Finally, its design actions are assessed as little satisfactory with relation to its design capabilities and abilities and its project objectives.

Figure 6.7 Results of the project performance



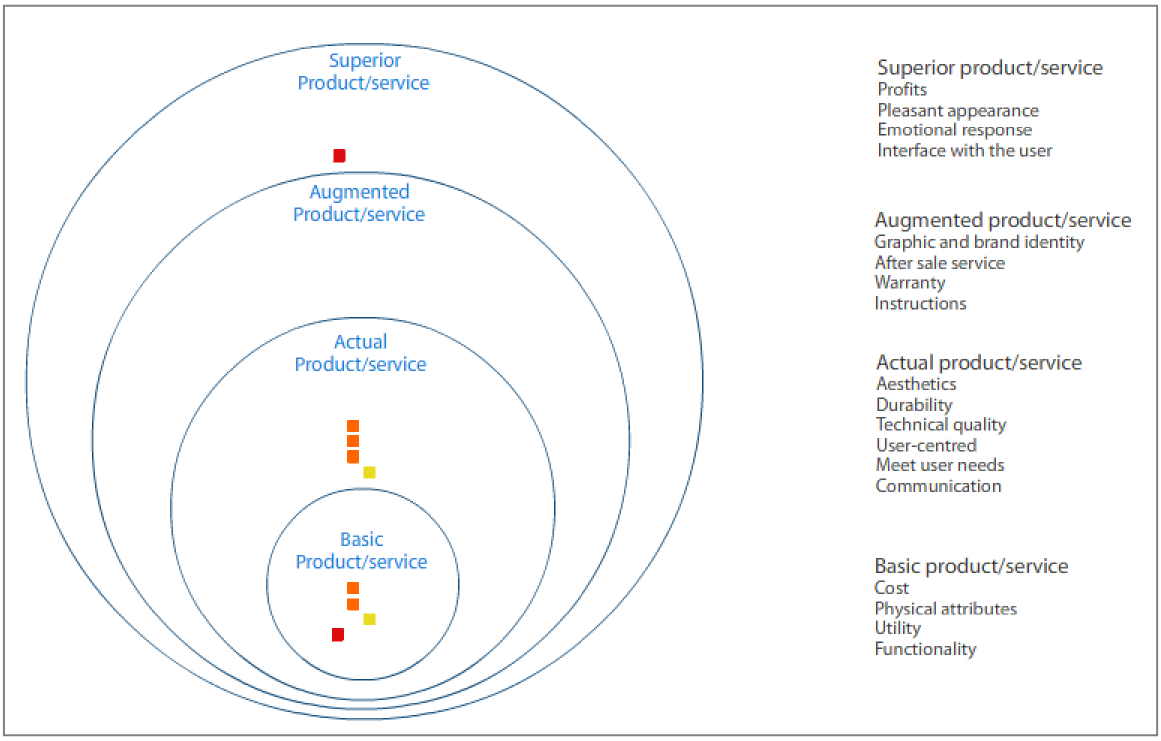
This means that the operational manager plans all the activities that are required during the development of a project. This includes the consideration of multidisciplinary teams in order to provide creative solutions to the projects. This provides to employees enough flexibility to develop activities for the project in a sequential, parallel and associated manner. Nevertheless, employees are not empowered to take decisions when they are doing their activities. The operational manger tends to organise in horizontal manner the structure of the project team inhibiting faster decision-making decisions and flexibility in the solutions of day-to-day encounters.

There is a documentation of the operational activities such as project budget, planning and project delivery. Nevertheless, the project leader and staff do not consider documentation of activities and information about the conceptualisation, development and implementation of actions, especially in technological projects. Thus, the company is not able to neither manage innovation nor internalise knowledge that leads them to expand the realm of their technological expertise. The operational manager communicates the objectives, progress and roles to each employee at the beginning and during the project development. Project changes are not communicated causing a delay in time and an increment in the cost. Finally, design is used in some projects to improve its results, but it is poorly utilised by designers and the firm. It is not applied to generate innovation, or position the product in the market, or increment the development of new products/services.

Product/service level

Figure 6.8 presents the elements considered along with its extent in the final product and service. As it can be seen, the product and service performs little satisfactory, as it does not fulfil on its entirety the requirements of the four levels of value delivered. As well as, the few requirements contemplated perform regularly and little satisfactorily. The firm satisfies basically the fundamental core attributes of the product and service (basic and actual level). This refers that the firm considers three basic elements of the product/service, utility, physical attributed and cost. It regards regularly the communication and little satisfactorily the technical quality, user needs and user-centred product/service in the actual level. This implies that the business is not able to offer an augmented or a superior product lessening possibilities to position the product in premium markets and thus compete under a differentiate strategy.

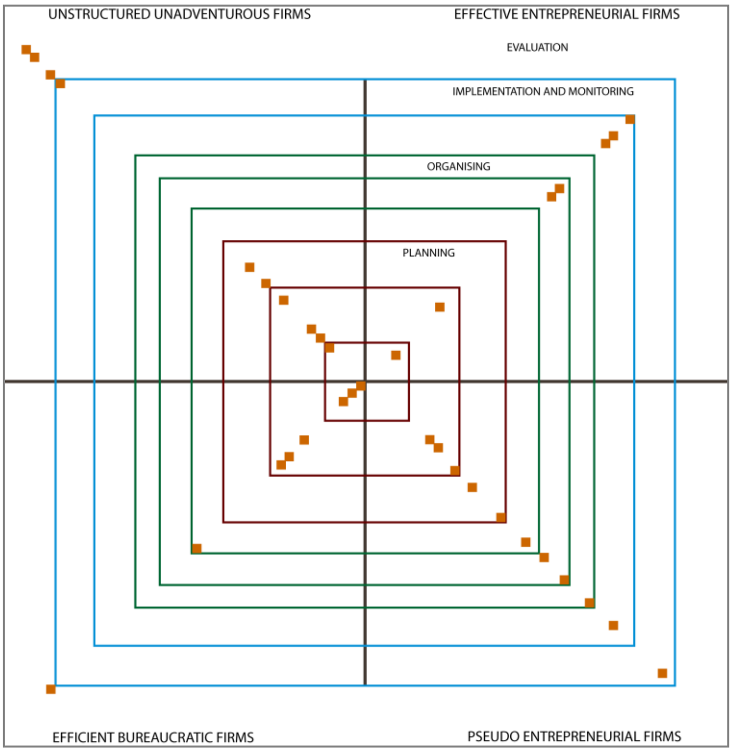
Figure 6.8 Results on the level of value delivered by the product/service



6.7.2 Case Study Two

The case study examines four areas: company, strategy, process and product/service. Figure 6.9 presents a detailed summary of the decisions and actions implemented in the planning (red squares), organising (green squares), implementation and monitoring (blue squares), and evaluation. As it can be seen, the case is inclined to pseudo-entrepreneurial and unstructured unadventurous style of management. It is interesting to observe that the organisation relies its planning under the style of efficient bureaucratic firms and unstructured unadventurous firms and pseudo entrepreneurial firms. Contrary, it organises, and implements and monitors its activities under the characteristics of pseudo entrepreneurial firms.

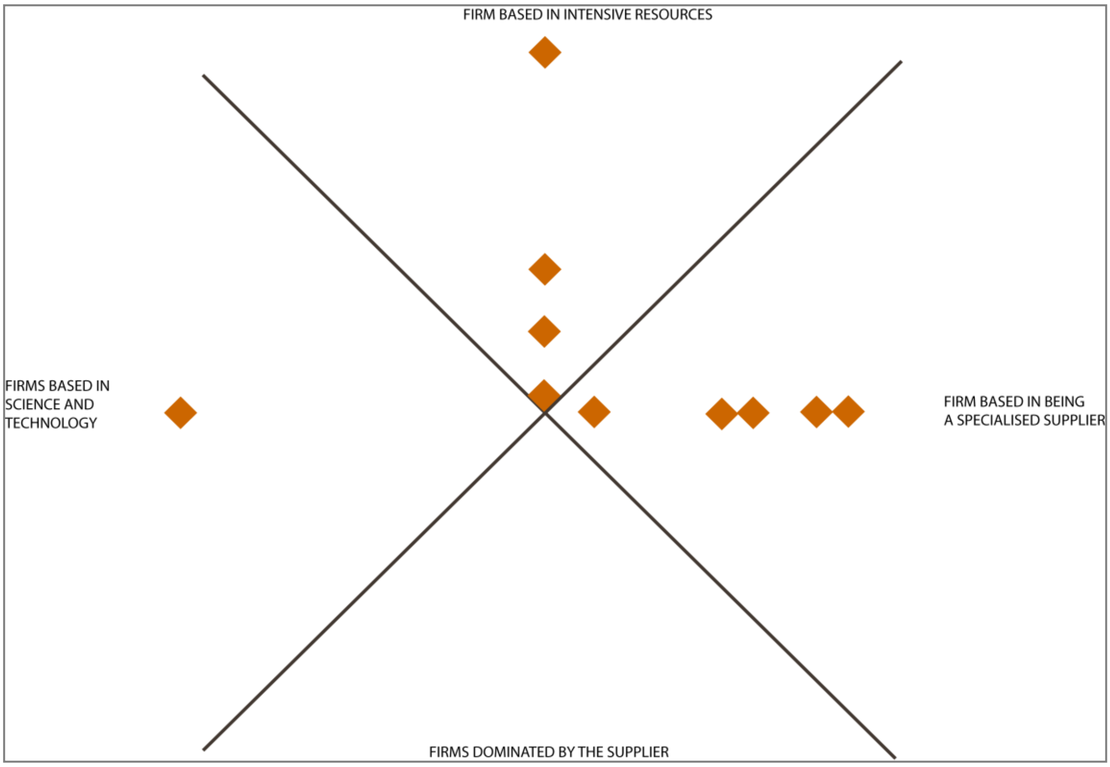
Figure 6.9 Results of the organisational structure and management style



This implies that the enterprise has a clear strategy and its objectives are well defined allowing the reflection of the business plan in its activities (planning section). But, it contemplates in informal basis future business opportunities. Interestingly, the general manager regards all the requirements to obtain the intellectual property of their developments. It also considers quality standards during the technological development and on its outcomes. The firm has an entrepreneurial and organic structure to quickly respond to the demand of the market place and industry and to facilitate dealing with challenges. Its organisational climate is based on collaboration between all the members, as this action minimizes bureaucratic barriers to innovation (organising section). Tasks are defined in a day-to-day basis because the firm depends on the injection of external financial resources to undertake activities. It is characterised for adopting open communication; although, its documentation is poor as it is based within a dynamic environment and hostile environment that does not allow formalising it (implementation and monitoring section. It bases its improvements on self-learning through the process and external means and it also invests on training for employees that required acquiring a specific expertise.

Figure 6.10 illustrates the tendency of the case study to adopt technological actions related to being a specialised supplier and based in intensive resources. This outcome is interesting because both strategies are directed to opposite strategies and technological developments and outcomes. Therefore, the implementation of distinct actions overlaps and halts the development of the scientific and technologic developments. For example, the organisation focuses its production on the generation of innovation in products and services. It invests time and financial resources to develop technological and scientific developments in order to meet the suppliers' needs. Its technological developments mostly depend on the need of suppliers. The general manager has a strong attitude for innovation; consequently, he encourages alliances with universities and research centres to improve the technological developments. However, the characteristics of the firm and structure of teams provokes the lost of valuable information in the innovation process because there is not management of knowledge and innovation.

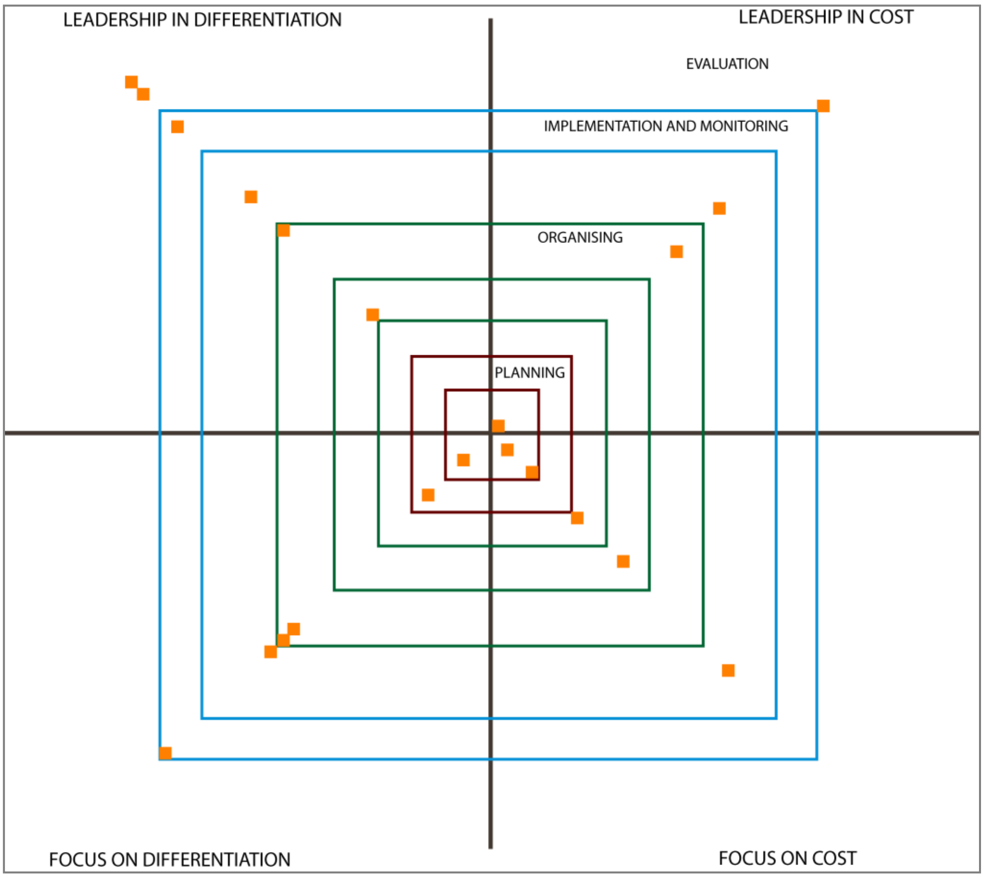
Figure 6.10 Results of the taxonomy of technology-based enterprises



Strategic level

Figure 6.11 displays the actions adopted by the firm in order to achieve its goals through the selection of a generic strategic. As it can be seen, the case study directs its efforts to differentiation strategies (leadership and focus); although, it embraces activities that pursue cost strategies (focus and leadership). For example, the case study plans activities under the perspective of focus on differentiation and cost. Then, it organises its activities under three strategies: leadership in differentiation, focus on differentiation and focus on cost. Interestingly, the firm accentuates the relevance of differentiation strategies when implements and monitors activities. Finally, it evaluates its activities under leadership in differentiation. Consequently, it can be suggested that the case adopt differentiation strategies to produce a superior technological development and cost strategy to reduce expenses on the development of activities.

Figure 6.11 Results of the generic strategies



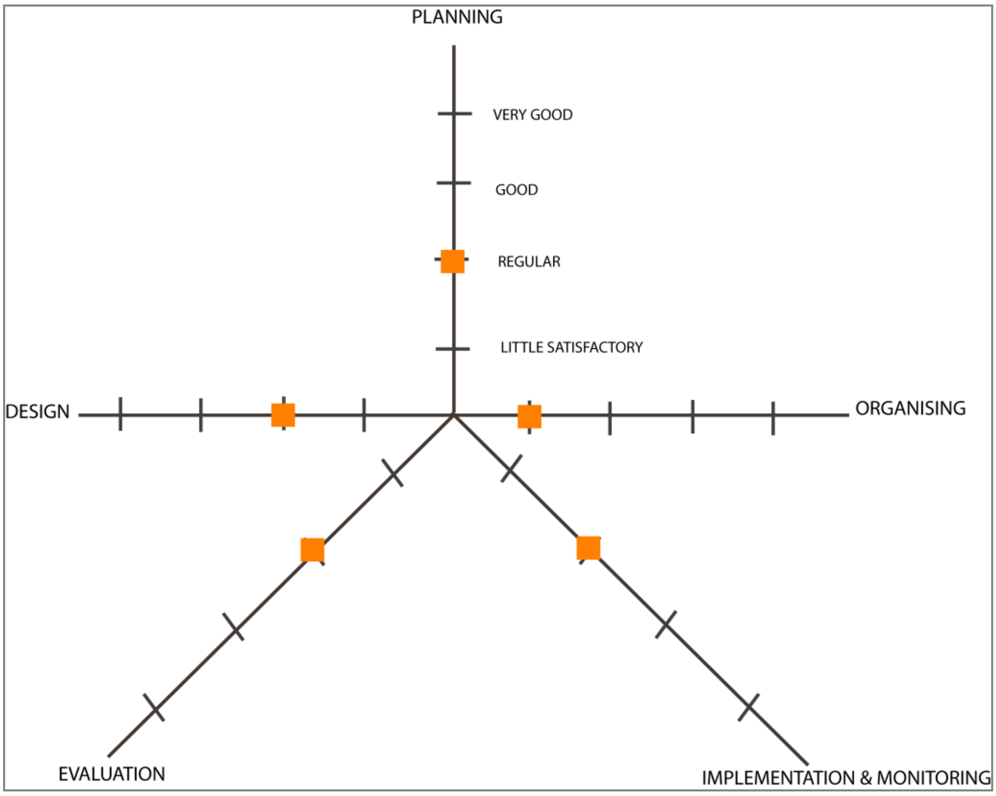
The firm centres its structure on reducing costs and facilitating manufacturing, but aiming to do not affect the technical quality of the product/service. It has established a flexible manufacturing structure in order to satisfy the requirements of the market niche. The general management has basic knowledge on management of financial and human resources and plans on a day-to-day basis. Employees have excellent communication, as all the efforts concentrate on developing a product/service that meets satisfactorily the company and market needs. The firm invests on training to improve its process and activities; although, it uses self-learning as an asset to improve its performance. Employees of the organisation know and understand their abilities and capabilities, which enables them to develop and implement better actions in the innovation process. Design is used to reduce costs and to a limited extent to meet market needs. The general manager has a conventional and basic awareness about the different types of design. This enables him to decide which type of design is required to undertake an activity. However, there is not a culture and awareness about design that helps them to use this resource within an efficient and effective manner.

Process level

Figure 6.12 reveals the regular performance of the case study on the NPD process. It has a regular functioning on the planning of activities; although, it is affected by the little satisfactory execution of organising tasks. Interestingly, the firm perform regularly in the implementation and monitoring and evaluation of activities, and in the use of design abilities and capabilities within the NPD process. This condition is strongly related to the lack of experience on this process from the case, as it represents its first product development. This implies that employees need to consider the development of a new radical product platform.

The company bases the planning through researching market opportunities of its future product in the market selected. Then, it is able to plan which type of technologies are going to be used to compete in a market with high levels of technological risk. The general manager organises the NPD process in an organic and flexible structure to adapt the team to the requirements of each phase of development. Employees embrace the process as a sequence of activities with a loop of feedback that allows rectifying the product/service development. This structure is supported by the openness of communication between employees and the owner. The general manager considers the direct cost of the process, but he does contemplate neither the indirect costs nor the intellectual activities of employees in the organisation of the NPD activities. The lack of both considerations leads the firm to delay the project due to insufficient financial resources and personnel. The project team documents the needs of the consumer, description of concepts, specifications of the product and materials used on their developments. However, they do not document the resources used during the NPD, causing the absence of current cost of development and product/service. The project team is constantly communicating all the changes produced in the product development and its successful evolution. Employees recognise the need for training in all the phases of the new product development. Finally, the firm uses design to improve results through the integration of designers within the prototype and production phases; although it is used not used effectively enough. Thus, design is not used as a tool to produce innovation and to increase the generation of new families of products.

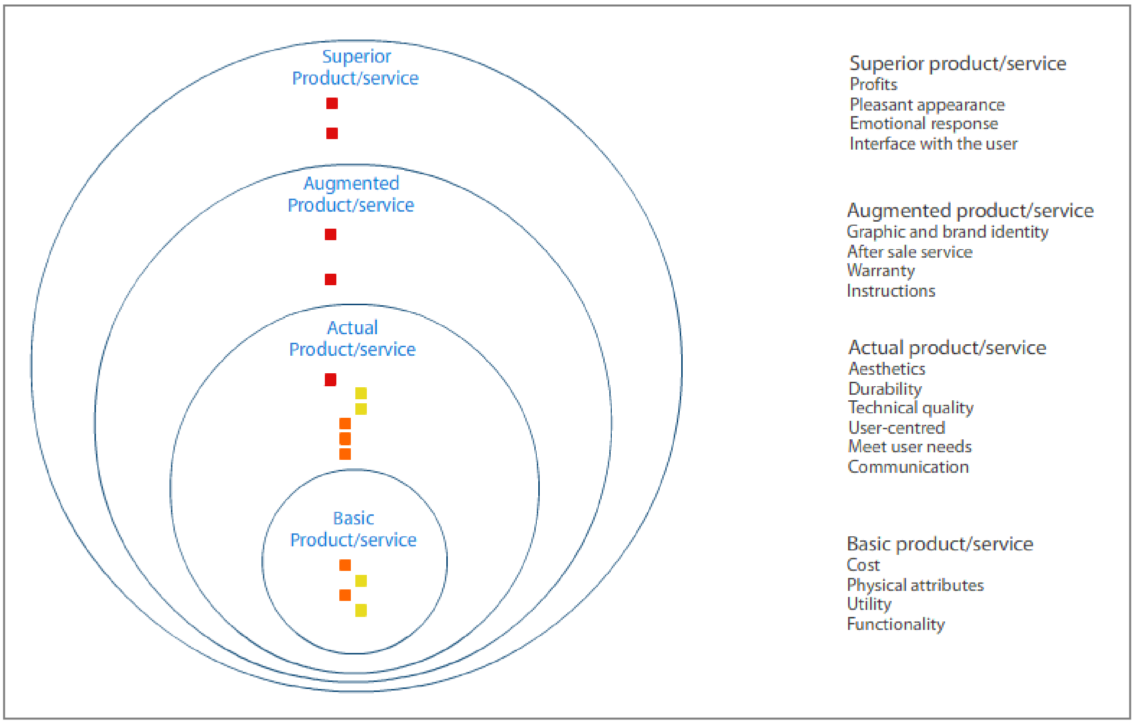
Figure 6.12 Results of the process performance



Product/service level

Figure 6.13 exhibits the elements considered along with their extent in the prototype of the product/service. As it can be seen, it performs regularly, as it does not fulfil on its entirety the requirements of the four levels of value delivered. The product/service performs regularly and good in its basic and actual value. Nevertheless, the requirements considered in the augmented and superior product/service value perform little satisfactory. Consequently, the firm ponders regularly utility and cost, and good functionality and physical attributes of the basic value of the product/service. The next level, actual value, is represented by the good appraise of technical quality and durability, regularly the communication, user needs and user-centre, and little satisfactory the aesthetics of the outcome. Nevertheless, the firm regards little satisfactory the instructions, and graphic and brand identity, and the emotional response, and profits of the outcome. This result shows that the firm has not achieved its strategy, as the current product/service cannot compete with large and recognised companies. Thus, it requires investing resources to reach a superior product that leads them to introduce satisfactorily the product/service into the market.

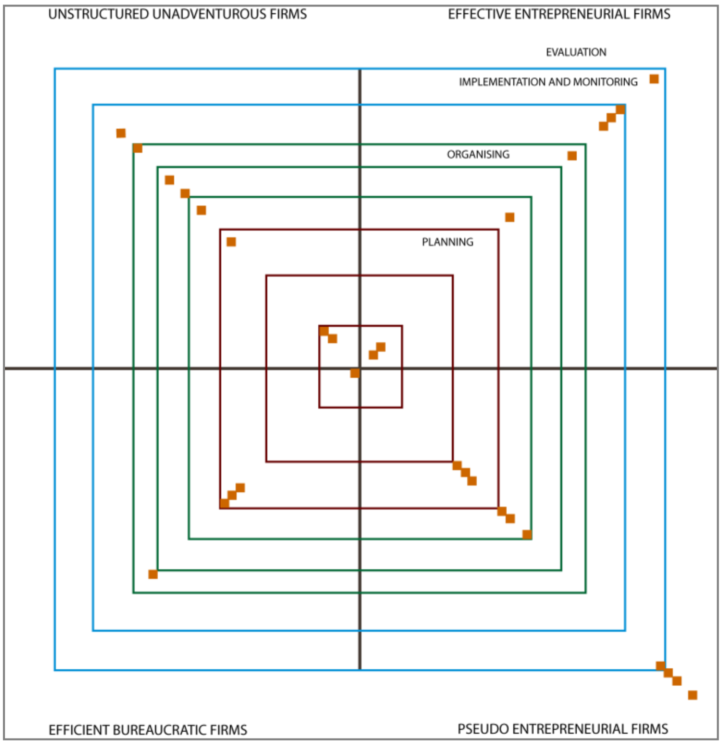
Figure 6.13 Results on the level of value delivered by the product/service



6.7.3 Case Study Three

The case study examines five areas: company, strategy, process, project and product/service. Figure 6.14 presents a detailed overview of the decisions and actions implemented in the planning (red squares), organising (green squares), implementation and monitoring (blue squares) and evaluation. As it can be seen, the case is inclined to adopt pseudo-entrepreneurial style; although, it is followed closely by characteristics of unstructured unadventurous and effective entrepreneurial activities. It was interesting to observe that the firm relies its planning under the style of efficient bureaucratic style and nearly come after by unstructured unadventurous and pseudo entrepreneurial firms. Then, it organises its activities under the range of unstructured unadventurous and pseudo entrepreneurial management style. Finally, the company implements and monitors tasks under the effective entrepreneurial style and it evaluates its activities using characteristics of pseudo entrepreneurial firms.

Figure 6.14 Results of the organisational structure and management style

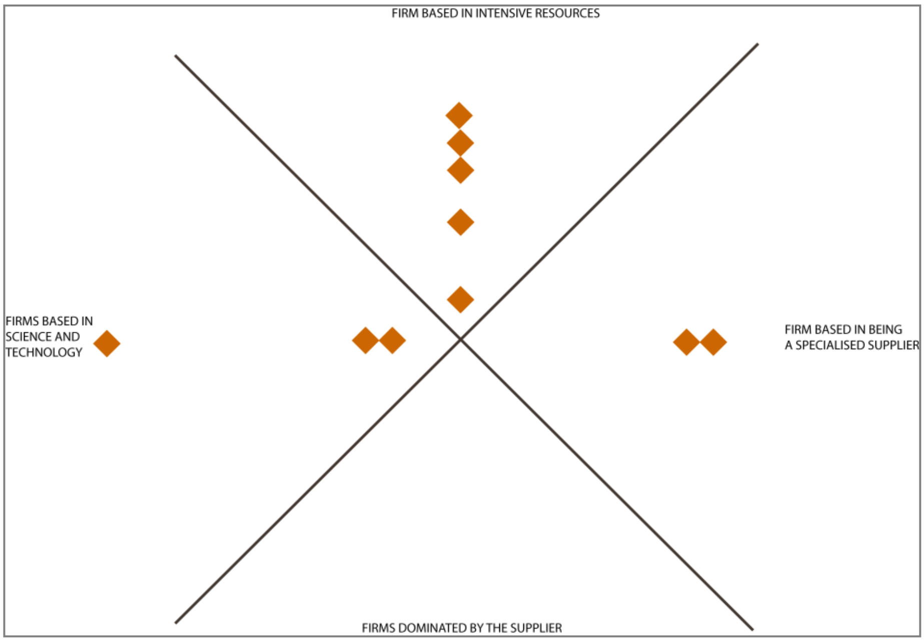


This implies that its strategy is well defined with respect to its business plan implementation (planning section). The enterprise informally considers future business opportunities within its strategies. It contemplates standards, especially those concern with legal requirements to obtain the intellectual property of its development. However, it has not addressed key standards that are of main importance on its industry such as quality standards and environmental standards in the development of activities and outcomes achieved. The organisation is adopting a formal structure, as it has been experiencing internal growth that requires order within its activities and implementations. This reengineering of the organisational structure is affecting activities, as the planning of corporative activities differs from the planning of process activities. This lack of alignment between the two levels is directly affecting the production phase. Another problem related to the organisational structure concerns its formality because it does not allow the business to respond rapidly to external and internal dynamics. As well as, this structural change is affecting the organisational culture and environment, as employees feel that the organisation is fractured in two levels.

The decision making of the business is centred at the corporative level provoking delays in the technological development. One of the major problems of the business was related to the management of financial resources (organising section). Thus, it has recently hired specialised in-house personnel to manage more efficiently the resources of the organisation. In what respect to the implementation and monitoring section, the communication between areas is efficient when it is necessary to solve problems in the short-term or to finish a project. Also, the firm does not have a formal documentation causing loss of time and information. The firm does not invest in training, as it hires specialised personnel in certain fields to participate in specific projects. Employees rely on self-learning as a key factor to improve their activities and the business performance. Finally, the firm evaluates the overall project in each milestone of the process; although, feedback is not provided to employees or formally documented.

Figure 6.15 shows the tendency of the case study to adopt characteristics of firms based in intensive resources. Although, it also considers actions of firms based on science and technology and specialised suppliers. This provokes a dependency of external suppliers to improve the development and performance of the technological innovation. Hence, this means that it has high levels of innovation in products and processes. The general manager has a strong positive attitude to innovation leading to use all the financial resources and time to innovative activities. The company is able to produce innovation internally; although, it also depends from external suppliers to obtain certain technological elements that are required to use, adopt or modify for its technological innovation.

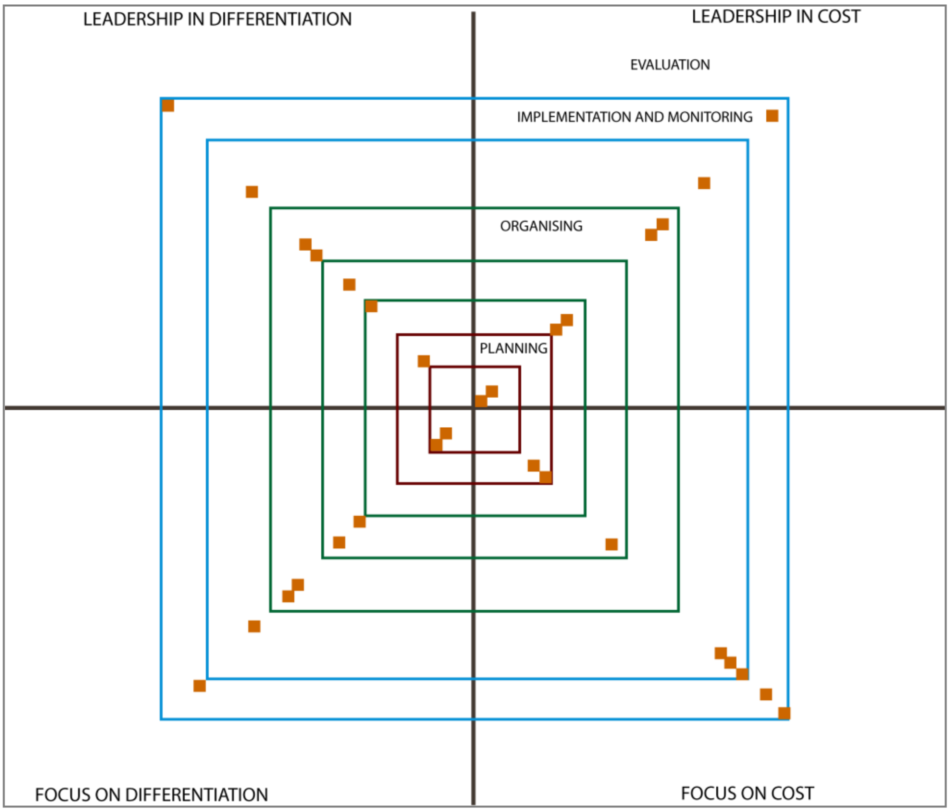
Figure 6.15 Results of the taxonomy of technology-based enterprises



Strategic level

Figure 6.16 displays the actions adopted by the firm in order to achieve its goals through the selection of a generic strategy. The case study directs its efforts to three different strategies: focus on differentiation, focus on cost, and leadership on cost. Thus, the firm plans its activities under the perspective of focus on differentiation and cost, and leadership in cost. Similarly, it organises activities through adopting actions of firms directed to leadership in cost, leadership in differentiation and focus on differentiation. Finally, the firm accentuates the relevance of focus on cost in the evaluation of actions. It is suggested that the case study presents a balance on the elements considered to produce differentiate products and to reduce costs in the process development. Therefore, the general manager needs to be careful on the decision and adoption of actions to embrace both strategies, as they have elements that are opposite.

Figure 6.16 Results of the generic strategies



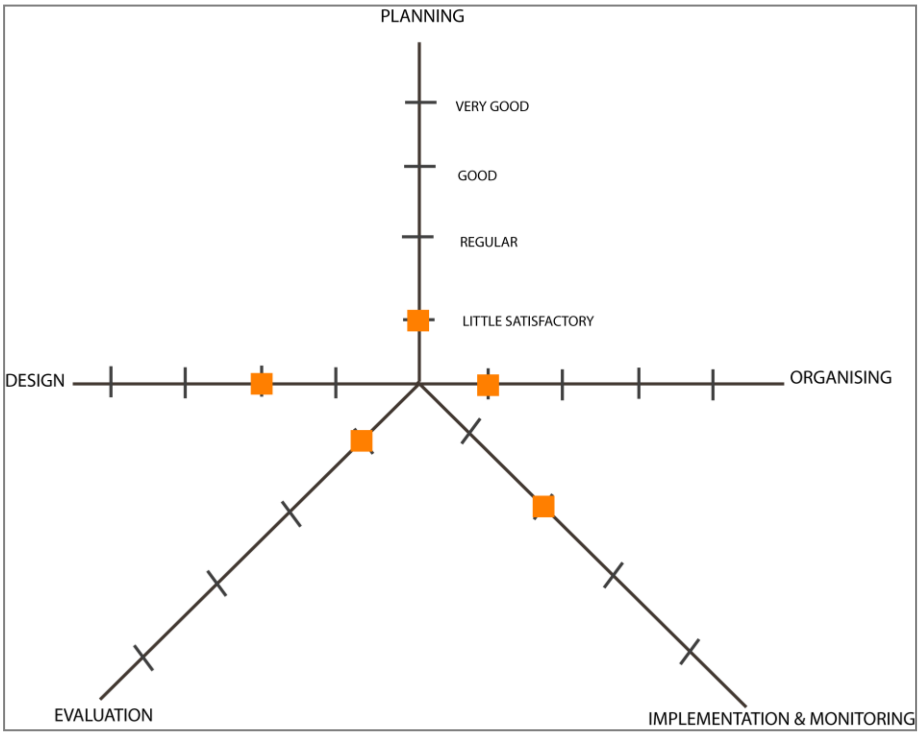
The case study plans its process under milestones in which employees need to deliver tangible outcomes. However, this plan does not consider physical and intellectual activities in the process development provoking delays in the deliveries. The corporate level clearly defines the roles of employees; although, they do not know the roles that they need to play in the new product development process (planning section). There is basic coordination between the different areas because this provides flexibility to the integration of new employees (organising section). The firm tends to invest most of its resources to solve problems in the short-term, specifically those affecting the current actions of the technological project. It uses informal means of communication (electronic and verbal) to cascade information among employees causing loss of information and delay in the process development (Implementation and monitoring section). The absence of formal means of communication and coordination among employees cause a misunderstanding between the different areas involved in the process. Employees' document results obtained during the process, but they do not register how they achieved those outcomes. They do not have an archival record of the modifications and changes experienced during the NPD process missing with it chances to produce further innovations. Finally, design is utilised at this stage to reduce cost and to improve outcomes.

This means that it is not used to generate or trigger innovation (radical or incremental) or produce add value products.

Process level

Figure 6.17 exhibits the little satisfactory performance of the NPD process. It has a little satisfactory performance in the planning, organising and evaluation of activities. This set of conditions is improved in the implementation and monitoring and design of activities. This result reflects the lack of knowledge of employees in the NPD process, as it represents their first product development. Indeed, this process also represents the first new product development generated by the business. Therefore, the firm needs to consider the creation of a new product platform.

Figure 6.17 Results of the process performance

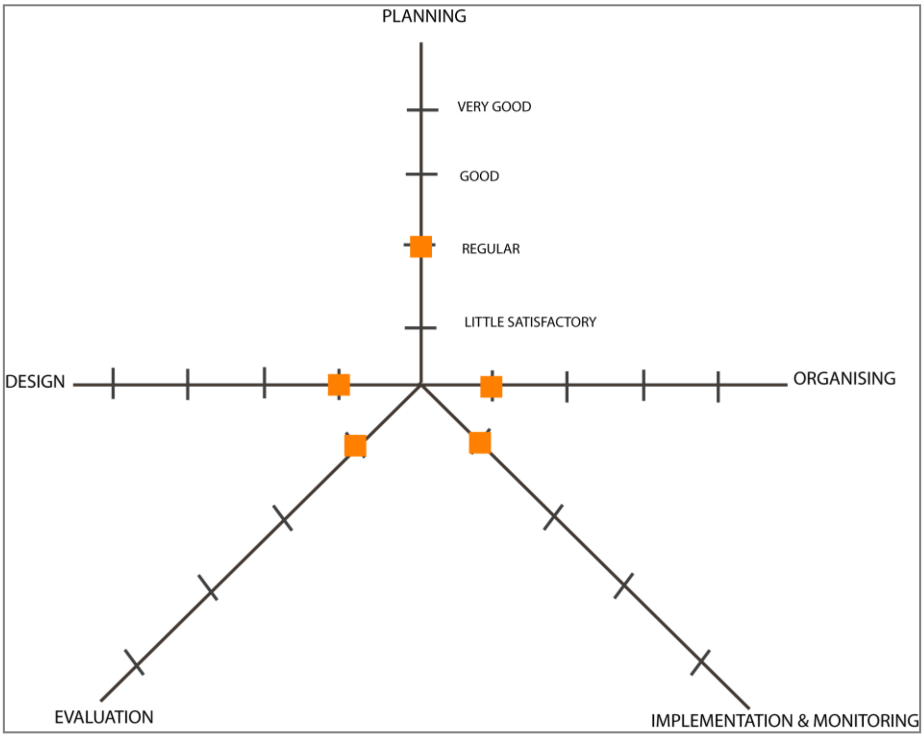


Employees regard planning of activities as an irrelevant action because there are many uncertainties involved on the process development. This paucity on the analysis of external and internal variables impacts the performance of the process and the final cost of the product. The process is organised within a linear sequence of activities with a loop of feedback to allow employees rectify the product development on time. The team is multidisciplinary in order to facilitate an open communication without barriers between all employees. The decision-making is centred at the corporate level affecting a delay on the projects and a bureaucratic structure. Although, it was interesting to observe that this centrality on decisions is set aside when deadlines are approaching the organisation. Then, employees are able to take relevant decisions in the process. The project manager regards direct costs, and few times indirect cost and intellectual activities in the organisation of activities. Employees and project managers scarcely document the resources used during the process development provoking an increment on the cost and waste of time at the production phase. Although, the team documents consumer needs, concept description, product specifications and some materials. Employees consider necessary training in all the phases of new product development, as few of them have experience. Finally, design is involved in the generation, evaluation and selection of concepts. Designers are recognised as key participants in the development, prototype and modelling, and production phase of the NPD process.

Project level

Figure 6.18 displays the condition of the actions undertaken in the project development. As it can be seen, the overall performance of the project is little satisfactory. The project team perform regularly on the planning of activities. Nevertheless, the development of activities in the organising, implementation and monitoring, evaluation and design perform little satisfactorily. For example, the project manager plans results required and deliveries of projects. Thus, the results attained sometimes are not the expected because there has not been established the aims of the project, requirements and successful criteria. The organisation of the project team is flexible in order to encourage employees to develop creative and innovative solutions. Nevertheless, the centralisation in the decision-making from corporative levels inhibits the creativity of the team. The project is characterised for having a basic management as it only considers the direct cost and physical activities of the project. Similarly, the project team performs a basic documentation because its records are focused on two-dimensional and tri-dimensional results from milestones, and the final results of the project. The project team does not have any system of communication, as they use electronic and verbal means to inform the advances and modification of the project. The evaluation of the project is poor because the project manager only applies two major assessments: concept and prototype. Finally, design is used in a basic manner, as it is used an informal design brief to address few requirements of the project, general vision of the project, needs of the project, planning of activities and time, and deliverables.

Figure 6.18 Results of the project performance



Product/service level

Figure 6.19 presents the elements considered along with their extent in the prototype of the product. The assessment of the product shows that it performs regularly, as it does not fulfil on its entirety the requirements of the four levels of value delivered. The product accomplishes to some extent and to limited extent the elements of the basic level. Then, it executes regularly the actual level, as two elements are little satisfactory, one regular and three good. Finally, it performs regularly one element of the augmented value level and three elements of the superior value level. This implies that the firm executes satisfactorily the utility and cost, and regularly the functionality and physical attribute of the product in its basic level. It also addresses in some extent the communication, technical quality and aesthetics of the product, and regularly the user needs. Finally, it considers regularly the graphic and brand identity, interface with user, emotional response and pleasant appearance of the product. The product has not reached the qualities required to be positioned in an augmented and superior level. This implies that the firm cannot offer a differentiate product that set the basis to achieve loyalty among customers.

Figure 6.19 Results in the level of value delivered by the product

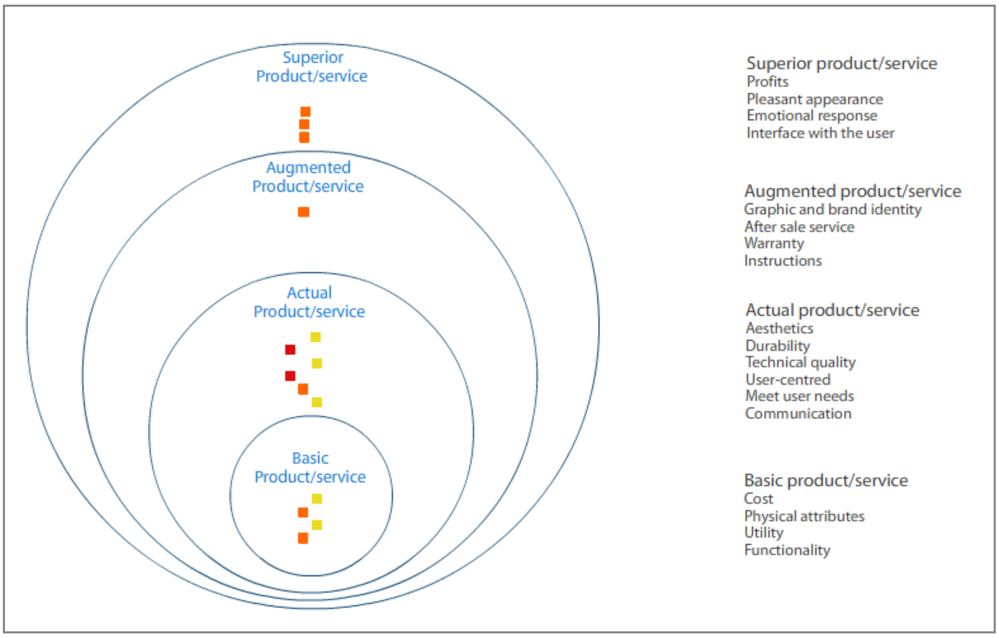


Table 6.16 provides a summary of the information produced throughout the section to describe the condition of the three case studies. This information is relevant to suggest the most adequate implementation, integration and use of design management actions. The information produced allows answering the second question: *'How can small Mexican technology-based enterprises in new technological industries use, implement and integrate design management within their activities?'*.

Table 6.16 Summary of the condition of the case studies

Level	Case 1	Case 2	Case 3
Company level	▪ It is placed as a pseudo entrepreneurial & effective entrepreneurial firm; ▪ It emphases planning, organising & control of activities; ▪ It contemplates informally future business opportunities; ▪ It is based as a scientific & technology TBEs; ▪ It produces innovation internally, but it uses suppliers to obtain certain technological elements;	▪ It is placed as a pseudo entrepreneurial firm & unstructured unadventurous firm; ▪ It considers quality standards (poorly) & intellectual property of its outcomes (to great extent); ▪ Its structure is organic to respond to market and industry demand; ▪ It regards informally future business opportunities; ▪ It is based as an intensive resource & specialised supplier TBEs;	▪ It is placed between pseudo entrepreneurial & effective entrepreneurial firm; ▪ It regards informally future business opportunities; ▪ The adoption of a formal organisation provokes problems in meeting the industry and internal needs; ▪ It considers the intellectual property of its outcomes; ▪ It is based as intensive resource TBE; ▪ It produces innovation internally, but it uses suppliers to obtain certain technological elements;
Strategy level	▪ It focuses in differentiation; but, it also centres key actions in a cost strategy; ▪ It tends to manage physical activities, & not intellectual activities; ▪ The information is poorly used & not documented at all; ▪ Lost of information, time and cost; ▪ Design is used in a strategic manner to create an image & improve communication with the market;	▪ It focuses in differentiation; although, its structure aims to reduce costs and facilitate manufacture; ▪ The management of resources and personnel is considered in a day-to-day basis; ▪ Lost of information in the innovation process because there is not management of knowledge; ▪ It is aware of its abilities & capabilities; ▪ Design is used to reduce cost & in a limited extent to meet market needs. No design culture & awareness to use it efficiently;	▪ It focuses on differentiation; but, it also centres in the process development cost; ▪ No planning of physical & intellectual in the process development; ▪ It tends to manage physical activities, & not intellectual activities; ▪ Design is utilised to reduce cost & to satisfy the market. It is not used to trigger innovation or produce add value products;
Process level	**The case study did not evaluated the process level**	▪ It has to create a new radical product platform; ▪ Its team is organic & flexible to adapt to the requirements of each phase of the process; ▪ No management of intellectual activities; ▪ Design is used to reduce costs & not as a tool to generate innovation & increase its development;	▪ It has to create a new product platform; ▪ It is considered as a linear sequence of activities with a loop of feedback; ▪ Teams are multidisciplinary-open communication; ▪ No management of intellectual activities & documentation of physical & financial resources deployed in the NPD process; ▪ Design is used in the development phase, & prototype & model phase
Project level	▪ It plans all its activities in a sequential, parallel & associated manner; ▪ Use a multidisciplinary team; ▪ It does not manage innovation nor internalise the knowledge generated that leads them to expand the realm of their technology expertise; ▪ Design is used to improve (physically) its results, but it is poorly used;	**The case study did not evaluated the project level**	▪ It performs poorly; ▪ The team is flexible to develop creative & innovative activities; ▪ Basic management, documentation & communication of information & actions; ▪ Design brief considers basic requirements such as project vision, project needs, & delivery of results;
Product / service level	▪ It considers to a limited extent the basic & actual requirements & not at all the augmented & superior product elements;	▪ It considers to some extent all the basic & actual elements of the product/service, & it considers in a limited extent the augmented & superior product/service elements;	▪ It satisfies most of the basic & actual requirements of a product & it considers in a limited extent the augmented & superior product elements;

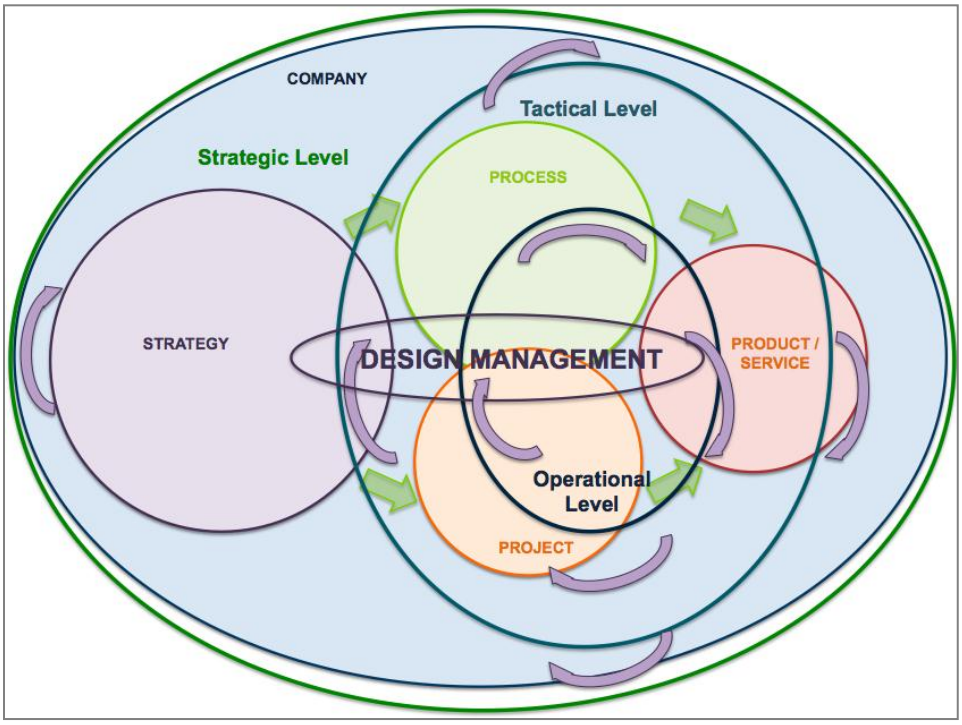
6.7.4 Design management implementation, use and integration

Design management implementation

The three small Mexican TBEs experienced an overlap in the three levels of decision. This means that the proximity of the general manager (strategic level) to the process and/or project level leads to embrace a general strategy in the adoption of activities. This suggests that the four key activities; planning, organising, implementation and monitoring, and evaluation, shows similarity at the three levels. Therefore, this provides the opportunity to implement design management actions at the three levels of the business; strategic, tactical and operational level. Design management, at the strategic level, could be used to define and set the basis of the business, and to direct the actions of the tactical level and operational level. At the tactical level, it could be utilised to align the general strategy with the needs of product/service development. Finally, these activities could be translated in actions at the operational level in which all the uncertainty and complexity pertains. Indeed, the operational activities represent the cornerstone of the business as its implementation and performance impacts the tactical and strategic level. Finally, it is important to establish a basic strategy to provide employees with a distinctive guideline that allows them to face any challenge in order to achieve their final aims.

Figure 6.20 presents the implementation of design management at the three levels of action. As it can be seen, the strategy produced flows through the definition of basic tactics in the process or/and project level. At this level, the tactics are translated in a series of actions that aim to fulfil the objectives established at the strategy. These actions become tangibles when the businesses obtain two-dimensional or tri-dimensional outcomes that can be introduced to the market to generate profits. Design management could support the delineation of strategies, tactics and actions during the development of new products and/services services. Therefore, design management could turn into a mean of communication that source the information from the strategy to the process and or project in order to achieve a desired product and/or service. Similarly, this role would impact and pertain from the activities of the operational level to the actions taken at the strategic level (purple arrows).

Figure 6.20 Design management implementation



Design management integration

Design management was integrated as a strategic tool in order to modulate the divergent and convergent cycles of innovation (Fig. 6.21). As well as, it is going to be integrated to transfer knowledge and information in a tangible outcome to satisfy the business requirements, customer needs and environmental demands. Design is integrated in this manner to reduce the current gap between the technological development and market (user) needs. This gap is also affected with the different specialised terms used by diverse areas involved in the technological development.

Figure 6.21 Design management integration

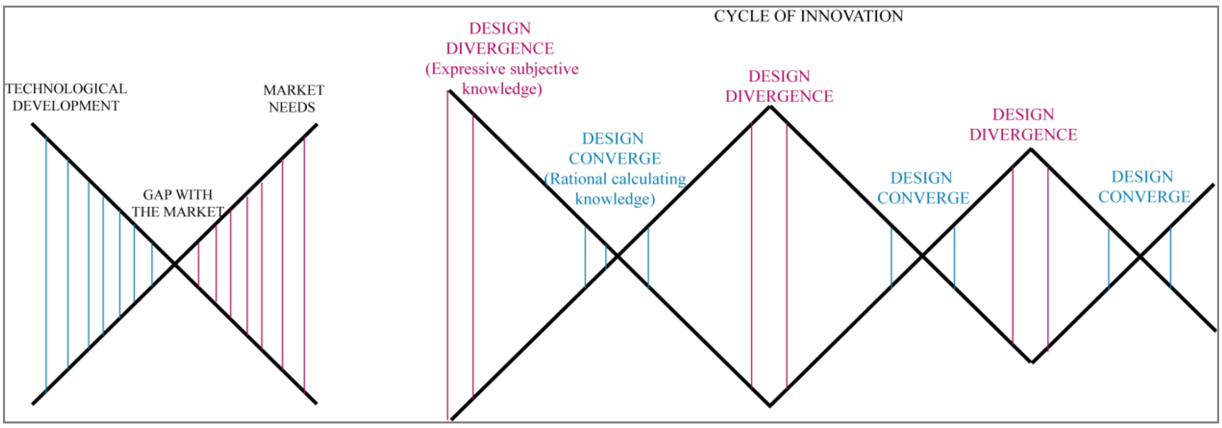
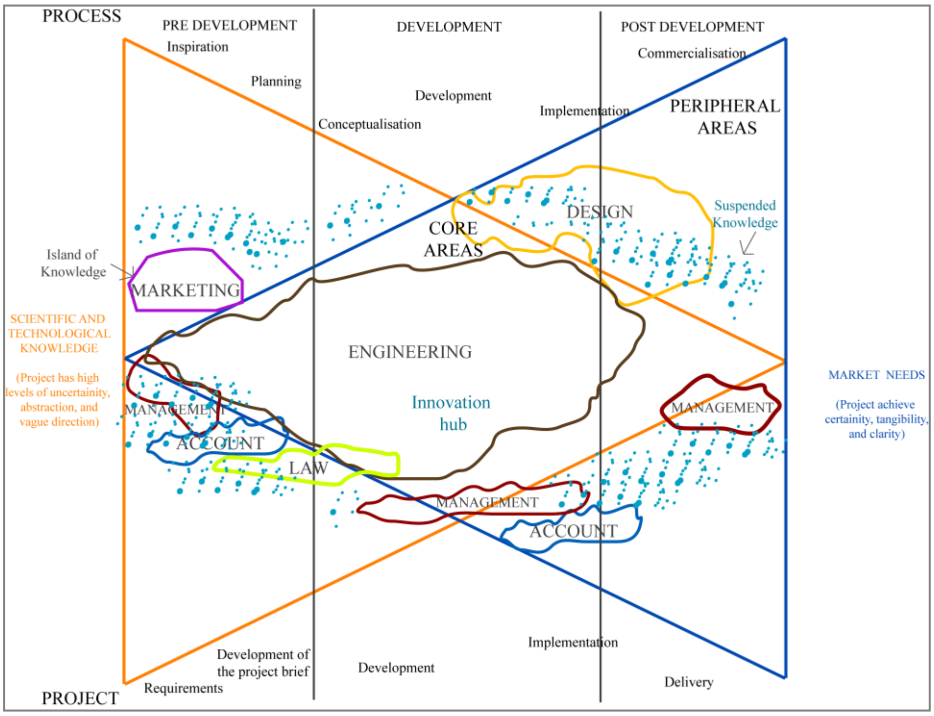


Figure 6.22 displays participation of the different areas within the technological development. Similarly, it presents the transition of the project from a scientific and technological knowledge basis to a more practical and tangible business approach. As can be seen, engineering is a core area in the innovation hub, and the other areas such as accounting, law, management, marketing and design are peripheral areas. They do not interrelate directly within the technological project, as they do not support the outcomes obtained from the different areas. There is suspended knowledge (blue spots) lost throughout process, as there are no means to capture and disseminate it. Design management can be integrated as lead area to manage the technological development (process/project) because it is ground under a multidisciplinary perspective. Designers from diverse backgrounds have different process of creation, but they share the use of methods, tools and techniques adapted from other areas such as management, engineering, ethnography, and marketing, among others. This implies that the use of this set of tools can help designers and non-designers to manage the complexity of the project or process. Similarly, these tools can trigger the expertise of employees in the way they create, develop and produce ideas and solutions, and transform this knowledge produced in sensible information that can be communicated among employees to generate a final outcome.

Figure 6.22 Design implementation in the technological development



Design management use

Design management was used as a means to implement, collect and translate the knowledge produced from the methods, techniques and tools provided to the cases. These aim to trigger the creative and rational thinking of employees in order to generate better solutions in their developments. These sets of tools are going to be used to collect the information produced and to translate it into a language that is understandable for all employees. This implies that the use of design management in this manner aims to trigger a new way of thinking and to link it with new configuration to lead the business. It represents the bridge between the different areas, levels, way of thinking and leading. Therefore, the design tools implemented are going to help to implement actions in the short, medium and long-term.

Figure 6.23 Design management use

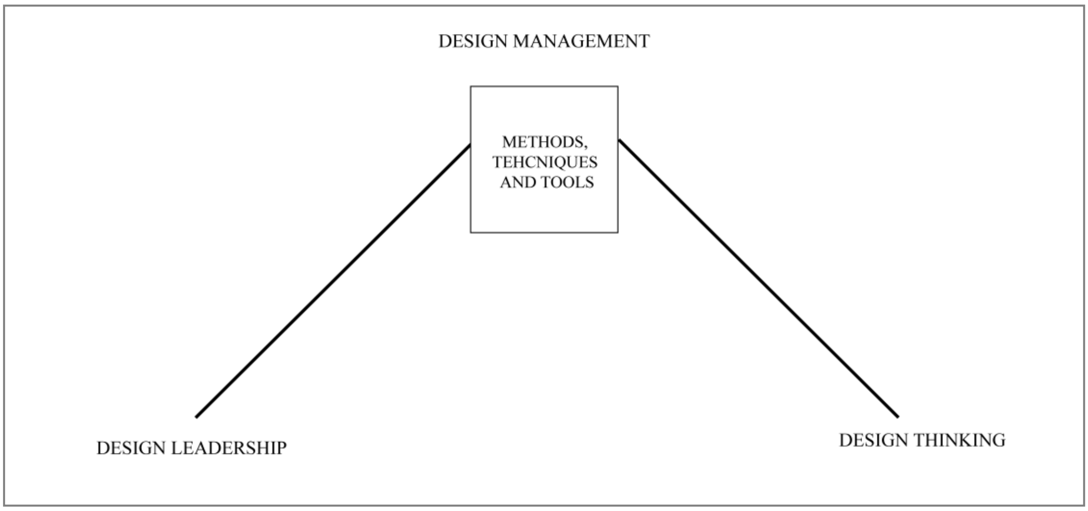


Table 6.17 presents the actions considered to improve the performance of the overall business. These actions are represented by a series of methods, techniques and tools that were aimed to help in the planning, organising, implementation and monitoring, and evaluation of the business activities.

Table 6.17 Tools, techniques and methods used to improve the case studies

Level of impact	Tool, technique and methods		Field of study
Short-term	Task analysis; Design brief; Alpha/beta analysis; Post implementation review; Product analysis; Estimating time accurately; Ranking and weighting; Problem abstraction; Marketing plan	Project brief; Gantt chart; Action plan; QFD; Project initiation; Project budget; Benchmarking; Selecting criteria;	Marketing Design Management Engineering
Medium-term	Logical framework approach; Critical path analysis; Product architecture; System engineering; Material and process selection; Morphological chart; Request for proposal documents;	Distribution; Project planning; Value analysis; Web analysis; Advertising; Service analysis	Marketing Design Management Engineering
Long-term	Corporative identity Cost/benefit diagram; Planning cycle; Risk plan; Failure modes and effect analysis Sustainable product development; Product feature permutation	Cause/effect diagram; Decision tree analysis; Life cycle analysis; System testing; Product development process;	Marketing Design Management Engineering

6.8 Research question 3

This section provides the evidence collected throughout the research in order to answer the main research question: ‘*Do small Mexican technology-based enterprises in new technology industries improve their performance using design management within their activities?*’. Consequently, it is possible to reveal whether design management can enhance the performance of the three small Mexican TBEs in new technological industries explored. Thus, the results need to be summarised in order to present the different levels assessed: company, strategy, process, project, product/service and culture. The results are presented using two techniques: descriptive diagrams and T-Test tables.

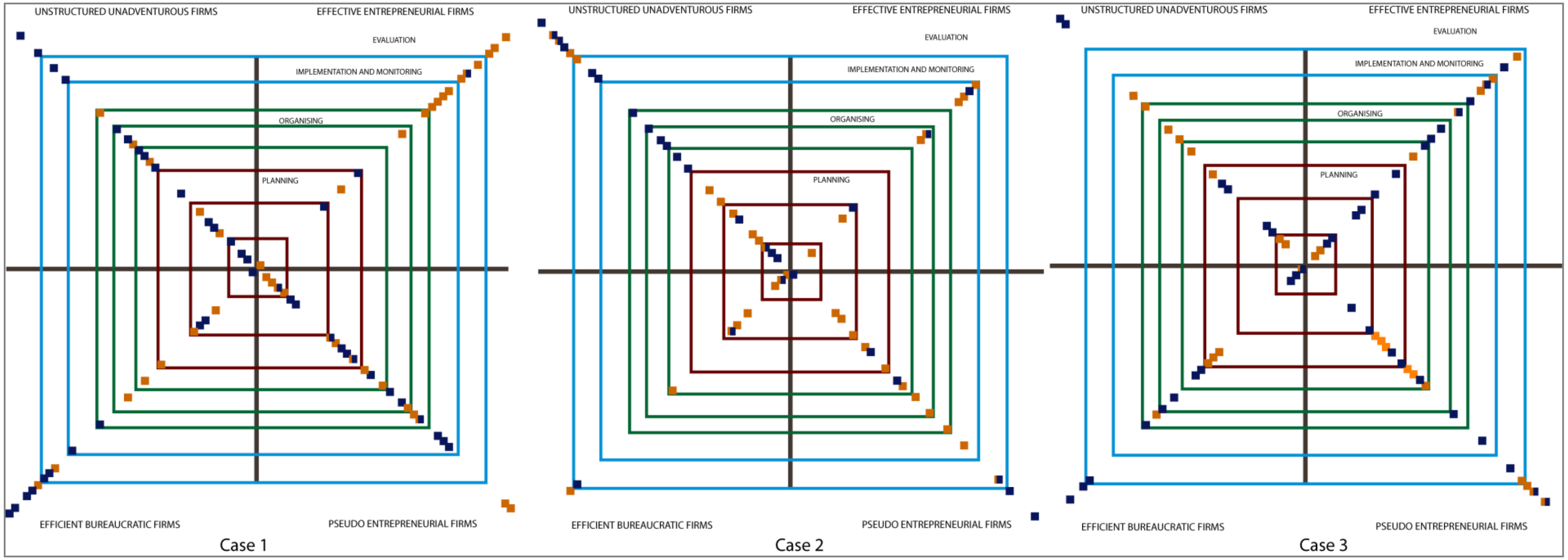
6.8.1 Company level

Organisational structure and management style

Figure 6.24 shows that the three cases have experienced modifications in their organisational structure and management style. Case 1, has undergone a formalisation on its structure and management style. In the pre-measure evaluation, the firm was positioned as an effective entrepreneurial and pseudo entrepreneurial business. However, after 6-7 months, it formalises the activities and roles of employees in order to use effectively its financial and human resources. In addition, the firm started to consider quality standards and environmental norms on its activities and outcomes. Another significant change was reported on the planning of corporative activities and the consideration of both types of resources financial and human. Unfortunately, the company remains centralising its decision-making at the corporate level and controlling the actions of its employees. Both actions inhibit the motivation and commitment of the employees. Similarly, employees are still having problems in the communication and documentation of information, as they have not been able to develop an efficient system of communication that lets them to provide information about the project performance.

Case 2, encountered in a different manner the transition of the business and the effects of the external environment. Hence, the firm embraces a formalisation of key aspects such as management of resources, plan in general actions, organise the resources and people, implement means of communication and documentation, and evaluate activities and outcomes. These actions did not affect either the organic structure of the business or the working environment. The organisation created a semi-formal information system empowering employees to take decisions in order to become more proactive in the development of activities. It is also used to embrace a new form of conceiving the business, as the financial crisis initiated the close of the office but not of its operation. However, its major problem remains on the dependency of financial resources from governmental programs, investors and family loans.

Figure 6.24 Pre-measurement and post-measurement evaluation of the organisational structure and management style



The orange squares colours represent the pre-measurement results;

The blue squares colours represent the post-measurement results;

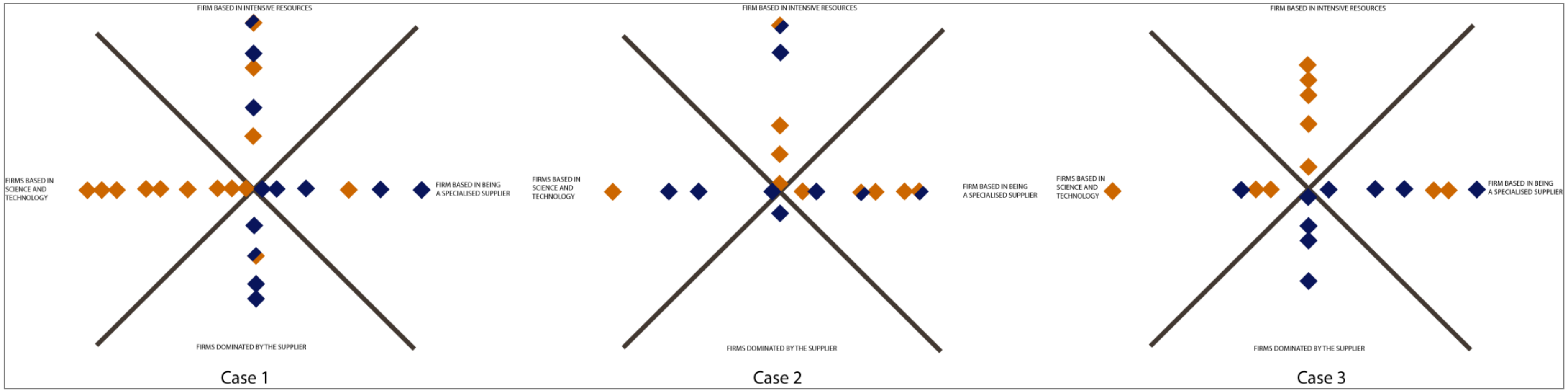
Case 3, continues with the formalisation of its activities through the establishment of an internal system of information. It considers all the areas in the development phase and the production phase. A specialist was internally hired to develop the system to document all the information produced at the operational level. The enterprise starts to consider quality and environmental standards during the development and the outcome. Unfortunately, the financial crisis combined with poor management decisions provoked the firm to halt technological development. This enabled the organisation to adopt again an organic structure, as more than half of its personnel were fired. Thus, the more experienced employees were required to undertake multiple tasks. Finally, the enterprise continues to be dependent on angel investors and governmental support to continue with its operations.

Taxonomy of technology based enterprises

Case 1 was placed in the pre-measurement as an enterprise based in science and technology, but the result obtained from the post-measurement shows that has been directed its efforts to become a specialised supplier (Fig. 6.25). The enterprise redefined its taxonomy as it discovered that it does not have the financial resources and expertise to rely its business in continual and intensive development of scientific and technological innovations. Therefore, it decided to direct its efforts to produce a series of innovations focused on specific niche markets and to develop innovation with lower intensity. This refers that the development of technological innovation has became a second priority activity in the business.

Similarly, Case 2 changed from specialised supplier to a business focused on the intensive use of resources in the generation of innovation (Fig. 6.25). The organisation recognised that it has the expertise to produce innovation either in the product/service or process. They realise that the business was able to offer a wide range of services (specialised in process); meanwhile, another employees could develop new products/services. Thus, the firm set the conditions to direct its efforts to support the new taxonomy adopted.

Figure 6.25 Pre-measurement and post-measurement evaluation of the taxonomy of technology-based enterprises



The orange rhombus shape colours represent the pre-measurement results;

The blue rhombus shape colours represent the post-measurement results

The taxonomy of case 3 was affected by the financial problems encountered during the last six-to-seven months of the study. The reduction of employees caused that the firm directed its investment to use suppliers to solve some of the activities that cannot be undertaken within the business (Fig. 6.25). The firm decided to embrace the taxonomy of a specialised supplier rather than focus on the intensive use of technology and science developments for the lack of resources, and abilities and capabilities.

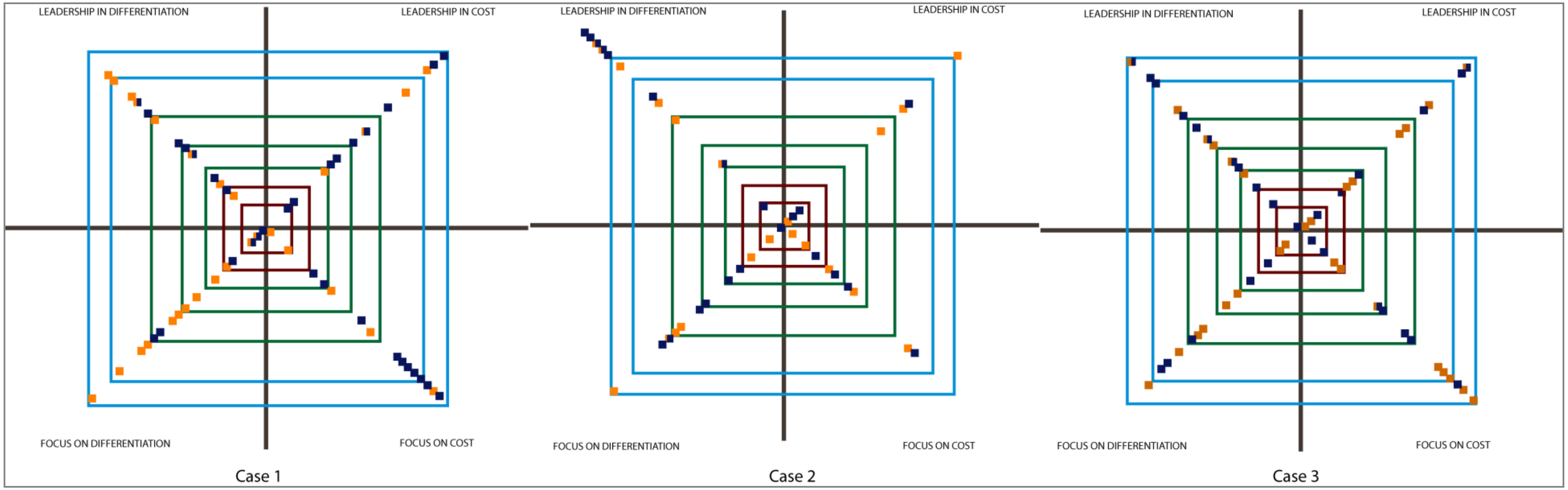
6.8.2 Strategic level

Generic strategy

Case 1 considered in the pre-measurement study a strategy centred on differentiation (leadership and focus) and then it adopted a strategy based on cost in the post-measurement phase (Fig. 6.26). This decision was contemplated after the financial crisis experienced in the world economic market, as many of its customers were not able to pay for its services and products. Its technological developments are based on differentiation strategies, as the products/service prices are premium. Nevertheless, these are positioned in a market that is not able and willing to pay such prices. Therefore, the new strategy concerns offering a product that is suitable on its cost to the market without reducing the product quality and performance.

Case 2 has strength its strategy, as in the pre-measurement and post-measurement analysis the organisation focuses to compete through the differentiation of its products and services (Fig. 6.26). The firm is investing on producing products/services with high technical quality, precision and performance. Similarly, it has been injecting financial resources to the creation of trustworthiness and reputation on the company, the brand and the product. This is due to this market is led by international companies that have considerable experience in the medical field. This refers that the strategy has to enhance the technological quality and to reduce production cost to compete in the national market without affecting the trustworthiness and reputation of the company.

Figure 6.26 Pre-measurement and post-measurement evaluation of the generic strategies



The orange squares colours represent the pre-measurement results;

The blue squares colours represent the post-measurement results

Case 3 adopted a complex strategy in the pre-measurement and post-measurement evaluation because the product was focused on differentiation and cost (Fig. 6.26). This was in order to offer a unique product in the market. This implies that the business aimed to minimise cost at the operational activities without sacrificing quality and performance of the product. The firm adopted differentiation as an external strategy to position the product, and reduction of financial resources and time as internal strategy to have financial resources to finish the project. Thus, it embraced different actions to minimise the cost such as the adoption of an information system that helps to communicate the advances to all the employees and document in a standardised manner the actions developed for each area and phase.

Innovation and design

Table 6.18 presents the summary of results form the pre-measurement and post-measurement study. The results display were obtained through T-test, as it assesses whether the means of two groups of results area statistically different from each other. Indeed, this analysis was considered the most appropriate to compare the means of the results from the pre-measurement and post-measurement assessment of the pre-experiment. In this study, the researcher used the statistic package SPSS to obtain the T-value. Then, it was possible to test the T-value against the table of significance in order to explore whether the ratio is large enough to say that the difference between the two set of results is not likely to have been a chance finding. To test the significance, it was set an alpha level (risk level) of .05, as it is widely used in social science research. It was also determined the degrees of freedom (df) for the test. Thus, given the alpha level, the df, and the T-test, it is possible to look the T-value up in a standard table of significance to determine whether the T-value is large enough to be significant. If it is, it can be concluded that the difference between the means of the two groups of results is different, even given the variability. In addition, the researcher regarded in the analysis the percentage of the answers obtained in the items of each sub-theme of the design toolkit evaluation ('diagnostic framework').

Table 6.18 Pre-measurement and post-measurement evaluation of innovation and design

Level of evaluation	Case 1		Case 2		Case 3	
	Pre-measure	Post-measure	Pre-measure	Post-measure	Pre-measure	Post-measure
Innovation	5 – 36.4% 4 – 27.3% 3 – 24.2% 2 – 3% 1 – 9.1%	5 – 18.2% 4 – 21.2% 3 – 18.2 2 – 3% 1 – 39.4%	5 – 4.5% 4 – 31.9% 3 – 27.3% 2 – 0% 1 – 36.3%	5 – 31.8% 4 – 9% 3 – 13.6% 2 – 9% 1 – 13.6%	5 – 36.4% 4 – 18.2% 3 – 31.8% 2 – 4.5% 1 – 9.1%	5 – 9.1% 4 – 18.2% 3 – 0 2 – 9.1% 1 – 63.6%
	T= 0 By conventional criteria, this difference is considered to be not statistically significant		**T= .4613** By conventional criteria, this difference is considered to be not statistically significant		**T= 0** By conventional criteria, this difference is considered to be not statistically significant	
Design	5 – 30% 4 – 3.3% 3 – 26.7% 2 – 0% 1 – 40%	5 – 18.3% 4 – 20% 3 – 21.7% 2 – 6.7% 1 – 33.3%	5 – 10% 4 – 20% 3 – 40% 2 – 0% 1 – 30%	5 – 10% 4 – 20% 3 – 30% 2 – 12.5% 1 – 27.5%	5 – 30% 4 – 5% 3 – 15% 2 – 20% 1 – 30%	5 – 5% 4 – 35% 3 – 25% 2 – 5% 1 – 30%
	T= 3.7947 By conventional criteria, this difference is considered to be statistically significant		**T= 1.8856** By conventional criteria, this difference is considered to be not quite statistically significant		**T= .9670** By conventional criteria, this difference is considered to be not statistically significant	

Table 6.18 shows that the only statistically significant difference was the one experienced by Case 1 in the design level. Contrary, the general results obtained from the innovation section emphasises that the businesses have been reducing investment in innovative activities. This behaviour may be understandable as the organisations have completed their technological developments and they are currently more concerned with solving technical and operational activities. This implies that the highest levels on innovation within a business are centred on the early stages of the technological innovation development (divergent stage). These innovative activities decreased when the company concluded its technological development and it is required to start the implementation and development of the outcome. Indeed, this transition requires innovation, but it is used in a different manner (convergent stage) by the employees, as the main concern is minimising the knowledge and information to produce tangible outcomes.

Regarding cases 1 and 2, they presented positive and high results on the use of design and its business performance in the pre-measurement phase. Nevertheless, evidence from the case studies reduced the bias of employees in the assessment, as they were not fully aware about the scope of design and the variety of actions that it can influence. This implies that its use was merely basic and in some instances inadequate. Nevertheless, in the post-measurement study, both businesses embraced the design strategy along with the generic strategy. Likewise, they embrace the use of design techniques, methods and tools in certain actions of the company such as triggering of ideas, organising, implementation and monitoring, and evaluation. Case 3 regarded design strategy not of main importance for the business, as its development focus at the tactical and operational level. Therefore, they use primarily design techniques, tools, and methods in three actions, planning, organising, and evaluation procedures.

6.8.3 Process level

The results of the T-Test (Table 6.19) show that both cases encounter minimal improvements at the process level. Case 2 has experienced a decline on the performance of the planning level because external designers were responsible on developing the final prototype. Thus, the general manager did not consider the planning of activities, as there were any activities in the process level. Similarly, the activities of organising and implementation and monitoring were affected for the lack of activities in the general process. The firm has been experiencing an improvement in the management of cost, employees, material, and knowledge produced. Likewise, the communication has advanced, as employees established a semi-formal system to document the evolution of the process. The firm had statistically significant changes in the evaluation level, as it became aware about the assessment of different elements such as financial resources, production, distribution, disposal, and recycle. Finally, the changes on design were not statistically significant, but employees are now able to adopt design at the different phases of the process, consider standards of design performance, product disposal and product recycling. This means that the firm wide its design scope at the process level because it is no longer embraced just as an activity of the process. But, it has become a part of the multidisciplinary team that formulates the strategy and develop the process.

Table 6.19 Pre-measurement and post-measurement evaluation of the process section

Level of evaluation	Case 2		Case 3	
	Pre-measure	Post-measure	Pre-measure	Post-measure
Planning	5 - 7.6% 4 - 50% 3 - 15.4% 2 - 0% 1 - 27%	5 – 15.38% 4 – 12% 3 – 3.84% 2 – 3.84% 1 – 65.38%	5 – 2.5% 4 – 19.2% 3 – 29.5% 2 – 3.9% 1 – 44.9%	5 – 12.3% 4 – 23.1% 3 – 4.6% 2 – 20% 1 – 40%
	T=2.3788 By conventional criteria, this difference is considered to be statistically significant		**T=.5724** By conventional criteria, this difference is considered to be not statistically significant	
Organising	5 – 0% 4 – 36.7% 3 – 0% 2 – 6.7% 1 – 56.66%	5 – 6.7% 4 – 6.7% 3 – 6.7% 2 – 6.7% 1 – 73.2%	5 – 2.2% 4 – 12.2% 3 – 16.7% 2 - 10% 1 – 58.9%	5 – 14.7% 4 – 22.6% 3 – 14.7% 2 – 20% 1 – 28%
	T=1.494 By conventional criteria, this difference is considered to be not statistically significant		**T=3.7990** By conventional criteria, this difference is considered to be very statistically significant	
Implementation and monitoring	5 – 19% 4 – 25.8% 3 – 4.8% 2 – 7% 1 – 45.4%	5 – 11.9% 4 – 9.5% 3 – 0% 2 – 19.1% 1 – 59.5%	5 – 15.9% 4 – 19.1% 3 – 12.7% 2 – 7.9% 1 – 44.4%	5 – 18.1% 4 – 14.3% 3 – 12.4% 2 – 21.9% 1 – 33.3%
	T=1.957 By conventional criteria, this difference is considered to be not quite statistically significant		**T=.2721** By conventional criteria, this difference is considered to be not statistically significant	
Evaluation	5 – 5.6% 4 – 22.2% 3 – 16.7% 2 – 11.1% 1 – 44.4%	5 – 33.3% 4 – 11.1% 3 – 5.6% 2 – 22.2% 1 – 27.8%	5 – 12.9% 4 – 22.2% 3 – 14.8% 2 – 5.6% 1 – 14.5%	5 – 8.9% 4 – 11.1% 3 – 13.3% 2 – 20% 1 – 46.7%
	T=1.9338 By conventional criteria, this difference is considered to be statistically significant		**T=.2610** By conventional criteria, this difference is considered to be not statistically significant	
Design	5 – 23.8% 4 – 10.5% 3 – 10.5% 2 – 2.6% 1 – 52.6%	5 – 11.9% 4 – 23.8% 3 – 11.9% 2 – 14.3% 1 – 38.1%	5 – 14.9% 4 – 8.8% 3 - 1.8% 2 – 3.5% 1 - 71%	5 – 18.1% 4 – 9.5% 3 – 9.5% 2 – 8.6% 1 – 54.3%
	T=.1403 By conventional criteria, this difference is considered to be not quite statistically significant		**T=1.1048** By conventional criteria, this difference is considered to be not statistically significant	

Case 3 has improved its planning but it is not statistically significant. Nevertheless, employees are now aware to consider physical and intellectual activities, and available capabilities and abilities on its planning. Consequently, this consciousness is reflected in the significant improvement in the organising level. The firm now is able to manage the cost of each employee, equipment, services, waste generated, and knowledge and information produced. Thus, employees are able to manage innovation and use this knowledge and information for future projects. The documentation section experienced minor changes, even though the firm is implementing an information system to document and to communicate in standardised manner the firm actions. The evaluation level has not illustrated further improvements on its performance. Finally, employees embraced design in a major number of phases of the process. As well, the designers integrated the follow elements on their activities: definition of design standards, alignments with other functional areas and consideration of the product disposal and recycling.

6.8.4 Project level

Cases 1 and 3 experienced subtle changes on the performance of the project (Table 6.20). Case 1 has a regression on the planning of projects, as the activities that used to consider to a greater extent now are considered to some extent such as milestones dates for the project revision and project brief. The operational manager made progress on the organisation of human activities and the establishment of an environment to encourage employees to be creative, facilitate participation with other areas, and produce innovation. In turn, the implementation and monitoring level has not suffered significant changes. Contrary, the evaluation level encountered an extremely significant change on its performance. The team now evaluates the results against the objectives, budget, and performance of employees. Similarly, design has suffered an extreme significant change, as employees that are no designers integrated in their expertise the development of design briefs and the ability to select designers for a project.

Case 3 had not improved in its planning level, on the contrary it had a regression in the consideration of different elements such as the planning of a project brief and project deliverables. Nevertheless, there is an extremely statistically significant difference in the results at the organising level. The different project managers have promoted a more creative environment and consider flexible teams in order to provide more innovations. Similarly, the implementation and monitoring level has very statistically significant difference between the first and the second evaluation. The organisation becomes less dependent of the need for training in the project management. As well as, employees are more aware to document the budget for each phase of the project and to provide feedback to employees. Finally, the evaluation level and design have no statistically significant differences. Although, some improvements were embraced by designers, such as development of procedures for selecting designers, definition of competencies for the project, and involvement in technological transference.

Table 6.20 Pre-measurement and post-measurement evaluation of project section

Level of evaluation	Case 1		Case 3	
	Pre-measure	Post-measure	Pre-measure	Post-measure
Planning	5 - 100% 4 - 0% 3 - 0% 2 - 0% 1 - 0%	5 – 62.5% 4 – 25% 3 – 12.5% 2 – 0% 1 – 0%	5 – 41.7% 4 – 0% 3 – 0% 2 – 8.3% 1 – 50%	5 – 0% 4 – 8.3% 3 – 16.7% 2 – 58.3% 1 – 16.7%
	T=2.4495 By conventional criteria, this difference is considered to be not quite statistically significant		**T=1.3278** By conventional criteria, this difference is considered to be not statistically significant	
Organising	5 – 46.6% 4 – 40% 3 – 6.7% 2 – 0% 1 – 6.7%	5 – 53.4% 4 – 30% 3 – 3.3% 2 – 10% 1 – 3.3%	5 – 6.7% 4 – 4.4% 3 – 6.7% 2 – 22.2% 1 – 60%	5 – 13.3% 4 – 17.8% 3 – 13.3% 2 – 37.8% 1 –17.8%
	T=.4004 By conventional criteria, this difference is considered to be not statistically significant		**T=4.5372** By conventional criteria, this difference is considered to be extremely statistically significant	
Implementation and monitoring	5 – 63.3% 4 – 22.8% 3 – 4.6% 2 – 9.3% 1 – 0%	5 – 68.2% 4 – 13.6% 3 – 9.1% 2 – 0% 1 – 9.1%	5 – 9% 4 – 9% 3 – 6% 2 – 9% 1 – 67%	5 – 11.1% 4 – 16.7% 3 – 33.3% 2 – 36.1% 1 – 2.8%
	T=0 By conventional criteria, this difference is considered to be not quite statistically significant		**T=4.3297** By conventional criteria, this difference is considered to be very statistically significant	
Evaluation	5 – 30% 4 – 10% 3 – 20% 2 – 0% 1 – 40%	5 – 80% 4 – 20% 3 – 0% 2 – 0% 1 – 0%	5 – 26.6% 4 – 0% 3 – 6.7% 2 – 0% 1 – 66.7%	5 – 20% 4 – 13.4% 3 – 6.7% 2 – 40% 1 – 20%
	T=6.9378 By conventional criteria, this difference is considered to be extremely statistically significant		**T=.4950** By conventional criteria, this difference is considered to be not statistically significant	
Design	5 – 16.7% 4 – 12.5% 3 – 0% 2 – 0% 1 – 70.8%	5 – 66.6% 4 – 25% 3 – 4.2% 2 – 4.2% 1 – 0%	5 – 8.3 % 4 – 11.1% 3 – 2.8% 2 – 2.8% 1 - 75%	5 – 12.1% 4 – 12.1% 3 – 9.1% 2 – 15.2% 1 – 51.5%
	T=5.3803 By conventional criteria, this difference is considered to be extremely statistically significant		**T=2.0742** By conventional criteria, this difference is considered to be not quite statistically significant	

6.8.5 Product/service level

As can be seen from the Table 6.21, Case 1 and Case 3 reported and extremely and very statistically significant differences on their T-tests. Case 1 had strength in its product/service at the basic level and actual level, as it had considered to some extent elements such as functionality, utility, physical attributes, user needs, and technical quality (section 6.6.4). Similarly, they regarded elements of the augmented level and superior level such as warranty, graphic and brand identity, interface with the user, emotional response and pleasant appearance.

Table 6.21 Pre-measurement and post-measurement evaluation of product/service section

Product/service level	Case 1		Case 2		Case 3	
	Pre-measure	Post-measure	Pre-measure	Post-measure	Pre-measure	Post-measure
Basic level	5 – 41.6% 4 – 0% 3 – 8.4% 2 – 8.4% 1 – 41.6%	5 – 80% 4 – 20% 3 – 0% 2 – 0% 1 – 0%	5 – 25% 4 – 50% 3 – 12.5% 2 – 12.5% 1 – 0%	5 – 25% 4 – 50% 3 – 12.5% 2 – 12.5% 1 – 0%	5 – 66.6% 4 – 16.7% 3 – 0% 2 – 0% 1 – 16.7%	5 – 75% 4 – 16.7% 3 – 8.3% 2 – 0% 1 – 0%
Actual level	5 – 27.8% 4 – 0% 3 – 5.5% 2 – 5.5% 1 – 61.2%	5 – 44.4% 4 – 11.1% 3 – 11.1% 2 – 16.7% 1 – 16.7%	5 – 25% 4 – 41.6% 3 – 16.7% 2 – 0% 1 – 16.7%	5 – 33.4% 4 – 41.7% 3 – 8.3% 2 – 8.3% 1 – 8.3%	5 – 16.7% 4 – 22.3% 3 – 66.6% 2 – 11.1% 1 – 5.3%	5 – 50% 4 – 22.2% 3 – 27.8% 2 – 0% 1 – 0%
Augmented level	5 – 16.7% 4 – 0% 3 – 0% 2 – 0% 1 – 83.3%	5 – 33.3% 4 – 0% 3 – 25% 2 – 8.4% 1 – 33.3%	5 – 37.5% 4 – 12.5% 3 – 0% 2 – 0% 1 – 50%	5 – 37.5% 4 – 0% 3 – 12.5% 2 – 0% 1 – 50%	5 – 0% 4 – 8.3% 3 – 25% 2 – 16.7% 1 – 50%	5 – 41.7% 4 – 25% 3 – 8.3% 2 – 8.3% 1 – 16.7%
Superior level	5 – 8.3% 4 – 16.7% 3 – 0% 2 – 0% 1 – 75%	5 – 33.4% 4 – 8.3% 3 – 0% 2 – 8.3% 1 – 50%	5 – 12.5% 4 – 37.5% 3 – 0% 2 – 12.5% 1 – 37.5%	5 – 37.5% 4 – 0% 3 – 12.5% 2 – 12.5% 1 – 37.5%	5 – 8.3% 4 – 41.7% 3 – 50% 2 – 0% 1 – 0%	5 – 58.4% 4 – 8.3% 3 – 8.3% 2 – 0% 1 – 0%
T-test	**T=4.0364** By conventional criteria, this difference is considered to be extremely statistically significant		**T=.1693** By conventional criteria, this difference is considered to be not statistically significant		**T=3.4981** By conventional criteria, this difference is considered to be very statistically significant	

In Case 2, there was no significant difference between the pre-measurement and post-measurement evaluation. This is mainly because the company had positively satisfied most of the elements from the basic, actual and augmented level. Thus, the elements that have been not adequately faced are because its implementation requires strategies at the medium and long-term. However, there is evidence to show that the firm is investing on elements such as brand identity, emotional response, warranty, after sale service and interface with the user.

Case 3 showed a significant difference between the pre-measurement and post-measurement condition. The case improved to greater extent the basic elements such as functionality, utility and physical attributes. Then, it enhances to some extent elements like user need, user-centred, technical quality and durability. It also considered the elements at the augmented product such as instruction, warranty, after sale service, and graphic and brand identity. Finally, the product had a good performance in elements such as interface with the user, emotional response and pleasant appearance at the superior level.

6.8.6 Culture level

Table 6.22 presents quite revealing set of results. First, Case 1 had a statistically significant difference in the general culture of the organisation. However, the results obtained from culture for design did not have a statistically significant difference. It is possible that the use of external designers did not trigger a culture for design among non-designer employees because it is not integrated on a day-to-day basis. Second, Case 2 exhibits very statistically significant variations on the results in culture and culture for design. This case hired external designers similarly to Case 1, but its results for design are positive. The evidence obtained from the case study and post-interview shows that non-designer employees embraced design as a way of thinking through the utilization of different tools, methods and techniques. Non-designers now develop strategies and tactics through a design perspective. Finally, Case 3 had very statistically significant variance in the culture for design, but its evaluation in culture was considered not statistically significant. This result is interesting because this case study has an in-house design department that interacts in day-to-day activities at process and project levels. Evidence points out that employees that are no-designers became aware about design and how it interacts with their areas. In this case, designers are responsible for design implementation.

Table 6.22 Pre-measurement and post-measurement evaluation of the culture section

<table>
<tr><th rowspan="2">Culture level</th><th colspan="2">Case 1</th><th colspan="2">Case 2</th><th colspan="2">Case 3</th></tr>
<tr><th>Pre-measure</th><th>Post-measure</th><th>Pre-measure</th><th>Post-measure</th><th>Pre-measure</th><th>Post-measure</th></tr>
<tr><td rowspan="2">Culture</td><td>5 – 0%
4 – 14.2%
3 – 67.9%
2 – 17.9%
1 – 0%</td><td>5 – 30.8%
4 – 44.2%
3 – 3.8%
2 – 0%
1 – 21.2%</td><td>5 – 0%
4 – 21.4%
3 – 39.3%
2 – 25%
1 – 14.3%</td><td>5 – 42.9%
4 – 14.3%
3 – 14.3%
2 – 17.9%
1 – 10.6%</td><td>5 – 8.6%
4 – 42.9%
3 – 28.6%
2 – 12.9%
1 – 7%</td><td>5 – 28.6%
4 – 8.6%
3 – 18.6%
2 – 22.9%
1 – 21.3%</td></tr>
<tr><td colspan="2">T=2.6645 By conventional criteria, this difference is considered to be statistically significant</td><td colspan="2">T=3.705 By conventional criteria, this difference is considered to be very statistically significant</td><td colspan="2">T=1.586 By conventional criteria, this difference is considered to be no statistically significant</td></tr>
<tr><td rowspan="2">Culture for design</td><td>5 – 0%
4 – 0%
3 – 68.8%
2 – 12.4%
1 – 18.8%</td><td>5 – 21.9%
4 – 34.4%
3 – 3.1%
2 – 3.1%
1 – 37.5%</td><td>5 – 0%
4 – 42.9%
3 – 21.4%
2 – 0%
1 – 35.7%</td><td>5 – 28.6%
4 – 35.7%
3 – 14.3%
2 – 14.3%
1 – 7.1%</td><td>5 – 14.3%
4 – 25.6%
3 – 22.9%
2 – 14.3%
1 – 22.9%</td><td>5 – 8.6%
4 – 8.6%
3 – 20%
2 – 8.6%
1 – 54.2%</td></tr>
<tr><td colspan="2">T=2.0544 By conventional criteria, this difference is considered to be not statistically significant</td><td colspan="2">T=4.5962 By conventional criteria, this difference is considered to be very statistically significant</td><td colspan="2">T=4.0330 By conventional criteria, this difference is considered to be very statistically significant</td></tr>
</table>

Table 6.23 shows the summary of improvements obtained of the design implementation. Indeed, there are different external and internal factors that could affect the improvement of the company. However, the researcher had a detailed record of the internal modifications of the firm and external changes (section 5.3.3). In summary, the implementation of design techniques, tools and methods help designers and non-designers to become aware about the relevance of the outcome obtained from the physical and intellectual activities. Design was implemented in short-term actions at the operational level in order to influence the outcome (product/service), the tactical level and subsequently the strategic level. Thus, design has an effect on the culture of design and in the general culture of the organisation.

The results presented in this section highlighted the overlapping of actions at the three levels of action of the business, operational, tactical and strategic level. This is due to the division among the different areas is blur in this type of businesses. It was also interesting to observe that design management not just transformed the organisation, but the organisation modified it into a transformative and hybrid expertise that not just focuses on design but it is able to have a more holistic approach supporting other areas. It can be concluded that design had impacted positively on culture (culture for design), product/service, and few operational actions within the three small Mexican TBEs in new technological areas.

Table 6.23 Summary of the improvements obtained from the pre-measurement and post-measurement evaluation

Level of evaluation	Finding
Company level	Change on the delineation of the strategic decision of the enterprise; Awareness of the available capabilities and abilities to develop certain activities; Develop environmental conditions to direct efforts to support the taxonomy of TBEs;
Strategic level	Awareness about the strategic decision of the business; Design become an active participant area in the strategic decision because non- designers use it to think strategically;
Process level	The organisation of activities were improved, as now are considered physical and intellectual activities (case 3); Improvements in the evaluation of financial resources, production, distributions, product disposal and recycle (case 2);
Project level	**Case 1** The team evaluates the objective, budget and performance of employees to reduce costs and to be more efficient in the project development; Non-designers integrated in their expertise the development of design briefs and the ability to select designers; **Case 3** Organising- It was promoted a more creative environment and it was considered flexible teams to generate major number of innovations; Implementation and monitoring- Employees document the budget for each phase of the project and provide feedback to employees; Design- Designers define the necessaries competencies for the project, but above all to demonstrate that they can participate on the technological transference;
Product/service level	There was an improvement in the implementation of basic and actual requirements. As well as, there was more acknowledge about the elements of the augmented and superior level
Culture level	Two companies experienced significant differences in the general culture of the business (case 1 and 2); Likewise there was a very significant modification in culture for design (case 2 and 3);

6.9 Conclusions

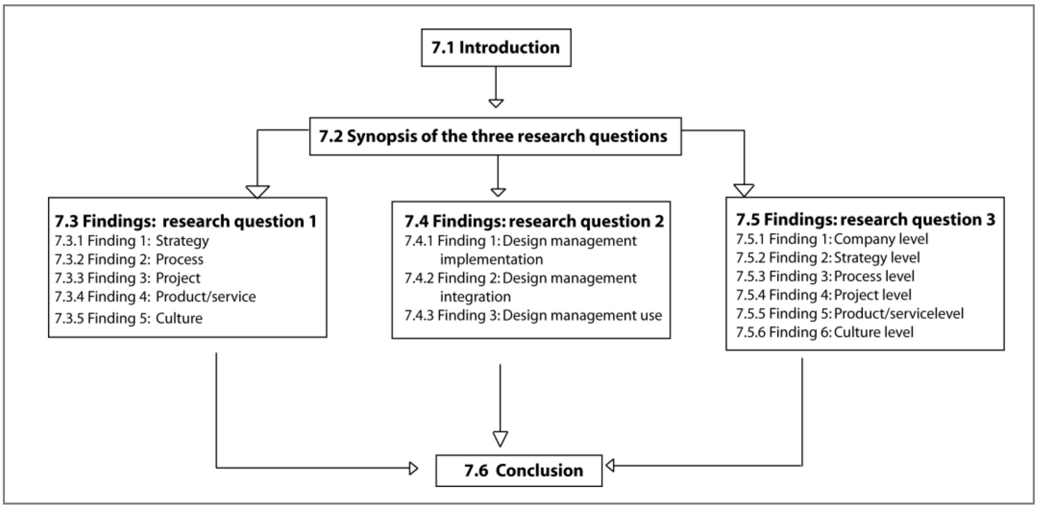
This chapter provided a detailed analysis of data collected from the case studies in order to answer the three research questions that give life to this research. This section started with a review of the design toolkit, then it considered the terms and codes of the data utilised in this research. Afterward, the researcher presented a concise account of the cases and their respondents. Then, it reviewed the first research question, which aimed to provide awareness about the consideration of design within the three case studies. Subsequently, it explored the second question that focused on the overall assessment of the firm's condition to produce a series of modifications. Finally, it addressed the main research question through the analysis of the pre-measurement and post-measurement evaluation. Chapter 7 presents the discussion of results and their implication in the research area. Therefore, it is important to compare and contrast the findings of the study with literature reviewed (chapter 2) in order to outline any implication of this research.

CHAPTER 7.0 DISCUSSION

7.1 Introduction

The following section examines the findings produced from the three research questions. It also compares and contrasts the study's findings with the literature reviewed (chapter 2) in order to outline the implications of this research. This leads to understand whether small Mexican technology-based enterprises in new technological industries can improve their performance using design management in their organisational activities. Each research question is discussed along with the findings generated, to identify their implications against current knowledge. Therefore, this chapter is structured in the subsequent manner (Fig. 7.1). It begins with a synopsis of the research questions and respective findings (section 7.2). Subsequently, it analyses the findings of each of the research questions to contrast and compare them with current theories, to present implications for theory and practice (section 7.3, 7.4, and 7.5 respectively). Finally, it produces conclusions to the section (section 7.6).

Figure 7.1 Outline of the chapter



7.2 Synopsis of the three research questions

The purpose of this research is to explore the impact of design management within the activities of three small Mexican TBEs in new technological industries. Through examining the effects of design management within TBEs activities, it can be deduced whether the effective use of design can improve its overall performance. It can then be assessed if design management does play a strategic role in the activities of small Mexican TBEs in new technological industries. To achieve this aim, the researcher had to answer three research questions in order to explore, in a sequential manner, the subject of research to produce its findings. Table 7.1 presents the research questions that directed this study.

Table 7.1 Research questions

Research question 1 (RQ1): How do small Mexican technology-based enterprises in new technological industries use and embed design in their business activities?
Research question 2 (RQ2): How can small Mexican technology-based enterprises in new technological industries use, implement and integrate design management within their activities?
Research question 3 (RQ3)/main: Do small Mexican technology-based enterprises in new technological industries improve their performance using design management within their business activities?

Research question 1 examines the role that design plays in the activities undertaken by small Mexican TBEs in new technological industries. The outcomes obtained provide insights into how these businesses use and embed design within their contexts. Thus, it is possible to explore how design management can be used, implemented and integrated in this type of businesses to improve performance (RQ2). It was required to assess the condition of the case studies and their design abilities and capabilities in order to suggest design implementations at the strategic, tactical and operational level. The last question assesses whether the introduction of design management actions improved businesses performance. This improvement refers to any intangible and tangible enhancements documented and/or observed in the diverse aspects and elements that are intrinsic in the businesses.

Table 7.2 lists the research questions (column I), the research findings related to the questions (column II), and the extent to which the findings are made explicit in the literature (column III). The extent to which the findings are made explicit in the literature is indicated by 'no', 'limited extent' and 'some extent'. In this case, 'no' means that the finding is not explicit in the literature and therefore it represents a significant contribution. Then, 'limited extent' indicates that the finding is explicit in the literature, but not to an extent that adequately explains the phenomenon. 'Some extent' relates to the findings that have been mention in the literature and are part of the general knowledge of the topic area; although, this data can represent other types of businesses, conditions and contexts. The order of the findings is related to each research question and this does not infer any level of importance in relation to other findings.

Table 7.2 Findings of the study

Research question (column I)	**Findings** (column II)	**Explicit in literature** (column III)
R1 (7.3 section)	**Finding 1** ***Strategy*** – Entrepreneurs/general managers establish a design strategy along with their general strategy that is generally mixed between two or more generic strategies, especially directed to cost & market; - General managers acknowledge to a limited extent the alignment between product, information & means of communication of the company; - *Design management abilities & capabilities*: General managers/owners regard to a limited extent the allocation of design resources, selection of designers & revision of designs developed by the competition; **Finding 2** ***Process*** - General managers involve to some extent designers (external or in-house) in specific NPD phases such as development phase & prototype & model phase. Although, designers are also integrated to a limited extent at the evaluation & selection of concepts phase & production phase; - *Design management abilities & capabilities*: General managers consider in a limited extent the firm requirements or consumer needs in the early stage of the process; & in-house designers produce design standards for performance & total quality & list of designers/suppliers that can participate (case 3); **Finding 3** ***Project*** - Operational manager & in-house designers develop an informal design brief in which they consider the project requirements, its general vision, desirable needs (case 1), the planning of time & activities & deliverables (case 3); - *Design management abilities and capabilities*: In-house designers use design to support technological transference (case 3); **Finding 4** ***Product/service*** - They fulfil to some extent the basic & actual elements of product/service & poorly the augmented & superior elements; **Finding 5** ***Culture*** - There is a limited commitment of the general managers to design, investment on its activities & support to creativity & innovation; Employees consider to a limited extent the relevance of design & its relation with other areas to deliver successful projects & effective solutions;	**F.1 NO** **F.2 Limited extent** **F.3 Some extent** **F.4 Limited extent** **F.5 Some extent**
R2 (7.4 section)	**Finding 1** Design management is **implemented** as an area that works along with other areas at the strategic, tactical & operational level to help on the technological development & its introduction into the market; **Finding 2** Design management is **integrated** as a tool to manage innovation in order to modulate the innovation cycles & to transfer knowledge & information in a tangible outcome that satisfies the business requirements, customer needs & environmental demands; **Finding 3** Design management is **used** as a mean to produce, collect & translate knowledge generated from techniques, tools & methods to develop design thinking & leadership among non-designers & designers;	**F.1 Some extent** **F.2 NO** **F.3 NO**
R3 (7.5 section)	**Finding 1** ***Company level*** - Entrepreneurs/general managers use design to help on the alignment of strategic decision of the enterprise; - Entrepreneurs/general managers are more aware about the capabilities & abilities required to undertake certain activities. They are able to create environmental conditions that support their taxonomy; **Finding 2** ***Strategic level*** - General managers are aware about the strategic decisions of the business, & they use design to think strategically when they undertake decisions; **Finding 3** ***Process Level*** - There is a major consideration of the physical and intellectual activities (case 3) and improvements in the evaluation of financial resources, product production, product distributions, product disposal and product recycle (case 2); **Finding 4** ***Project level*** - Case 1 improves in the evaluation of projects and integration of design expertise among non-designers (design brief); - Case 3 progresses in the organisation of projects promoting a more creative environment & flexible teams; the implementation & monitoring of activities through documenting the budget of each phase & providing feedback to employees; & on design as in-house designers define the competencies for the project & increased its participation in the technological transference; **Finding 5** ***Product/service level*** – It was documented an improvement regarded in basic & actual levels, & there was an increment in the elements considered in the augmented & superior level; **Finding 6** ***Culture level*** - Two companies experienced significant changes in the general business culture (case 1 & 2), and two cases changed in their culture for design (case 2 & 3);	**F.1 NO** **F.2 NO** **F.3 Some extent** **F.4 Some extent** **F.5 Some extent** **F.6 Limited extent**

7.3 Findings: Research question 1

This part details the findings relating to research question 1: How do small Mexican TBEs in new technological industries use and embed design in their business activities. The results display that there are five relevant discoveries from the research question. Thus, each of the conclusions will be discussed in detail in the follow subsections.

7.3.1 Finding 1: strategy

One unanticipated finding deals with the use of mixed generic design strategies in order to support the actions directed to achieve the main strategy. Entrepreneurs or general managers (non-designers) tend to mix design strategies related to meet costs and market needs (section 6.6.1). They implement one strategy at the strategic level and the other in the process/project level in order to set the direction of their: tactics, operational activities and outcomes (final product/service). The condition of this type of enterprises favours the adoption of these complex tactics, as they hire specialised personnel that are able to solve technological problems with few resources (financial and human) during the innovative process. Consequently, this helps to reduce costs at the operational level and to infuse the majority of resources into the technological development. In addition, they embrace different strategies to cope with the different external and internal factors that affect their business performance. Prior studies on design implementation at the strategic level (Best, 2006; Borja de Mozota, 2003; Candi, 2007; Stevens, 2007; Tether, 2006) have not reported any data related to the adoption of different design strategies undertaken by non-designers in small sized enterprises or technology-based enterprises (Table 7.3).

Another finding corresponds to the limited awareness of owners on the alignment between products/services and information provided to the market through the means of communication available to the company. This alignment is relevant, as it delivers clear information about the product/service and the business through different means of communication to the market. General managers are responsible on directing these actions, as they are the originators and promoters of the technology and the business. Design is used in this activity to support or to improve the alignment between the product/service, information and means of communication. It is then possible for firms to establish communication with investors, suppliers and customer/clients (section 5.3.1). Literature focused on large enterprises has contributed many examples and insights about the positive impact that design delivers in the development of a coherent corporate communication (Best, 2006; Danish Design Centre, 2003; Design Council, 2008; Stevens, 2007). However, there is no research that suggests, or mentions, that this phenomenon is adopted, or lead, by non-designers in small sized enterprises or technology-based enterprises (Table 7.3).

General managers are able in a limited extent to allocate design resources, select designers and review designs developed by their competition. It was unexpected that non-designers had the ability to differentiate the required design expertise from a wide scope of specialties (section 6.6) and to perform specific activities. Similarly, they appear aware of the financial resources needed to invest in design in their businesses and the product/service designed by the competition. This design consciousness has been triggered by self-learning actions of the owners, as a reaction to the many constraints endured by the businesses (section 6.6.1). Very little literature has been found concerned with the expertise of non-designers to manage to a limited extent design resources at the strategic level (Table 7.3). Nonetheless, the findings support previous research developed in large organisations concerning with the management of design resources at the strategic level.

7.3.2 Finding 2: Process

An interesting finding of this section represents the evidence of a semi-formal new product/service development process in two cases of the small Mexican TBEs in new technological industries. By semi-formal it is referring to the formalisation in certain activities such as documentation of outcome of the different stages of the new product/service process development, whereas, some activities are informal such as planning, communication and documentation of activities. It was interesting to find that designers (external and in-house) are involved to some extent in the development phase, and prototype and model phase of the NPD process. Design was considered in the last phases of the NPD process because it aimed to support the aesthetic appearance of the product/service. After the design implementation, the two cases integrated designers in a limited extent in the evaluation and selection of the concepts phase and production phase (section 6.6.2). The present findings are consistent with research (Bruce and Bessant, 2002; BIS, 1999; Danish Design Centre, 2003; Hollins, 1991, 1999; Moultrie, et al., 2006; Ulrich and Eppinger, 2003) that describes design implementation at different stages of the NPD process in large and medium size enterprises (section 2.6.4.2). Nevertheless, limited research shows that design is implemented in small TBEs in the new product/service development at different key stage (Borja de Mozota, 2006; Bruce, et al., 1999; Dickson, et al. 1995; Frias-Peña, 2005; Herbruck and Umbach, 1997; Kavanaugh, 1997; Moultrie, et al. 2006).

It was also documented that businesses consider in the new product/service development process either the firm requirements or the consumer needs (section 6.6.2). Enterprises tend to adopt one requirement to direct their process and outcomes to achieve a desirable product/service that satisfies either the firm or the market. There is limited research that discusses how design (management) is used in different key stages of new product/service development of small sized or TBEs (Bruce, et al., 1999; Frias-Peñas, 2005), especially when it is implemented by non-designers. In addition, in-house designers (case 3) address design standards for performance, total quality and a list of designer/suppliers that can participate in the NPD process (section 6.6.2). This is due to the current design leader having previous experience working in the NPD process for large or medium size enterprises. This expertise enabled designers to get more involved in the different activities of NPD development. This in turns provoked that designers become more participative and proactive in the semi-formal NPD process. Therefore, designers have been able to position their expertise in the NPD process, and other employees have the opportunity to appreciate the role that design plays in the process. In this respect, there is limited literature that deals with the actions and roles undertaken by designers in the NP/SD process on small TBEs (section 2.6.4.2 and Table 7.3).

7.3.3 Findings 3: Project

The findings of this section indicate that non-designers and designers have the ability to develop an informal design brief with the general vision of the project, its desirable needs, and planning of time and activities. In-house designers (case 3) are responsible to support the technological transference in the development of physical artefacts in the project. First, the development of an informal design brief is related to the fact that project or operational managers have expertise in project management (section 6.6.3). This infers that non-designers have a basic idea of what aspects need to be considered at the start of a design project, especially when they need to hire external design services. This finding is consistent with the research of Bruce, et al. (1999), in which they recommend the design need for briefing, sourcing, launching and evaluating the overall project (section 2.6.4.3). What concerns the support of design in the technological development can be attributed to two factors: the internal environmental condition of the company and the knowledge, abilities and capabilities of designers (section 6.3.3). The intrinsic relation between both elements can trigger and boost innovative and creative thinking among designers and non-designers in order to shift from intangible resources (knowledge development) to a tangible outcome (product or service). Indeed, this process requires the internalisation of technological innovation to transform it into a marketable product/service. This finding is supported by literature developed in large, medium and small sized enterprises at project level (Table 7.3)

7.3.4 Finding 4: Product/service

The case studies appraise to some extent the basic and actual elements of the product or/and service and poorly its augmented and superior components. This result is interesting because researchers relate the introduction of design with differentiation, appearance, high quality products, etc (Best, 2006; Dreyfuss, 1967; Kotler and Rath, 1984; Powell, 2004; Stevens, 2007). A possible explanation for this finding has its origins in the fact that most design decision-making is undertaken by non-designers. Designers are integrated at different levels of the company, but their roles are specific because they were hired to deliver a predetermined outcome. This implies that owners hire designers under specific sets of guidelines in which they choose certain skills, abilities and processes of thinking. Meanwhile, designers are limited to the design awareness of owners and employees, as their involvement is going to depend on the range of freedom and support that the firm offers them.

Table 7.3 Summary of the literature related to the findings

Level	Use and effects of design	Authors
Strategy	- Design as innovation asset - designer collaborates with the owner/manager to adopt an innovative approach to all the business foundation; - Product differentiation; - Exploit technological innovation, innovation in service, & use design as a revenue model; - Strategic design acts a position area, informant of strategy, & leader on implementing a strategy; - Create a brand image & corporate reputation; purchase influence/emotion; design (ROI)/cost saving; enable product & service innovation; design patents/trademarks/IP; enable strategy/enter new markets; increase customer satisfaction/develop communities; - Produce products/services with higher premium pries; better reputation and user reputation; distinctiveness and user awareness; - Small businesses tend to grow faster; better performance on share prices; increase sales; - Company image; communication with customers; increase profits; -Affect competitiveness; enhance exports; retain & regain market share; improve financial performance; -Powerful mean to convey persuasive ideas, attitudes & values; change patterns; diversify design - Integrate social values; contribute to both price & non-price; - Create a company image	Danish Design Centre, 2003 Ulrich & Eppinger, 2003 Candi, 2007 Stevens, 2007 Lockwood & Walton, 2009 Joziasse & Selder, 2009 Design Demand, 2007 Design Council, 2007 DTI, 2005 Bruce & Bessant, 2002 Cooper & Press, 1999 Walsh, et al., 1992 Kavanaugh, 1997 Hertenstein & Platt, 1997
Process/ Project	- Improve time to market & development process; improve usability; - Lower production cost; lower marketing cost; shorter time to market; - Design facilitates the management of positive relationship with customers & collaborates in the developments; - Product-late stage 'window dressing'; & effective design is involved early to shape & develop products; - Design activity as data source (thinking, imaging and decision-making, information gathering, drawing & model-making); -Break into new markets; quality; & reduce cost; - Concept-based innovation, product/service obtained by design effort with not or minimal technological novelty; - Delivery time; Non-price quality & price; - Inject life in mature markets; introduce new/adapted products - Address the human side of the business; and improve communication between areas in the NPD process;	Lockwood & Walton, 2009 Joziasse & Selder, 2009 Candi, 2007 Steve, 2007 Pedgley, 2007 Design Council, 2007 Veryzer, 2003 Bruce & Cooper, 2000 Tether, 2005 Walsh, 1992 Oakley, 1990 Roy & Wield, 1995 Herbruck & Umbach, 1997; Oliver, Gardiner & Mills, 1997
Product/ Service	- Add perceptual and functional value to make the sale & optimise the user experience; - Service design consider user interface; tangible artefacts (counteracting intangibility); documents; usability; communication with customers; community building; & customer experience; - Appearance, utility, easy to maintain & improve communication; - Quality of user interfaces; ability to maintain & repair; & emotional appeal; - Appearance; performance; quality; cost & durability;	Powell, 2004 Candi, 2007 Dreyfuss, 1967 Ulrich & Eppinger, 2003 Kotler & Rath, 1984 Jordan, 1997

7.3.5 Finding 5: Culture

Employees regarded to a limited extent the commitment of general managers to support design activities. Therefore, their design experts (external and in-house) perform poorly, as they are not encouraged to rely on their creative and experimental competencies. Similarly, employees consider on a limited extent the relevance of design in the development of successful projects and/or effective solutions. Both results may be explained through the lack of awareness of design expertise among non-designers, and the passive and reactive role of designers in their development of actions. According to Borja de Mozota (2006), one of the major criticisms for designers is their lack of understanding of businesses and other functional areas. This can lead to problems when there is a need for them to work in teams (section 2.6.4.3). Thus, designers need to provide clear communication of their developments with other areas (Cooper and Press, 1999; Cross, 2008).

In essence, the three small Mexican TBEs in new technological industries embrace design throughout the different levels of the business. It was interesting to reveal that general managers/owners use design at the strategic level. However, its use is deficient, as the owners' awareness of design was limited and narrowly focused. The evidence documented exhibits that they tend to concern more on the technological development than on the management of the business and market decisions. Thus, design is used as a support in the last stages of the technological development with its product/service integration into the market being poor. It was relevant to discover that external designers play a reactive role rather than proactive in the delivery of satisfactory results. Alternatively, in-house designers experience a more proactive role and their expertise can expand further to other business activities than the ones expected at the time of being hired. These findings provide evidence that shows that these types of businesses are prone to incorporate different areas of expertise in order to produce and introduce within the market a technological development. However, caution must be applied with a small sample size and specific characteristics, as the findings might not be transferable to different type, size and regional location of businesses.

7.4 Findings: Research question 2

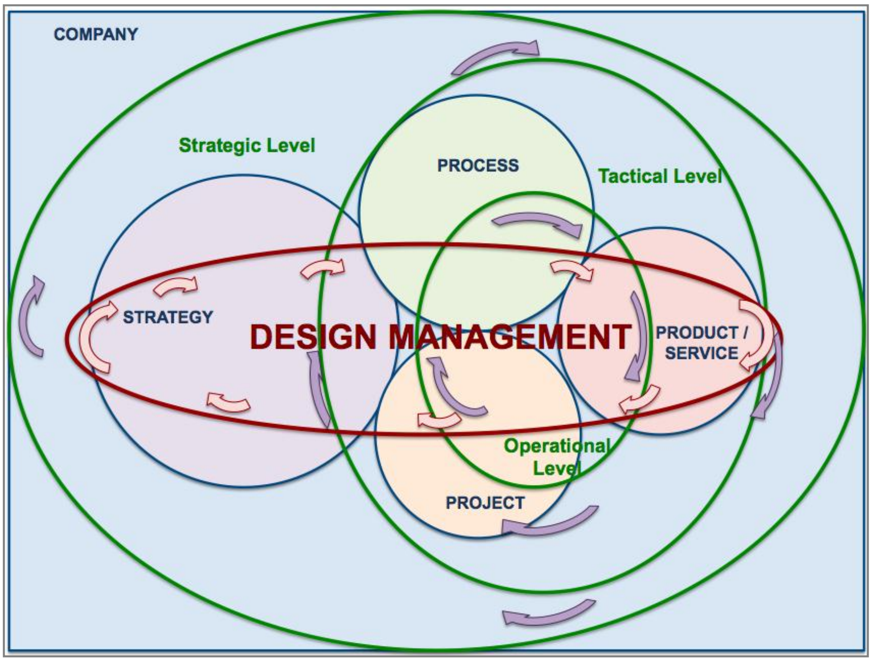
This part describes the findings associated to research question 2 about, how small Mexican TBEs can use, implement or/and integrate design management within their activities. The evidence reveals three relevant discoveries from this research question.

7.4.1 Finding 1: Design management implementation

The evidence illustrate that the case studies implemented design management, as an area that works along with other areas at the strategic, tactical and operational level to help on the technological development and its introduction within the market (section 6.8). This situation is possible due to the cases have an overlap on the different levels of action provoking the spreading of knowledge among the different levels. Thus, employees have the ability to undertake any strategy designed at the top level and to transform it at the operational level in a set of effective day-to-day activities (sections 2.4.1 and 2.4.4). Design management works as a link that helps in the transition of the different stages of the technological innovation development until it reaches the market (Fig. 7.2). This study produced results that corroborate the findings of previous works that concern the implementation of design management in large-size organisations and the introduction of special design expertise and actions (section 2.6.4). Nevertheless, it is important to highlight that there is limited research that has explored the complexity of small technology-based enterprises and their organisational structure in order to know how design management is implemented under such circumstances.

Figure 7.2 exhibits the implementation of design management in small Mexican TBEs in new technological industries. Under this circumstances design management works as a link in the transition from the strategy development to its translation into tactics and actions in the operational activities in the process or project (red ellipse and arrows). These activities have as aim to achieve products and/or services that are profitable for the business. Similarly design management is implemented as a mean to deploy the knowledge produced from the operational level to tactical and strategic level (purple arrows). This is in order to achieve consistency throughout the different levels of actions within the company.

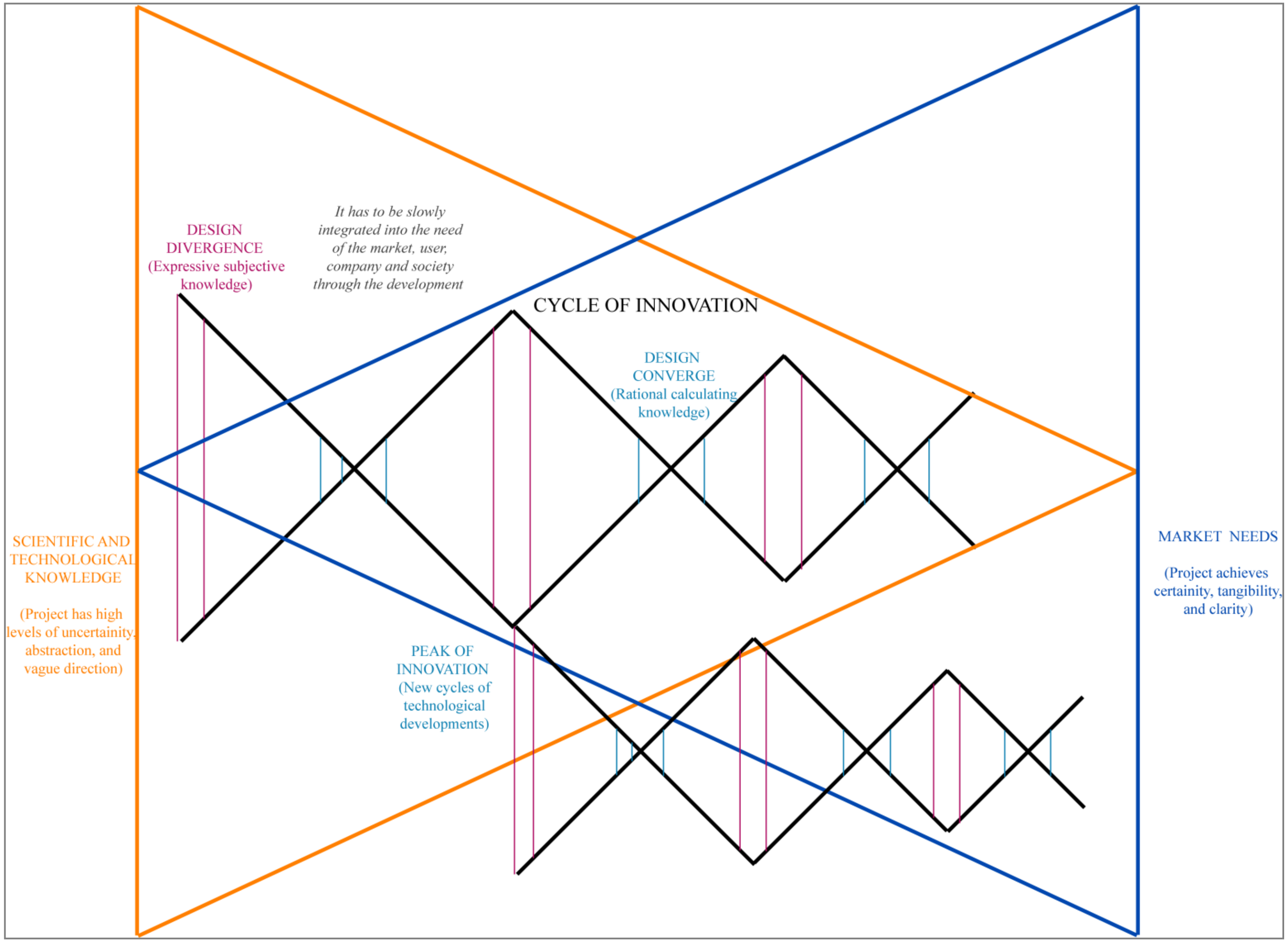
Figure 7.2 Design management implementation in small Mexican TBEs



7.4.2 Finding 2: Design management integration

One unanticipated finding is that design management is not only integrated as a tool to manage innovation in order to modulate the innovation cycles and to transfer knowledge and information. It is also the mean to present a whole proposition that allows determining which technological aspects are going to be present in a product, service or process to meet the firm requirements, market needs and environmental demands. This refers that it is not only concerned with the management of technological developments and the delivery of outcomes that meet existing needs, but it also aims to enable firms to consider their position into the market. Design tools, methods and techniques are used to reduce the complexity of the project and to translate the technological development into a product that satisfies the market needs. Figure 7.3 exhibits the cycle of innovation in where the idea of a new product or service has its origins in the generation of scientific and technological developments. During this development, the role of the scientific and technological knowledge (orange triangle) is reduced as it become nearest to the end of the project because market knowledge (blue triangle) assumed a major role to introduce products or services into the market. The most important asset in this transition is knowledge, as it is adapted, developed and new one is created. It transits through different cycles of divergence and convergence in order to control the amount of knowledge produced. This provokes peaks of innovation that leads to produce new technological developments from the innovation generated.

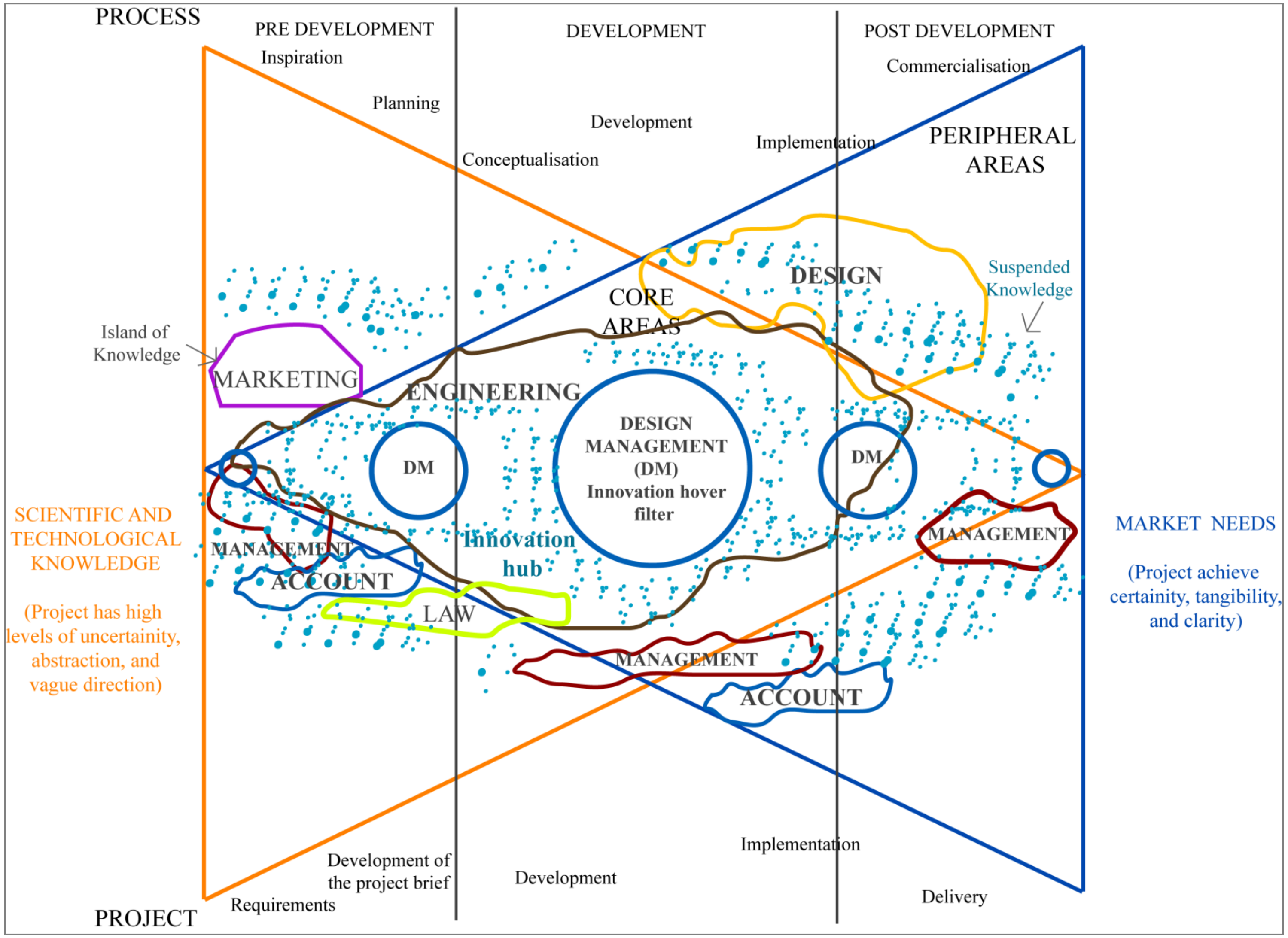
Figure 7.3 Integration of design management in small Mexican TBEs



The integration of design management into the technological development aims to absorb the knowledge produced from other areas to transform it into sensible data and then in tangible outcomes to produce successful solutions. Figure 7.4 presents the interaction of design management in the technological development. As it can be seen, design management it could be integrated either in the process (head of the Figure 7.4) or project (footnote of the Figure 7.4) of the case studies. This is in order to help on achieving a consistency from the generation of a scientific and technological idea to its introduction into the market through marketable products or services. Similarly, design management aims to help on absorbing knowledge developed and generated from the different islands of knowledge and the suspended knowledge (innovation) that is allocated in the core area and the periphery of the innovation hub. Design management expertise could be used as a brokering of languages among different areas (Hagardon and Douglas, 2001; Hagardon and Stutton, 1997; Verganti, 2003). According to Hagardon and Douglas (2001), Hagardon and Stutton (1997) and Verganti (2003), designers can play a crucial role in the development of radical innovation of product languages. This is possible through capturing, recombining and integrating knowledge about socio-cultural model and product semantics in several different social and industry settings, designers help in creating breakthrough product meaning.

It is important to highlight that in two cases (case 1 and 2), non-designers were in charge to integrate design management tools to assist in the business activities (section 5.3.2 and section 6.7.4). Contrary, in-house designers were in charge to implement design management actions in case 3. A possible explanation for the positive embracing of design management integration is due to businesses needs to be consistent throughout the technological development. This implies that employees (internal and external) from different areas are going to use diverse methods, techniques and tools as a means to plan, organise, implement, document and evaluate activities in the technological development. Indeed, it was documented that employees had previous experiences and awareness about the use of the diverse tools considered in the implementation of activities. Design management and its integration in the technological development of small TBEs is devoid in current literature. Although, there is a significant amount of work that has covered the management of innovation and product development process (Bruce and Bessant, 2002; Bruce and Cooper, 1997; Cross, 2008; King and Anderson; 2002; Oakey, et al., 1988; Sobrero and Roberts, 2002; Roy and Wield, 1995; Smale, 1998; Tidd et al., 2005; Twiss, 1992).

Figure 7.4 Integration of design management in the technological development



7.4.3 Finding 3: Design management use

Design management is used as a mean to produce, collect and translate knowledge originated from the techniques, tools and methods implemented in the technological development. Non-designers and designers embraced a design way of thinking (design thinking) and then adopted design as an asset to lead them (design leadership) to produce a complete business proposition. It possible that these results are part of the effect of the owners inclination to invest resources in innovation, to design organic work environment to exploit innovation, to use creativity to reduce the effects of the lack of resources, and to hire human capital with different expertise (section 6.7). This study generated results that corroborate findings from previous works; although, these originated from the design leadership area and design thinking area.

Research on design thinking has explored the use of design tools, methods and techniques to connect knowledge in design process and knowledge embodied in design outcomes (Cross, 2008; Jones, 1980; Laurel, 2006; Lawson, 2005; Pedgley, 2007; Tether, 2006; Voguel et al., 2004). When design thinking is used along with design management at the organisational level, its effects lead to transform business strategies and the way organisations do business (Cooper, et al., 2009). On the other hand, research concerning design leadership has focused to explore the intersection of leadership with design strategy (Gloppen, 2009) in order to know the potential of design as a transformative force in business and society (section 2.6.4.1). Several researchers have linked design management to business management and design leadership issues (Borja de Mozota, 2003; Cooper and Press, 1999; Dumas and Mintzberg, 1989; Gorb and Dumas, 1987). As design management seeks to link design, innovation, technology, management and the end-market across the triple bottom line, economic, socio/cultural and environmental factors, to produce improvements. Nevertheless, any research has underlined the integration of design thinking and design leadership as a natural flow from the implementation of design management in the business activities. This implies that it has not been proposed yet a holistic proposition about the intrinsic relation of these three key areas of study.

In summary, the three small Mexican TBEs in new technological industries integrated design management as an asset that was used at their three levels of action (strategic, tactical and operational level) in order to manage innovation. This is possible through the modulation of cycles of innovation and the transfer of knowledge and information to introduce their technological innovation into the market place. The empirical research presented evidence about the role played by non-designers, as responsible on the implementation of design management actions. This offered the owners the basis to align design management with the different levels of action and phases of development within the business. Meanwhile, employees used design tools, methods and techniques in their day-to-day activities (design thinking) to deal with the uncertainty, intangibility, and vague knowledge of their technological developments. Indeed, designers are involved in the development process, but they are used at specific phases, specifically in those, in which their expertise provide efficient solutions and support actions for the process or project. It is important to emphasise that caution must be applied in a small sample size and specific characteristics, as the findings might not be transferable to different type, size and regional locations of businesses.

7.5 Findings: Research question 3

This part presents the findings of the principal research question: Do small Mexican technology-based enterprises in new technological industries improve their performance using design management within their business activities?. Therefore, it was required to prepare a pre-measurement and post-measurement evaluation in order to assess if the case studies experienced any significant improvements. Evidence shows that there were differences and these are going to be explored in this last part of the discussion.

7.5.1 Finding 1: Company level

One unanticipated finding was that general managers/owners use design to support them to align the general strategy with tactical decisions (section 6.8). The implementation of the design toolkit, especially the design toolbox, in that the business impacted the owners and employees awareness about the abilities and capabilities required to develop certain type of activities and the consideration of organisational conditions to promote technological developments (section 6.8). These findings have not previously been described in literature of small TBEs; although, these actions have been largely described in the literature of large and established firms in which designers lead and champion design activities (section 2.6.4). Furthermore, there is a lack of information concerning the impact that design has on other non-design activities related to strategy definition. These findings can be explained in part by the culture that TBEs embrace (section 2.4.1 and 2.4.4) and the management style within small TBEs (section 2.4.3).

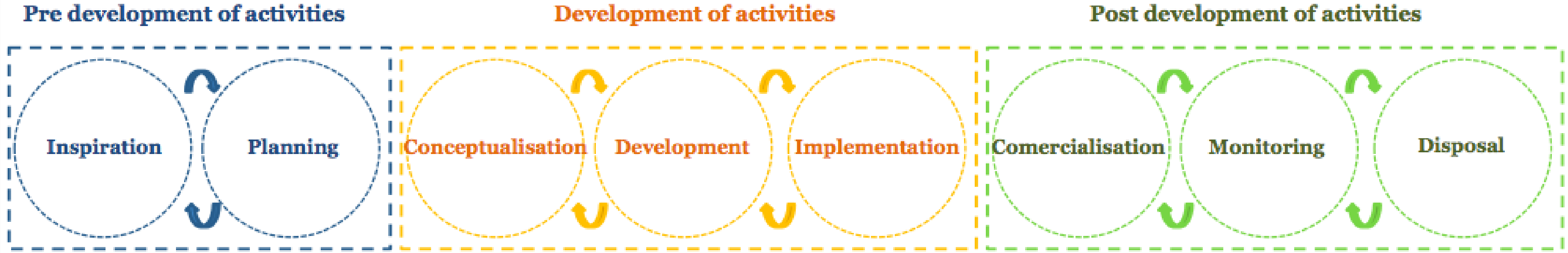
7.5.2 Finding 2: Strategic level

The follow findings concern the change experienced by general managers/owners on the awareness of strategic decisions within the business and the use of design to think strategically when they undertake decisions (section 6.8.2). A possible reason for this phenomenon concerns the awareness of owner/general managers to the external and internal elements related to business success, especially those that affect the organisational structure and the communication and documentation of knowledge generated (section 2.4.3). The effects of this result are displayed on the reduction in the number of problems suffered by TBEs, such as leading the abilities of employees to develop new technologies (Cosh, et al., 2005) and considering internal factors that can hamper the coordination, interactions and collaboration between departments (Miller and Tolouse, 1986; Wissema, et al., 1980). This implies that the results have effects in narrowing the gap between setting strategies and directing employees' abilities to develop new technologies. The importance of this finding is that the gap between management and implementation of actions in TBEs can be reduced with the use of a more flexible area of expertise, such as design management. This is due to it supporting the transition from analytical activities to creative activities and vice versa.

7.5.3 Finding 3: Process level

The improvements in the process level were experienced in the organisation and evaluation actions in the NPD. Organisation actions were exceeded in case study 3 because project managers considered the planning of physical and intellectual activities. Similarly, case 2 improved its evaluation action, as they recognise the relevance of financial resources, production, distribution, disposal and recycle of the product/service. A possible explanation of these results concerns the necessity of each case to invest resources to improve, in the short-term, the current phases of development in which they are allocated.

Figure 7.5 New product/service development process adopted



1. Observation, research and analysis;
2. Identification of needs and opportunities;
3. Specifications and rationale;
4. Fast evaluation (models and mock ups);

5. Specification of the oportunity;
6. Strategy of the product development;
7. Planning of financial resources;
8. Planning of physical resources;
9. Planning of human resources;

10. Concept design;
11. Concept description;
12. Concept generation;
13. Development of models and/or mock ups;
14. Concept evaluation;
15. Concept selection;

16. Design specification;
17. Development of product or service activities;
18. Design detail;
19. Alpha and beta prototype;
20. Identification of failure modes of the product/ service and redefinition of specifications;
21. Evaluation;

22. Design incorporation;
23. Evaluation of design incorporation;
24. Identification of failure modes in manufacturing;
25. Manufacturing;

26. Launch;

27. Evaluation;

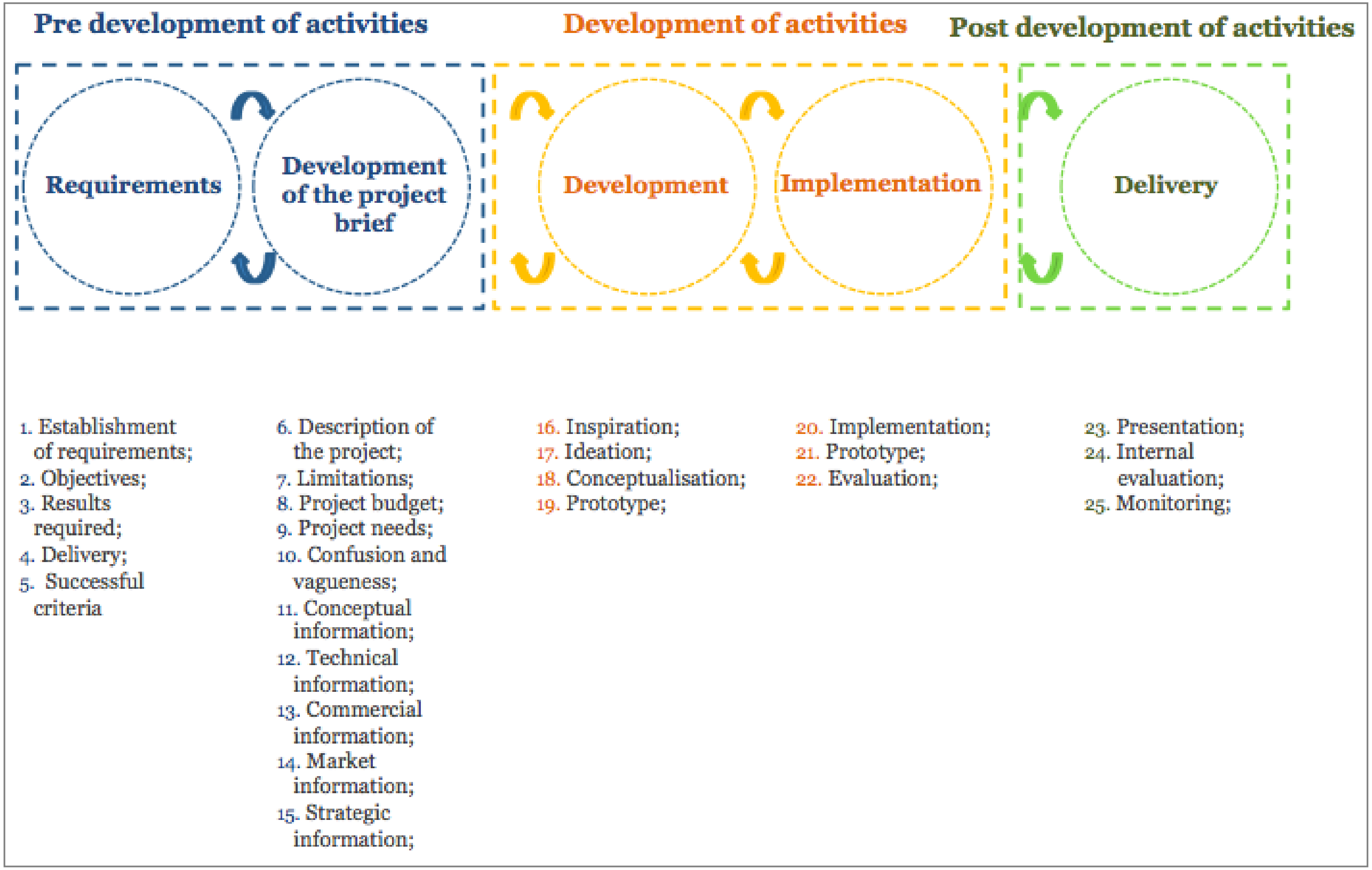
28. Re-use;
29. Recycle

This study corroborates previous research produced in which design plays a support role in the NP/SD process, as it makes it more effective and efficient through the coordination of tasks and information (Bruce and Bessant, 2002; BSI, 1999; Hollins, 2001; Sebastian, 2005). In order to achieve that condition, it is important to consider two major implementations; first, a flexible NP/SD process (Fig. 7.5); and second, tools, techniques and methods that harness design thinking to help teams to learn, to structure information, to prompt thinking, to communicate effectively and to manage knowledge (section 2.6.4.2). The results recognise the assistance of design to manage innovation and its development process through the iterative, cooperative and cumulative interactions among all participants.

7.5.4 Finding 4: Project level

The findings of the project level show improvements in the evaluation (case 1), the organisation, the implementation and monitoring of the project (case 3), and the use of design (case 1 and 3). The first result supports previous research pertaining to the use of a design brief to improve projects, especially in the evaluation of outcomes (section 2.6.4.3). It aims to analyse the concepts or results against tangible and intangible measures such as sales performance, market success, satisfaction of needs, etc. Another improvement experienced relates to the organisation of projects. It has been recognised that design management promotes creative environments and with the use of a design brief encourages the creation of flexible teams that embody the most promising principles of the project (Eder, 1998). The next finding, implementation and monitoring, is not supported by previous literature. Borja de Mozota (2006) and Cooper and Press (1999) argued that the management of tangibles represent a common problem faced within a project among design managers. It seems possible that this result is due to the people in charge of undertaking these actions were non-designers and therefore, they were able to document the budget of each phase and provide feedback to employees (section 6.8). Similarly, the introduction of a project development checklist (Fig. 7.6) was useful to ensure that all the requirements were fulfilled during its progress. Finally, non-designers and designers were able to produce a design brief to define the necessary design competencies for the project in order to support the technological transference (section 6.8). Thus, non-designer and designer can hire the most adequate designers for the project, and consequently make possible the technological transference (section 2.6.4.3).

Figure 7.6 Checklist adopted in the project development



7.5.5 Finding 5: Product/service level

The result of the product/service section indicates that it was an improvement in the assessment of elements of the basic and actual levels. Similarly, case studies more acknowledged elements of the augmented and superior levels of the product/service. Therefore, they were able to improve the added value delivered to the consumer through their product/service. These results might be explained through the introduction of designers and diverse methods, techniques and tools to develop strategies that then were translated into operational activities. The present findings seem to be consistent with previous research developed in which design improves product/services making them more appealing to the necessities established by the business (See Table 7.3).

7.5.6 Finding 6: Culture level

The introduction of design management provoked changes in the culture of two case studies (case 1 and case 2), and transformations on the culture for design in Case 2 and Case 3 (section 6.8.6). There is limited literature related to this finding; although, it is recognised that design management can influence the way of thinking within businesses (Cooper, et al., 2009; Fraser, 2009; Hull and Langenderfer, 1997; Jordan, 1997; Sebell and Goldsmith, 1997). This may be possibly because when it is used at the organisational level it can transform business strategies and the way they do business (section 2.5.4.1). However, it is surprising that people charged to implement design actions within the business are non-designers. A possible explanation for this phenomenon is related to the fact non-designers was supported throughout the intervention (modification stage) by the researcher to implement design actions. Finally, the three cases encountered a change in their perception of design within the business. Owners and employees regard it as an area of expertise that can support the process or project, and as an asset that can improve the performance and competitiveness of the overall business.

To conclude, the three case studies showed an improvement at the different levels of the case studies. The findings provide a holistic view of the impact of design management on the firm and the interrelation of design with other areas of organisational activities. The present results are significant in at least three respects. First, the implementation of diverse tools, methods and techniques in small Mexican TBEs provoked a change in the way of thinking among employees that pertain to activities undertaken at the three levels of action. Secondly, design management along with design thinking helped the owners/general managers interconnect the scientific and technological developments with market needs. This was in order to align their strategies, organisational structure and organisational style, and taxonomy of innovation (design leadership). Indeed, this does not imply that the case studies are going to direct their strategies to compete by design. Nonetheless, it means that the owners are aware of a wide range of factors that are relevant to introduce a product/service within the market. Third, design management has this impact because the businesses have different areas of expertise that reduced the weaknesses that the designers have in their education, such as poor knowledge of project management (section 2.6.4.3), limited skills to communicate with other areas (section 2.6.4.2), and fuzzy, informal, intuitive, creative and spontaneous parts of design (section 2.6.4.1). This means that design per se cannot as an individual activity improve the company, nor the culture, because it depends on other areas to show their own strengths, as it is part of a virtues circle (value chain cycle). Consequently, design management requires other fields of study and design specialties to deliver the values that can lead the enterprise to improve its performance.

7.6 Conclusions

This chapter has provided a detailed discussion about the findings obtained from this research. It presented a synopsis of the three research questions that give life to this study in order to introduce the findings produced throughout it. The first research question offered five relevant discoveries on the use and embedding of design within the three small Mexican TBEs in new technological industries. These were related to the use of design at the different levels of the company, although, its utilisation was deficient. Subsequently, it reviewed the three findings attained in the second research question, which relates to the use, implementation and integration of design management into the three case studies. It noted that businesses integrated design management as an asset that is used at three levels of action in order to manage innovation. This is possible through the modulation of the cycles of innovation and the transference of knowledge and information to introduce the technological innovation into the market. Finally, it examined the six findings produced in the third research question that assess whether the three small Mexican TBEs improved their performance using design management or not. These findings showed an improvement in the different levels that are part of the business. Consequently, chapter 8 will present the conclusions reached in the study in order to yield contributions for theory and practice. As well as, it will describe the limitations encountered in the study and the opportunities for further research.

CHAPTER 8.0 CONCLUSIONS

8.1 Introduction

This chapter reports on the research undertaken and the significance of the findings that addressed the research problem: *Does design management improve performance of small Mexican technology-based enterprises in new technological industries when implemented within their activities?*. The purpose of this research has been to explore the impact of design management within the activities of three small Mexican TBEs to deduce if it can improve its overall performance of the businesses. Through examining the effects of design management within TBEs activities, it can be deduced whether the effective use of design can improve its overall performance. It can then be assessed if design management does play a strategic role in the activities of small Mexican TBEs or not. Therefore, it is important to outline the different chapters that support the conclusions presented in this section.

Chapter 1 outlined the research problem and presented the importance of TBEs, especially small sized enterprises, to the national economic in Mexico. It discussed the relevance of TBEs in the continuous technological innovation development. Similarly, it examined the problems that these organisations suffer during the technological development and the introduction of this into the market. It further argued that it was required to consider corporate strategic elements, organisational culture and NPD process features to improve the performance. Then, it described the relevance of design activities within the business context, as it had documented its positive impact on the performance of the organisations (Best, 2006; Borja de Mozota, 2003; Bruce and Bessant, 2002; Lockwood and Walton 2009; Oakley, 1990; Veryzer, 2005; Veryzer and Borja de Mozota, 2005). Subsequently, it introduced design management issues related to its positive influence on the performance and competitiveness of enterprises. Therefore, it discussed that design management offers an opportunity to encounter the internal organisational problems suffered by small Mexican TBEs.

In chapter 2, it reviewed the literature relating to the research problem in order to develop a theoretical underpinning for the research. The chapter began with a general description of the Latin America region and Mexico (section 2.2) to comprehend the context of the study. It also defined the terms of small Mexican technology-based enterprises (section 2.3.1) and its application of technology and innovation. Next, it explored the organisation and management style in small TBEs (section 2.4), as it represented the introduction to interrelate themes such as organisation within TBEs (section 2.4.1), taxonomy (section 2.4.2), management style (section 2.4.3), and culture style (section 2.4.4). Then, it introduced new product development (section 2.5) through its definition (section 2.5.1), different types of processes (section 2.5.2) and success factors (section 2.5.3). Finally, the last section sought design as a value asset within the business environment in its three level of implementation, strategic, tactical, and operational level (section 2.6). It was necessary to define two terms, design (section 2.6.1) and design management (section 2.6.2), as both allow to establish the views that consider design as a strategic asset within the business context (section 2.6.3). The last section concluded by examining design management levels, strategic, tactical and operational level, within the business context (section 2.6.4). It is important to note that the themes covered in the literature review were primarily based within the context of large and established firms in developed countries. Correspondingly there has been no research of design management in the context of small TBEs in new technological industries of developing nations available by the time of the research.

Chapter 3 outlined the research design utilised to address the three research questions that give life to this investigation (Table 8.1). First, it was explained the research design (section 3.2) to decide then the philosophical foundation, pragmatism, under which is based this study (section 3.3). Subsequently, it was discussed multi-method design (section 3.4), along with the criteria employed for judging its quality. The multi-method design chosen, QUAL⇒quan (section 3.5), was explained in order to present the methods and techniques used to collect and analyze the data of the development of the design toolkit (section 3.5.1) and pre-experiment (section 3.5.2). Finally, this section concludes with a discussion of the ethical considerations (section 3.6) relevant to this research.

Table 8.1 Research questions

Research Question 1 (RQ1): How do small Mexican technology-based enterprises in new technological industries use and embed design in their business activities?
Research Question 2 (RQ2): How can small Mexican technology-based enterprises in new technological industries use, implement and integrate design management within their activities?
Research Question 3 (RQ3)/main: Do small Mexican technology-based enterprises in new technological industries improve their performance using design management within their business activities?

Chapter 4 provided an account of the procedures adopted to develop the design toolkit that was used to evaluate the condition of the firm and its abilities and capabilities of design. Thus, it was first mention the objectives and premises considered in the study (section 4.2), to later define the terms utilised for describing the condition of small Mexican TBEs and design abilities and capabilities (section 4.3). Next, the research phases of the study were explained, exploratory study, instrument development and validation. The first phase (section 4.4.1) explored the context of study and sense-checked the content and structure of the design toolkit. Then, it tested its feasibility to confirm the basic viability of the approach and the content and structure (section 4.4.2). Finally, it refined the design toolkit to implement it into the case studies, to later validate it with further assessments (section 4.4.3). The follow section detailed the methodological developments for each phase (section 4.5), and to later explain the results obtained from the design toolkit to assess the reliability of the scale (section 4.6).

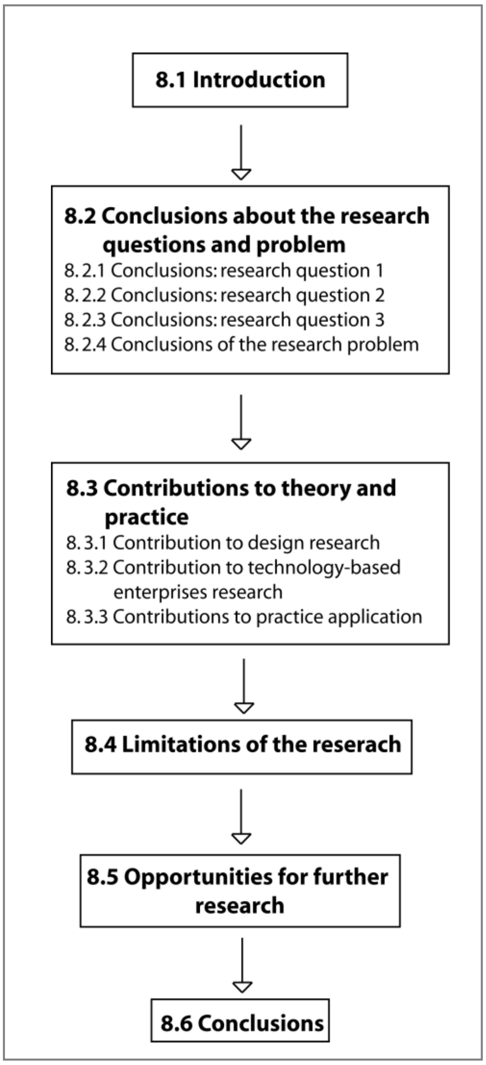
Chapter 5 explored the implementation of the design toolkit to assess whether the three case studies reported changes in their condition and design abilities and capabilities. Therefore, it detailed the three research phases carried out in the pre-experiment, pre-measurement, modification and post-measurement. The pre-measurement phase (section 5.2.1) appraised two actions, the implementation of the design toolkit and the description of the firm's condition within the context of the study. The modification phase (section 5.2.2) analysed the evidence produced to develop specific modifications that were implemented and followed up during a period of seven months in each case study. The post-measurement study (section 5.2.3) concerned with the second implementation of the design toolkit within the three previous case studies. The same order was used to describe the methodological development for each phase (section 5.3).

Chapter 6 analysed the data collected from the three case studies in order to yield answers for each research question posed. The first section reviewed the design toolkit as it represents the main instrument to assess the three case studies condition and design abilities and capabilities (section 6.2). Subsequently, it presented the terms used throughout the research (section 6.3) to later describe the data displayed in the chapter (section 6.4) and a summary of the case studies (section 6.5). The next three sections were aimed to answer each of the research questions of the study (section 6.6, 6.7 and 6.8). This section finished summarizing the key findings of the data analysis section (section 6.9).

Chapter 7 began with a synopsis of the three research questions and its respective findings (section 7.2). Afterwards, it was analysed each of the research questions findings to contrast and compare with current theories in order to present the implications for theory and practice (section 7.3, 7.4, and 7.5 respectively). Section 7.6 detailed the conclusions of the section.

This chapter presents the conclusions of the research questions and research problem (section 8.2). These are followed by a presentation of the contributions for theory and practice (section 8.3) and the limitations of this research (section 8.4). Finally, it provides opportunities for further research (section 8.5). Figure 8.1 shows a summary of this chapter.

Figure 8.1 Outline of the chapter



8.2 Conclusions of the research questions and problem

This section examines the conclusions reached in this research. Hence, it is important to present the key conclusions attained in each research question and then in the research problem.

8.2.1 Conclusions: Research question 1

The evidence from this study suggests that the three small Mexican TBEs in new technological industries use design at different levels of the organisation; strategic, tactical and operational. This premise infers three key issues in the use and embedding of design under the context of study. First, general managers/entrepreneurs are aware about their participation in design actions and decisions. Unlike, previous research in small sized enterprises in which silent design decisions and lack of awareness of design are common, these case studies presented a basic understanding of design. General managers were able to adopt generic design strategies; align the product/service with information and means of communication; consider the firm requirements or consumer needs in the NPD process; and use an informal design brief in the project development. Indeed, it is important to emphasise that these design decisions and actions are very limited, but they provide at least a direction to the technological projects and some design benefits in the outcomes.

Second, general managers invest on multiple design disciplines in the different levels of the organisation, especially at the operational level in which they use it in specific phases of the NPD and project development. They have achieved this level of expertise through trial/error actions, as they have used design expertise in different phases of development in which designers' abilities and capabilities were not the most suitable. In the case studies, owners introduced design action at the strategic and operational level, as opposed to previous research in which the introduction of design is championed and executed by designers (Borja de Mozota, 2003; Cooper and Press, 1999; Stevens, 2007). Hence, non-designers were able to recognise design abilities; allocate resources to the different design specialties; and scout the designs developed by their competence. Similarly, they were able to introduce to some extent design in different phases of the NPD process, such as the development phase, and prototype and model phase. Finally, in-house designers (case 3) championed their participation in the technological transference in the projects.

Finally, the narrow and limited awareness of design of owners along with the poorly implementation of designers provoked that the benefits desired and outcomes required were not fully released. This infers that the investment of design expertise does not fully warranty the successful achievement of results required and desired. Thus, the use to some extent of design at the development, and prototype and model phase, and its utilisation to a limited extent in the selection of concepts and production phases, results in the poor obtaining of benefits, as designer expertise was not linked throughout technological development. Similarly, the project level reported an identical experience in the use and embedding of design. This is due to non-designers leading projects, and hence they consider few elements that guide designers to deliver effective solutions and successful projects. This in turn directs businesses to achieve some elements of the basic and actual levels in their products/services.

8.2.2 Conclusions: Research question 2

The findings of this research suggest that the three small Mexican technology-based enterprises in new technological industries have used, implemented and integrated design management within their business activities. Design management has been implemented at three levels of actions in order to amalgamate fully and consistently the different areas to create new technological products, services and/or processes that reflect the business strategy and its technological core competence (section 5.3.2). This implementation was possible because the technological development process represents the organisation in itself in the three case studies. This means that each technological development modifies the strategy and tactics adopted for this period of time by the firm.

Therefore, design management is integrated as an asset that is used at the three levels of action (strategic, tactical and operational) to manage innovation through modulating its cycles of innovation and to introduce its technological development into the market. This assumption highlights three aspects; first, it presents the intrinsic need of design management to integrate design thinking into the business and to comprehend design leadership perspectives to effectively implement actions. Secondly, these results enhance and document the natural flow in the relation of design management, design thinking, and design leadership in complex environments, and uncertain and challenging internal projects. Thirdly, design management can exploit its benefits when it shares its responsibilities and actions with other areas of activity and adopted from other backgrounds that is not design. This is because design actions were delineated by a design manager but implemented, integrated and used by non-designers.

Finally, design management requires the use of diverse tools, methods and techniques to produce, collect and translate the knowledge generated into actions that lead to complete the stages of the project. This implies that it is regarded as an asset that transfers knowledge and information into tangible outcomes to satisfy the business requirements, user needs and environmental demands.

8.2.3 Conclusions: Research question 3

The results of this research reported statistically significant changes in some specific activities and outcomes in the short-term (six-to-seven months) in small Mexican technology-based enterprises in new technological industries. Nonetheless, it is important to highlight that caution must be considered with a small sample size and specific characteristics, as they might not be transferable to different type, size and regional location of businesses. The improvements experienced at the company level are related to the use of design in the alignment of strategic decisions, the recognition of abilities and capabilities required to undertake project, and the consideration of environmental conditions to promote technological developments (section 6.8.1). At the strategic level advances are associated to the increment of awareness of strategic decisions in the business and the use of design, as an empowering driving force to help in strategic thinking. At the process level changes are connected to the organisation process, as there is a major consideration of physical and intellectual activities (case 3), and to the process evaluation as they recognise the relevance of financial resources, product production, product distribution, product disposal and product recycle (case 2). The project level had enhancements in the evaluation (case 1), the organisation, the implementation and monitoring of the project (case 3), and the use of design (case 1 and 3). The result of the product/service section indicates that there was a better implementation of the basic and actual elements, and there was more acknowledge about the augmented and superior elements of the product/service. Finally, the introduction of design management provoked changes in the general culture of two case studies (case 1 and 2), and as well as transformations on culture for design in cases 2 and 3 (section 6.8.6).

It is important to note that design actions were implemented in the business with the intervention of the researcher by non-designers. This explains the reduction in the number of weaknesses that designers present in project management. Likewise, this result reveals the importance of design management in narrowing the gap between setting strategies and directing actions in the process/project (tactics). This is possible because design management is a flexible area that helps on one side to manage analytical information, and on the other side, to produce and manage creative outcomes. Finally, it is important to recognise its role in supporting the management of innovation and its process of development through the iterative, cooperative and cumulative interaction among participants.

8.2.4 Conclusions of the research problem

The results obtained to address the research problem: *Does design management improve performance of small Mexican technology-based enterprises in new technological industries when implemented within their activities?*; support the statement that design management can improve the performance of these types of enterprises. The three case studies showed an improvement in all the levels of the organisation. The findings attained, helped to present a holistic view of the impact of design management and its interrelation with other areas to achieve different results. These results are significant in at least three major aspects.

First, the implementation of design tools, methods and techniques in small Mexican TBEs influenced the way of thinking of employees (designer and non-designers) at the three levels of action in the business. Secondly, design management along with design thinking assist the owner/general manager to interconnect the scientific and technological development with the markets needs. This is in order to align the strategy of the business, its organisational structure and organisational style, and taxonomy of innovation (design leadership). Obviously, this does not imply that the business directs its strategy to compete by design, but it is used to consider a wide range of factors that are relevant when a product/service is going to be introduced into the market. Third, non-designers introduced and championed design along with the researcher within the business (except from case 3). Similarly, the people that used and integrated the design tools were non-designers (section 5.3.2). Design management had this impact because there was expertise from other areas that reduce the weaknesses that designers bring to the project (section 2.6.4.3) such as, reduced skills to communicate information with other areas (2.6.4.2), and tendency to use flexible and creative thinking rather than analytical (2.6.4.1). This means that design per se cannot improve the company neither the culture because it depends from other areas to demonstrate its own strengths, as it is part of a virtuous circle (value cycle chain). Consequently, design management requires from other areas and design specialties to deliver the values that can lead the enterprise to improve its performance. It is important to emphasise that these findings were obtained from specific types of businesses (section 6.5). Therefore, with a small sample size and specific characteristics, caution must be applied, as the findings might not be transferable to different type, size and regional locations of businesses.

8.3 Contributions to theory and practice

The research findings of this investigation have been presented within the context of study, in order to answer the research problem and the associated research questions. As a result, there are a number of implications for academia in design research and technology-based enterprise research, and for that of the practitioner.

8.3.1 Contributions to design research

The origins of design, as an economic activity, can be traced to the XVII century, and to later evolve in different cultural and social movements that encouraged the widening of its scope. Two centuries later, it became more academic because of the increasing pressure to set a basis for design practice. Obviously, design as another social science area, it is intrinsically related to the praxis and effects that external factors provoke on it as an area of study. This implies that its basis and principles are evolving continuously because its nature transcends through the understanding of its diverse manifestations and its implementation in practice. In the case of design management, there is a clear historical development in which it can be highlighted the proliferation of the awareness in the area of study (Borja de Mozota and Young-Kim, 2009). There are diverse approaches of design management within the business context, as it has been increasingly adopted by large sized enterprises and/or championed by extraordinary designers (mavericks). Nonetheless, when these novel approaches are implemented in small and medium-sized enterprises the impact of design management is not necessarily as expected (Borja de Mozota, 2006; Bruce, et al., 1999; Frias-Peña, 2005). Therefore, these researches have emphasised that it is necessary to consider new ways in which design can be adopted in these types of businesses to achieve better results.

The current body of knowledge relating to design management, explained in chapter 2, have tended to focus on implementations experienced in large and established firms rather than smaller, start-ups and technology-based enterprises (Joziasse, 2009). Recent studies and research in small and medium sized enterprises (Borja de Mozota, 2006; Bruce, et al., 1999; Frias-Peña, 2005; Peters, et al., 1999) offer some insights into particular problems faced in the internal activities of small TBEs. For example, Candi (2007) has done research concerning the role of design in the development of technology-based services. This investigation found that the role of design was smaller in the sense that it was used either to counteract or to exploit one or more of the distinguishing characteristics of services already developed by the business. Similarly, in the study developed by Bruce, et al. (1999) it was emphasised that design was used in specific projects. They highlighted that in order to manage it effectively in SMEs it is necessary to master three methods sourcing, briefing and evaluating design. However, this thesis research found that small Mexican TBEs use design at the strategic, tactical and operational level. In particular, it was discovered that these businesses consider different design strategies. For example, they use design externally (strategic) to build a brand and internally (tactical and operational level) to reduce cost. Also, it was perceived that designers (in-house and external) are involved in the new product/service development processes and projects. For instance, they were responsible for one complete phase, such as prototype and modelling phase. Finally, design was also contemplated in the final product/service, the results shows that the outcomes fulfil all the basic and actual elements, and in a limited extent, few elements at the augmented and superior level.

Furthermore, the fact that design management research has been largely drawn from studies based on larger and established firms rather than small and start-ups (such as TBEs) reflects the traditional linear relationship between the different levels of implementation and its timing of execution. Correspondingly, research in new product development (section 2.6.4.2) mentions the connection between the firm's pre-established corporate strategy and the new product strategy and resulting NPD activities (Balachandra and Friar, 1997; Cooper, 1990; Cooper and Kleindschmidt, 1995). Nevertheless, this research found that corporate strategy development and NPD activity occur in parallel and overlapping manners, and the operational activities have an impact on the reshaping and evolution of the corporate strategy. Hence, the case studies implemented design management at the three levels of action to support the transference of the scientific and technological knowledge into a marketable product/service. This was possible because design management was part of a multidisciplinary team that amalgamates knowledge to traduce the scientific and technological knowledge into a product/service that meet the business requirement, market needs and environmental demands.

Finally, this study contributed to provide a holistic perspective on the use of design management, and above all, enhance the intrinsic relationship of three lines of research in design: design management, design thinking and design leadership. The study of design management in small sized organisations has focused on implementing specific design activities such as industrial design, graphic design, product design, web design, among others specialities to improve operational activities. Identically, research suggested that design under the direction of non-designers could not provide a design proposition that impacts the business in the short, medium and long-term. However, this study provides a different perspective, it presented an integrated holistic use of design management. The design weaknesses widely divulged in the literature (section 2.6.4) were reduced, as design management implementations were directed and championed by non-designers. In addition, it reported the intrinsic need of design management to integrate design thinking in the business in order to adapt to a design leadership perspective in small Mexican TBEs. It was documented in this research, the natural flow in the relation between design management, design thinking and design leadership in complex environments and uncertain and challenging internal projects.

8.3.2 Contribution to technology-based enterprises research

Research in TBEs has been increasing in the last three decades in developed nations. These studies have focused on defining the characteristics of TBEs (Camacho, 1998; Fariñas and Lopez, 2007; Little, 1977; Perez and Marquez, 2006; Olalde, 2001; Storey and Tether, 1998), their taxonomy of innovation (Tidd, et al., 2005), and the tangible and intangible factors that drive their scientific and technological development (Merino and Villar, 2007). Nonetheless, research in Mexico is limited and there is no information about how these enterprises undertake their activities and face specific challenges with respect to their technological developments. This research produced a detailed account of the conditions in which these types of businesses operate. Thus, it was possible to produce a framework (design toolkit) in which TBEs can assess their condition, abilities and capabilities of their different levels of implementation. Another important contribution refers to the description of the different strategies that these businesses use to maintain operational running. On one side, they develop technological developments, and on the other side, they offer a series of services that can be related, or not at all, to their expertise. Interestingly, these organisations survive through offering services that are not related to the generation of technological innovations in their core competences.

This research documented that the strategies of small Mexican TBEs in new technological industries are modified according to the experiences encountered externally (PEST) and internally (operational) during the technological development. This infers that the strategy is reshaped according to the external and internal effects experienced by the business rather than evolving as the company grows. The findings of the research also emphasised the management of innovation. It has been recognised in the literature (section 2.2.1.2 and 2.6.4.2) that small enterprises, including TBEs, do not appear to have a formal new product development process, and thus organisational structures in turn makes it difficult the management of innovation. Nevertheless, this research noticed that small Mexican TBEs adopt an informal NPD process, and they are able to manage innovation through modulating the converging and diverging cycles with informal and creative tools.

8.3.3 Contributions to practice application

This research used a pragmatic worldview in order to question and to assess the relevance of previous knowledge generated on design management within the context explored. It has been argued that the impact of design management into that of a business depends on the awareness of the people that are in charge of implementing it and on designers' abilities and capabilities. Consequently, it is key to acknowledge the cultural understanding of design pursued in the host country because it is going to be possible to produce customised implementations and specific resultant improvements.

One of the most important contributions of the study is the development of a design toolkit that allows firms to undertake three actions; to assess their condition and design abilities and capabilities; to obtain results and suggestions about their condition; and to suggest a series of tools, techniques and methods that they can use and implementation on their activities. This design toolkit was elaborated in order to fit the cultural knowledge of design (management) of Mexican businesses and designers. This will allow the shaping of future lines of research in Mexico and to develop designer abilities and capabilities. Likewise, it can be used as a support for designers and managers to understand, to use and to implement design within their every day activities.

It also contributed in producing the first introduction of design management in Mexican businesses. This helped to reveal new lines of research in the country, especially in design management, design thinking, and design leadership. Identically, it produced a detailed description of small Mexican TBEs. The taxonomy developed can be useful for governmental organisations that have programs for these types of businesses, as they can provide ad-hoc support to these businesses. As well, it can help to redesign the national programmes in order to deal with the current condition of the programmes developed for this type of organisation. Finally, the data obtained can lead to encourage public institutions to invest and produce further research that support the development of new polices in technology and science.

8.4 Limitations of scope

A number of important limitations were encountered during the research. These limitations can be clustered into three groups: selection of cases, unit of analysis and methodological impact.

The first limitation concerns the selection of the pilot and principal case studies due to the subjects of study being required to fulfil the follow requirements (Table 8.2). Therefore, it was necessary to identify adequate firms for inclusion in the study, although, there was a potential limitation. There were an unknown number of small Mexican technology-based enterprises in new technological industries. Previous research documented a limited number of small Mexican TBEs, and even less that use design. Consequently, both issues were addressed by accessing the list of enterprises that are part of the program 'AVANCE' from

CONACYT, as it has the most complete list of national TBEs. The researcher went personally to each firm, before any implementation was undertaken, to explain the research purpose and to assess whether the data provided from CONACYT was accurate. In most of the cases, the firm did not fulfil the requirements established in the design strategy because the list of CONACYT was not updated. As a result, an appropriate and representative sample of target firms for this study could not be identified. Additionally, it is important to raise another issue, the number of staff employed in the principle case studies fluctuated drastically during all the pre-experiment stage and this could affect outcomes.

Table 8.2 List of requirements

List of requirements	Sub-variables
Being a technology-based enterprise	Use scientific and technology activities; innovative activities; aim to introduce (technological) innovations within the market
Small sized enterprise	Number of employees from 0 to 50
Mexican enterprise	Owned by Mexicans; National Intellectual Property (IP); Mexican workforce in its majority
Private organisation	
Use design within its activities	At the strategic, tactical or operational level; industrial design, graphic design, engineering design etc;
Active in the development of new product/services	Product; service; process
Develop innovation continuously	Radical (new to the market or new to the world); and incremental
Established in the business for more than three years	
Establish in new technological industries	Biotechnology; ecology; electronic; energy; new materials; and telecommunications

It was necessary to define the unit of analysis within the study in order to produce a pre-experiment. This is mainly due to being required to develop an instrument that lets the researcher shape the condition of the subject studied to later implement an intervention. It is important to emphasise that at the moment of the research there was not any instrument available to assess small Mexican TBEs in new technological industries. Thus, the researcher had to develop one. First, it was necessary to understand the condition of these firms to generate a taxonomy that positioned the firm according to their results. It was also important to know how design was used and which abilities and capabilities were used within the organisations. Consequently, it was necessary to produce an instrument that evaluated the condition of the firm in any productive sector of new technological industries, and its abilities and capabilities of design. After obtaining this information, it was possible for the research to fulfil its aim, which was to introduce design management actions and to assess whether these actions affected the condition of the firm. Several limitations to this pre-experiment study need to be acknowledged. The sample size is reduced because the limited financial resources and personnel resources available to undertake a major sample of case studies. Likewise, the time of the pre-experiment was short (six-to-seven months) because it was required to finish on time the collection the data to submit on time the PhD thesis.

Three major methodological concerns were also considered during the research: impact of the researcher, causality, and generalisability. The first pertains to in the influence of the researcher in the outcomes obtained due to their personal knowledge, skills or characteristics. Thus, feedback was key to reduce the potential for research bias in interpreting the impact of the development of the design toolkit and pre-experiment. Causality was another aspect that relied strongly in the feedback of the usability and usefulness of the design toolkit. Therefore, the data obtained from the design toolkit was triangulated with multiple data sources to address the issue of causality, as far as it was reasonably possible. Mainly due to the development of a new instrument, it is difficult to attribute any observed effect to the procedural intervention itself (Maslen and Lewis, 1994). The last issues relate to generalisation as this study had a limitation because it used action research and case study methodologies (Warmintong, 1980; Yin, 2003). Both methodologies focus on small number of companies and validate results through actions in the context studied. This instrument has been created to raise awareness of design issues in small Mexican TBEs in new technological industries. It is expected or desirable that all companies exhibit different performance within the different areas. Hence, different responses to questions would be attained in different contexts, sectors of new technological industries, cultures, and sizes of businesses. Nevertheless, a potential limitation of this work is that it may face difficulties to demonstrate the external validity or generalisability of the procedure (Moultrie, et al., 2006; Yin, 2003). The inclusion of a final validation phase to wider industrial feedback goes some way towards addressing this concern, as this study aimed to find funding to keep researching the design toolkit.

The last limitation is related to the researcher's knowledge and expertise to undertake the research design proposed. Indeed, the researcher required an autonomous learning to develop an understanding about the different research methods and techniques required for the investigation and to leverage her critical thinking skills. This implies that this reflective practice is composed for two interrelated components, practice and reflection. In the case of this practice based assignment was necessary assessment methods that seek to elicit evidence of both the practice performance and the reflection on that performance (Evans, 1997). Thus, the researcher experienced two kinds of reflection: 'reflection in action' and 'reflection on action'. The first occurred whilst a problem was addressed, as it exposed the crucial issue of how practitioners manipulate the gap between one specific practice interaction and the next to give them enough time for appropriate reflection (at the beginning of each phase of the research design proposed). Hence, this activity allowed the researcher to modify the already prepared research phases or interventions, and improved them according to the expertise and knowledge previously learned. The other reflection coexist on past practices due to it is attempted after the event (end of each research phase), and is consciously undertaken, and documented. This activity allowed the researcher to send feedback to previous phases to improve the overall performance of the research activities or intervention actions whilst changed the course of the follow research phases or interventions. Both practices helped the researcher to question what she knows and what she does not know, and stress how she can come to know it during the research process. In conclusion, practice and reflective appraisal are activities that are interrelated during the everyday life of a researcher. Both of them are an intrinsic part in the development of research. It can be considered that for experienced researchers both activities are unconscious, when actually these activities become natural procedure on their decision making process. Students that aim to be researchers must consider both activities as core part on their research process.

8.5 Opportunities for further research

This research employed three case studies to assess whether design management have an impact in small Mexican TBEs in new technological industries. Therefore, it is required to do further research in order to test the results obtained (theory developed) and the design toolkit produced to assess small Mexican TBEs. As a result, four suggestions for further research arising from this study are proposed.

The first suggestion deals with further research to broaden the findings in small Mexican TBEs in new technological industries. As well, it will be interesting to have longitudinal studies of five years to explore the changes experienced in the short, medium and long-term of the case studies. It is important to recommend that the next studies need regard to experiments with control and experimental groups in order to assess the differences between both groups, and then address reliability in the study. Furthermore, it is suggested to research in other developing countries to find out if there is any patterns in evidence produced, or not.

Next, it may be valuable to undertake a similar natured study being applied to large and medium TBEs in new technological industries. Then, it can be explored whether design management can have the same impact or not. Likewise, it will be relevant to discover if these types of businesses implement, integrate and use design in similar manner that small TBEs. Besides, it is interesting to explore the way in which these enterprises generate and manage technological innovations. Although, this approach may provide some difficulties to the researcher in identifying a suitable sample size of firms for the study, and then obtain permissions to explore them, as a result on the high levels of privacy and resources (financial and time) to undertake the research.

Another important line of study is to implement the design toolkit, specifically in the areas of strategy, process, project, product/service, and culture within small and medium sized Mexican enterprises. It can be compared whether design management have a similar impact in these type of businesses and small TBEs in Mexico. This research can have a major impact, as these businesses represent over 90% of the businesses in the nation. This in turn can help to support the development of the first Mexican Design Policy.

Finally, it is of main importance to pursue further research on the acquirement of tacit knowledge and the impact that this has in the unaware decisions undertaken on design (silent design), engineering, management, strategy and marketing activities by employees during the development of projects, strategic decisions and in the overall business' life. This issue is of main importance due to the knowledge produced by this type of business is lost over time with the departure of personnel or the hectic day-to-day activities. It is necessary to find new means and produce new models that help on elicit the mental process during the knowledge production and application, but also in retaining knowledge in complex environments. As knowledge is tacit in nature, and is highly particularistic. The production of further investigation will help researchers to improve the performance of businesses, as they require displaying a high degree of efficiency, adaptability and flexibility (Mott, 1972). Therefore, in order to achieve an optimal performance is important to recognise the relevance of the knowledge produced within the organization and the personnel who influences the business' decisions. As the decision-makers are the ones that undertake changes, make improvements and procure the continuous generation of innovation and record of knowledge. Consequently, throughout the understanding of different design methods, techniques and tools it can be possible to be aware about the most suitable set of actions to achieve efficiency, flexibility and adaptability in the business activities. According to Ulman (1997) these methods, tools and techniques contribute to five areas: learning, structuring information, prompt thinking, communicate effectively and manage knowledge.

8.6 Conclusions

This chapter presented the conclusions of the research problem *Does design management improve performance of small Mexican technology-based enterprises in new technological industries when implemented within their activities?*. The results of this study reported statistically significant changes in some specific activities and outcomes in the short-term (six-to-seven months) in small Mexican TBEs in new technological industries. Nonetheless, it is important to highlight that caution must be considered with a small sample size and specific characteristics, as they might not be transferable to different type, size and regional location of businesses. Three major aspects need to be highlighted. First, the implementation of design tools influenced the way of thinking of employees at the three levels of action. Second, design management along with design thinking assists the owner to interconnect scientific and technological developments with market needs. Third, the people that introduced and championed design within the business were non-designers (except for case 3). This implies that design per se cannot improve the company nor the culture because it depends upon other areas to demonstrate their own strengths, as part of a virtuous circle (value cycle chain). Consequently, design management is contingent on from other areas and design specialties to deliver the values that can lead the enterprise to improve its performance. Finally, this chapter finishes with the display of contributions to theory and practice to later establish the limitations and further opportunities of research.

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