International Journal of Humanities Social Sciences and Education (IJHSSE)
Volume 2, Issue 7, July 2015, PP 27-39
ISSN 2349-0373 (Print) & ISSN 2349-0381 (Online)
www.arcjournals.org

Unimaginable Problems and the Knowledge Creation Process Associated with Innovation in a Technology-Based Company

Antonio de S. Limongi França

Universidade Nove de Julho - UNINOVE, São Paulo, SP, Brazil.
Doctor (2013): Organizational Strategies – Innovation.
Rua Barão do Triunfo, 142, apt. 111A, Brooklin, São Paulo, SP, Brazil, CEP 04602-000.
antonio.limongi@hx8.com.br

Abstract: *The present article is based in a recent research conducted by the Author. After conducting it in a multinational company that holds a strong position in different sectors of the economy, the research identified a corporate strategic dimension, with the main objective of creating a stimulating environment for initiatives related to innovation. The research also identified eight operational dimensions typical of research in innovative product development environments. One of these operational dimensions is about the problems that may arise during the development of the product, specifically unimaginable problems, impossible to be predicted in the structuring stage of the project. This article focuses on understanding this dimension and its relevance in the context of the development of innovative products.*

Keywords: *Unimaginable problems, innovation, knowledge creation, complexity.*

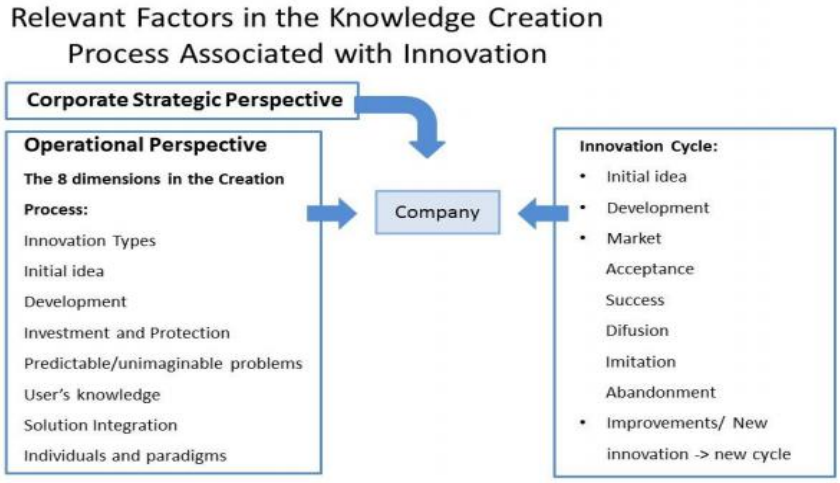
1. INTRODUCTION

The prerequisite for any innovative product development process is the perception of managers and developers that unimaginable problems may arise during the development, prototyping and the testing stages, or even during the launching of an innovative product. Such problems may take the project through unpredictable paths, creating new opportunities or difficulties, which require unpredictable solutions, so that the project is feasible. Therefore, these problems cause an impact on cost, deadlines and experiences. They may also be the cause for new research, new tests etc. They may also reduce or expand the product scope, taking it to new markets, not perceived by the developers or the strategists of the company.

This article is based on a recent research, which presents a table with nine dimensions observed in the development of innovative products in a multinational company operating in different economic sectors.

The results observed in Author's research are presented in the Relevant Factors to the Knowledge Creation Process Associated to Innovation Table:

Table1. *Relevant Factors in the Knowledge Creation Process Associated with Innovation*



As explained in Author's research, the Table presents the Organization, which has, on top, a reference to the Corporate Strategic Perspective. To the right, there is the so-called Innovation Cycle, a natural sequence of innovation in products and processes. To the left, there is the Operational Perspective of the knowledge creation process associated with innovation.

The perspective related to Corporate Strategy searches to give developers corporate tools to promote specific developments, according to quality and scale global patterns, but still paying attention to cultural patterns and legal limitations in each country where products are offered.

On the other hand, the operational perspective summarizes the various possible strategies along the way during the development process of innovative products. Such a variety of situations, which are sometimes complex, shows that the problems to be faced can be predictable or unimaginable.

The aim of this article is to understand the relevance of the so-called unimaginable problems that may arise during the development of innovative products.

Section 2 aims at developing theories which are essential to the theme, including issues on knowledge, learning, experiences, perceptions and innovation methods, themes that influence the paths to be traveled during the development of innovative products and that may lead to different solutions.

Section 3 presents the research methodology, highlighting the qualitative method of field research.

Sections 4 and 5 study the results and conclusions, with a suggestion on new research.

2. THEORETICAL REVIEW

When talking about relevant theories on technological innovation, Schumpeter (1985) affirms that it is the entrepreneur who has the task of creating innovations, which are the mainspring of Capitalism.

According to Nelson (1990), R&D activities form the base of technological innovations, mainly the research laboratory, foundation of modern Capitalism.

According to Barbieri (2003), technological innovation is the result of the generation of an idea implemented with positive results. It is important to note that innovation may occur in the product or in the process, or still in the organization or market itself. It may be continuous, an ongoing improvement, or a breakthrough innovation, that breaks paradigms and customer normal followed rules and offer value; the diffusion of innovation will occur, if there is widespread use, via licensing agreements or transfer of technology, or even through imitation.

Tidd, Bessant and Pavitt (2001), on the other hand, argue that innovation refers to various degrees in terms of novelty, in relation to changes. It may be incremental innovation, improving existing products or processes, or radical innovation, in situations where the technological base is changed, making performances better and differentiated, changing ways of thinking about a certain problem; having, therefore, a high degree of novelty.

Innovation may be imitated, diffused, but in certain circumstances, the innovative process goes the other way around, from imitation (which occurs during the diffusion stage) to innovation. Kim (2006) observes this phenomenon in South Korea.

Kline and Rosenberg (1986) highlight the existing links between different research activities and the activities developed in industrial and commercial sectors. In this model, not always basic research results in technological development. The innovation process evolves from simple techniques to more complex and sophisticated practices.

Chesbrough (2003) says open innovation is a paradigm that goes from the principle that assumes that firms can and should use external ideas as well as internal ideas. With the paradigm of open innovation, business models should use both internal and external sources of new ideas to create value, and at the same time define internal mechanisms to use some fraction of this value.

For Hippel (2005), innovation customers must be identified, for they will be the source of new ideas that will create value to the product, thus divulging the innovation, so that everyone can share the ideas that have already become innovative products and processes.

In discussing the solutions taken to customers, Sawhney et al. (2006) present a new framework, the "innovation radar", with a total of 12 dimensions of technological innovation of products and

processes. This article aims at highlighting the solutions dimension, which reflects the integration of products from different origins, so that certain technological needs are met. In Brazil, where technological resources are fewer than in developed countries, but with a growing technological competence, there is field for the development of innovations, not only and necessarily in the product itself, but mainly in the usage of the product in an integrated environment. This is what iscalled the solution innovation. Such an innovation refers to the innovation in the usage of the product, together with other products, from other manufacturers.

According to the Oslo Manual, published by OECD, in its third edition (OECD, 2005), innovation can be divided into four main types: Product Innovation, Process Innovation, Marketing Innovation and Organizational Innovation.

The Manual defines Product Innovation as the introduction of a new product or service. It is not enough to invent, improve, create or test a prototype; the product has to be put on the market. As for Process innovation, it is the implementation of a new productive process, with the actual implementation in production.

An Organizational Innovation is the implementation of a new organizational method in the firm's business practices, workplace organization or external relations. (OECD, 2005).

A Marketing Innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. (OECD, 2005).

Freeman (1995) states the relevance of understanding and valuing national or regional studies focusing on innovation, even in a global environment.

An important issue is the protection of investments made in the development of innovative processes and the sharing of economic results, respecting each one of the investors. (Leonard-Barton & Straus, 2001; Utterback, 1994).

For Nonaka and Takeuchi (1995), the innovation concept is based on a new theory of the creation of organizational knowledge based on the distinction between tacit and explicit knowledge. According to Nonaka and Takeuchi, the secret for the creation of knowledge is the mobilization and the conversion of tacit knowledge into explicit knowledge, formal and codifiable, comprising the spiral that goes from the individual to the group and the organization, reaching other organizations.

Polanyi (1964)analyzing the so-called "reality structure", says that both a mere observation that leads to scientific research and any look upon a simple act are informal, tacit forms of knowing. According to the author, *"We shall see that, beside perception and the imagination, the forming of conceptions can also involve a tacit integration of clues amounting to a structuring of reality"*(Polanyi, 1964, p. 1). Polanyi (1964) believes that every practical knowledge is developed through practical experience, whereas in science every observation comes with testing and evidences. To better explain the concept of tacit knowledge, Polanyi uses a concept from transactional psychology: *Gestalt.*

Gestalt psychology is based on the observation that we often experience different things from a simple object. A person may see a woman´s face, while an artist sees the possibility of painting an exotic figure. A child may see a ball, but his worried mother will see the danger, for the child may fall and hurt his knees.

The particularities observed, together with the specialty and the experiences of the individual who sees the object may lead to different conclusions about the same reality.

In summary, Polanyi (1964) sees tacit knowledge as personal and larger than the knowledge that can be explained with objectivity (explicit knowledge). Additionally, the parts that make up the whole are different when analyzed individually. If the parts are observed separately, the whole is missed and if only the whole is perceived, you are not conscious of the parts. Parts are of secondary importance even though they can be clearly seen.

An aspect to be considered is that we cannot affirm there is a conversion from tacit knowledge to explicit knowledge when the result is smaller than the reference. Polanyi (1964) affirms that only part of tacit knowledge is transformed into explicit knowledge.

Another aspect is that explicit, declared, formalized and codified knowledge is not, necessarily, a direct consequence of a determined initial reference, but a personal interpretation of someone who explicits something, or even the consequence of interactions among the components of a discussion group (either virtual or presential), or even the result of tests, observations and simulations. It can also be produced by a random event, a coincidence (Newell et al., 2009).

Advancing on the analysis of theories that lead us to innovation, Cook and Brown (1999) state that many current papers on the creation of organizational, capital or intellectual knowledge rest on a single, traditional understanding of the nature of knowledge. We call this understanding the "epistemology of possession," since it treats knowledge as something people possess. Moreover, the epistemology of possession tends to privilege explicit over tacit knowledge, and knowledge possessed by individuals over that possessed by groups. Organizations are better understood if explicit, tacit, individual and group knowledge are treated as four distinct and coequal forms of knowledge (each doing work the others cannot), and if knowledge and knowing are seen as mutually enabling (not competing). The authors hold that, besides these forms of knowledge, we must consider the knowledge applied to the practice of activities.

In the example of a professional fixing a car, Cook and Brown (1999) affirm that it is not enough to mention the professional´s knowledge about auto mechanics, but there is a need to understand his knowledge while he is fixing a car, in practice. This is called "knowing", an expression first used by Dewey e Bentley (1948), and it defines a concept to complement the traditional "knowledge", more static.

What is sought for is the epistemology of knowledge that leads to innovation, rooted on traditional knowledge and on knowledge based on observation and participation in real life, checking hypotheses, analyzing alternatives, experimenting, observing controlled situations or not (Cook & Brown, 1999; Newell et al., 2009).

The knowledge that comes from doing, participating in practice (knowing) is one of the pillars of organizations that learn. To use new technology, both in products as in processes, there is a need to know the subject very well, be it a product or changes in manufacturing or quality, packaging etc.(Leonard-Barton, 1995).

When discussing both process as well as product innovation, we have to observe what already exists and will be used together with something brand new (a tool, a machine, a robotized system, a basic software etc.).

Understanding in minimal details the situation that is being modified, automated or integrated is, therefore, an essential part of the activity of implementing changes. This is the activity of system analysts, production engineers, methods and process analysts etc. It is a method that has been used since the beginning of mass production, since when old handicraft stores gave way to industries and the steam machines (Prince, 1975). The main point of this argument refers to the issue of conceptual knowledge and the knowledge that is obtained in practice, while one is doing the activity, either individually or in group (Newell et al., 2009).

Another aspect of knowledge creation associated with innovation can be observed through the concepts discussed by Hildreth and Kimble (2002). These authors highlight the fact that there is knowledge that cannot be captured, since knowledge resides in people and not in machines or documents.

Leonard-Barton (1995) observes that complex machines and tools can bring within themselves some tacit knowledge, incorporated by experienced technicians who implement characteristics that are inaccessible to machine operators.

Both Hildreth and Kimble (2002) as Leonard-Barton (1995) affirm that knowledge can be developed by people working in communities of practice, in a knowledge sharing environment, where knowledge can be created, observed, developed and kept. These authors say that knowledge tends to be conceived as structured knowledge, which would be information, a dimension of knowledge, a codifiable commodity, ready to be stored and technically viable to be transferred to different physical means.

For Kuhn (2006), a research starts with individual premises, past experiences in other fields, beliefs, problems and so on. A question to be asked is: what are the researcher´s choice in the beginning of his

work? According to Kuhn (2006), scientists spend most of their time with normal science defending their principles, eliminating fundamental novelties because they cannot explain them with normal science, using the concepts of the paradigm in the area.

Kuhn (2006)identifies two characteristics in the concept of paradigm: (1) it has no precedent, so that it attracts a group of scholars who used to study other paradigms; (2) the earlier paradigm did not answer relevant questions, so the need for new studies became clear. However, at a certain moment during research, the so-called anomalies take form, when something does not work according to what theory or normal science predicts. There is also the concept of scientific revolution, which appears when professionals can no longer avoid these anomalies, leading the professionals to a new set of references and principles not comprised by normal science.

Similar to the concept of science paradigm, there is the concept of technological paradigm, developed by Giovanni Dosi (1988), which stems from a radical innovation. For Dosi (1988), a paradigm becomes dominant because of the researchers´ beliefs, the investors´ support, market research, intuition of those who have the power to decide, acceptance of a new pattern by the market, the diffusion of new technology, and even piracy, which can take innovation to new markets.

Giovanni Dosi (1988), in his study on the development of products and processes from new technological paradigms, highlights the technological trajectories related to the development of new products.

Incremental innovation follows the logic of the paradigm trajectory, improving what already exists, thus improving functionalities. Radical innovations would stem from new technologies, as a result of new scientific research; incremental innovations would come from market demands. Such considerations contribute to the notion of knowledge creation associated with innovation, for new scientific paradigms would lead to the creation of new technologies, which would be the base for the creation of new products or processes.

For Nicolsky (2010), only a small portion of inventions is related to truly new products and processes, for they require high investments in new technologies and research and development, which occurs over long periods of time. On the other hand, most inventions, or innovations, are improvements on existing products or processes, derived from market needs or internal observations.

Another relevant issue related to knowledge creation associated with innovation is debated by Utterback (1994). He affirms that what makes a company innovative will ultimately make it conservative. This is precisely what happened with Thomas Edison, who invented the incandescent light bulb, which, decades later, was substituted by fluorescent lights. Edison defended, both in the technical and the political level, the maintenance of the incandescent system and the inadequacy of the fluorescent system. For Utterback (1994), Edison had a clear position defending his product, a former innovation, against the innovations of the time, introduced on the market by new competitors.

Leonard-Barton (1995) presents an opposite view, arguing that success may lead to failure if the company does not stop its incremental innovations at the exact time their growth starts to decline.

Both Utterback´s (1994) and Leonard-Barton´s (1995) point to the moment when emergent strategies have to be considered by the company´s strategists, searching for a change in the trajectory of its product line of its productive methods. Emergent strategies become necessary when new opportunities or new problems – unimaginable – arise.

Chagas Jr. (2008), in his research on relevant issues on organizational learning in the development of high technology systems with multiple functionalities, discusses, in the China-Brazil Earth Resources Satellites – CBERS, the relevance of learning in practice, in harmony with the existing knowledge. That is so because several applied technologies, when integrated, have great potential for generating new situations, which may lead to unpredictable problems, which, in turn, may lead to new knowledge resulting from "knowing" itself, as presented by Dewey and Bentley (1948) and discussed by Cook and Brown (1999)andKim (1993).

Chagas and Campanário (2014) call "emergent properties" the problems that arise in an unpredictable way, when there is the integration of different products that had never been integrated before. That´s what happened with the telescope developed by China and Brazil. In that case, there was an unimaginable problem, as described below:

> "The infrared multispectral scanner (IRMSS) camera, which is a medium-resolution scanning imager, operates on an oscillating mirror in order to scan an image on the various optical sensors, thereby making it a camera scanner. The movement of this mirror was observed to cause certain vibrations and, by means of mechanical coupling between subsystems, made the mirror of the CCD camera become resonant, which decreased image sharpness. For CBERS 2, other tests were performed. The joint analysis of multi-disciplinary team enabled the coupling causes to be identified and removed. It is noteworthy that this phenomenon is not linear, which makes the identification of the cause and effect more subtle, since they do not operate on the same scale. To understand coupling effects and how they propagated through the system in its operational environment was an extremely challenging research effort."

Innovation treads diverse and complex paths that have, as initial base, several types of knowledge, information, among them objectives, goals, scope, several restrictions, conceptual, operational knowledge, logical, tacit, explicit principles, perceptions, experiences, learning abilities, present or virtual exchange of information among members of internal or external groups, errors, misunderstandings, trajectory changes, leadership or member changes, deadlines, costs, conflicts of ideas and ideals, different interpretations of reality. All this leads researchers to create alternatives, a prototype that will follow different paths, with new findings, predictable or unimaginable, up to the moment when one obtains the result of the research, the aim of the project, materialized in a product or process ready for the market (Mintzberg, 2000; Kim, 2006; Chagas Jr., 2008; Leonard-Barton, 1995; Utterback, 1994). One should remember that innovation is a concept to be extended to the market environment and the company itself (Chesbrough, 2008; OECD, 2005; Schumpeter, 1985).

As to the composition of development groups, participants may generate unpredictable new ideas, depending on their experiences (Leonard-Barton & Straus, 2001; Newell et al., 2009). Such a theme is related to corporate strategies, either planned or emergent (Chagas Jr., 2008; Mintzberg et al., 2000). The initial moment of the creation of an idea that leads to innovation reflects the experience and the knowledge of the members of the group, sometimes stimulating new possibilities for creation, different from the ones planned before, with the need for reviewing plans and deadlines of the project. For Mintzberg et al. (2000), innovation may sprout from emergent strategies; it can also sprout from the analysis of the market intelligence group (Rodrigues & Riccardi, 2007), as well as from external pressures from competitors (Schumpeter, 1985). Demands or comments from clients also originate innovations (Sawhney et al., 2006), as much as the experience of professionals, according to Polanyi (1964), Kim (1993), Cook and Brown (1999) and Newell et al. (2009). In sum,it is possible that unimaginable situationscan take the company to a new level of competitivity.

Influential authors in the academic world, Nonaka and Takeuchi (1995) believe the board of directors of a given company should be responsible for the initiative of technological innovation, and specialists should just put into action what the board has already imagined and planned.

On the other hand, Sawhney et al. (2006) and Chesbrough (2008) believe development groups should include several partners, with no prejudice, as long as these partners collaborate in giving decisive contributions to the process and the product. Clients, suppliers, scholars, competitors sometimes, all should participate in the development stage, what makes it even more complex, taking the process to unimaginable possibilities.

3. RESEARCH METHODOLOGY

At first, the researcher articulated theories, studying several authors. Later, in field research, the researcher used the qualitative method approach, with the survey of multiple cases, having as base the theories of both Yin (2010) and Eisenhardt (1989).

The reason for the use of multiple cases in the original research is that, despite the fact that the research deals with a single company, it includes specific cases, with different participants, with different cultures and business configurations, each one unique. The cases were studied with the developers, technicians and project managers in an individual and specific manner, with an initial semi-structured questionnaire, according to applied methodology (Flick, 2009; Vieira, 2004; Yin, 2010). For Biancolino (2010, p. 146), "A case study may comprise multiple cases. In Administration, some examples are the study of innovations introduced in different areas of the same company, where each area is viewed as a unique case, or the comparison of operational strategies among different industries in the same field."

From the research questions that served as basis for the original research, the researcher starts his field work with the Technology and Innovation Director of a multinational company with headquarters in Brazil for many decades.

The researcher analyzed five different innovative development cases:

- A product designed for the electric power distribution sector, developed with a client.
- An integrated software system, with the possibility of connection, in real time, with sensors and actuators, to optimize resources such as energy, water, gas etc., developed with the collaboration of several countries, and with custom made finalization for each client. In Brazil, there was a partnership with a local university.
- An integrated action and control system of a GPS positioning equipment for use in high seas.
- An electromechanical component for large-scale production.
- A business unit to develop innovation together with partner start-up companies.

The first stage of the original research focuses on the dimension of corporate strategies as support for the development of innovative processes and products. After conducting interviews and proposing questionnaires, the conclusion of this stage was the reading of the company´s internal newspapers and journals, when the researcher understood the set of corporate strategic initiatives that stimulate an environment that leads to internal innovation, which, on its own, can be defined as organizational innovation.

The operational dimensions were analyzed according to the same procedures (questionnaire, interviews, internal material research etc). Such contents are found in Author's research, with the following denominations:

Strategic Dimension A – Innovation: Strategic Perspective of the Company;

Operational Dimension B – Types of Innovation;

Operational Dimension C – Initial Moment of the Creative Process;

Operational Dimension D – Product Development and Implementation Stage (End result of the Project)

Operational Dimension E - Investments and creations: Legal Protection and Economic Returns;

Operational Dimension F – Predictable Problems and Unimaginable Problems;

Operational Dimension G – Knowledge and Information available to the user;

Operational Dimension H- Solution Integration;

Operational Dimension I – Individuals and Paradigms – specific contributions.

Based on Author´s research, this article presents an overview of the meaning of the analyzed dimensions.

Dimension A (Innovation: Strategic Perspective of the Company) focuses on the understanding of the strategic mechanisms of stimulus to innovation in a multifaceted environment: different countries and cultures with different products for different economic sectors (Schumpeter, 1985; Utterback, 1995; Chesbrough, 2008, among others).

Dimension B (Types of Innovation) searches for the understanding of the theoretical nature of innovation designed for each analyzed case, from an almost imperceptible innovation to a radical innovation (Kuhn, 2006; Dosi, 1988; Kim, 2006; Nicolsky, 2010, among others).

Dimension C (The Initial Moment of the Creative Process) reflects the initial moment of a product or process project that can be a future and crucial innovation. This moment marks how the innovation started, showing the various strategic theories related to the innovation (Schumpeter, 1985, Mintzberg et al. (2000); Rodrigues & Riccardi, 2007; Sawhney et al., 2006; Polanyi, 1964; Kim, 1993; Cook e Brown, 1999; Newell et al., 2009).

Dimension D (Product Development and Implementation) deals with the developments that lead to innovation, presenting, in a general way, a well-behaved version, in the theoretical line of Nonaka and Takeuchi (1995), but, at the same time, presenting deeper issues (Nelson, 1990; Sawhney et al., 2006; Chesbrough, 2008; Utterback, 1994; Mintzberg et al., 2000; Leonard-Barton & Straus, 2001; Chagas Jr., 2008; Chagas Jr. and Campanário, 2014).

Dimension E (Investments and Creations: Legal Protection and Economic Returns) analyzes the investment issue and its associated returns, which require protection to the shared information, the obtained knowledge, inventions and other novelties inherent to the development and research process (Utterback, 1994; Leonard-Barton & Straus, 2001; Chesbrough, 2008).

Dimension F(Predictable Problems and Unimaginable Problems) analyzes the problems that may arise in practice, both in the testing and simulation stages and in the actual usage of the product or process, due to the fact that several things may occur in a different way than what was planned or discussed. That may happen because some situations, when integrated or analyzed together create new opportunities or restrictions, sometimes unimaginable. This dimension will be articulated in detail in the next section.

Dimension G (Knowledge and Information Available to the User) deals with the knowledge and information available to the user and indirectly aims at protecting the investments made. Due to some technology transfer contracts, many times the user does not have access to the knowledge, formulas, etc., that are part of the intelligence of the product, process or software (Dewey e Bentley, 1948; Dosi, 1988; Utterback, 1994; Leonard-Barton, 1995; Kim, 2006; Cook and Brown, 1999; Nelson, 1990; Chesbrough, 2008).

Dimension H (Solution Integration) deals with the integration of solutions stemming from different products and components, of different origins. It also deals with the limits of the product and the participation of users in its creation (Sawnney, Wolcott and Arroniz, 2006).

Dimension I (Individuals and Paradigms) points to the basic question of the original research, searching to retrieve from the respondents the individual perception and contribution on the knowledge acquisition process associated to innovation in a technology-based company, where products and processes are, most of the times, integrated and used together with products from other manufacturers. This is to show that nothing happens in an isolated way, but together with several technologies from specific researches, using varied paradigms (Kuhn, 2006; Dosi, 1988; Ashby, 1970; Chagas Jr., 2008; Dewey and Bentley, 1948; Utterback, 1994; Leonard-Barton, 1995; Cook and Brown, 1999; Hildreth and Kimble, 2002).

The studied theories are the starting point for the questionnaire. The questions and answers are the basis for the set of conclusions presented in the research. This article highlights the results and the conclusions of the Operational Dimension (F), related to the predictable problems and the unimaginable problems.

The survey and analysis stage used the non-linear process method, as suggested by Lima (2010) and Eisenhardt (1989), adjusting to the concept proposed by Yin (2010) on the study of multiple cases using the qualitative method. In sum, as the research progressed, there was a review of the data, analyses, comparison of practical questions with studied theories and a reflection on the new set of data and available information.

Based on the articulated theories, the questions referring to the original research, specifically about this theme are:

- During product development, were there any unpredictable problems? If the answer is yes, how were they solved?
- In the testing and simulation stage, were there any unpredictable problems? How were they solved?
- In the actual use stage, on the market, were there any unpredictable problems?
- How were they solved?
- Could they have been avoided?

- What are the reasons why these unpredictable problems couldn´t have been avoided?
- Was the implementation of the product treated differently in different cases?

Other questions of the original research, relevant to the present theme, are:

- If the research team had had other components, with different profiles (in relation to the actual members of the team) can we say the results would have been different? Why?
- Were some of the ideas abandoned without much attention? We are talking about
- The ideas outside of the dominant paradigms in the area.
- Were there themes that were left aside because of conservative views after the innovation took place?

4. ANALYSIS AND DISCUSSION OF THE RESULTS

During Author's research, two questionnaires were prepared. The first questionnaire, related to the strategic dimension of the company, was answered by the Technology and Innovation Director, and was complemented by an Innovation Specialist. This questionnaire dealt with themes related to the company´s strategies regarding innovation and the operational incentives. It also dealt with the strategies that led to the creation of a collaborative environment in a global corporate sphere.

The second questionnaire, related to operational dimensions (eight dimensions), aimed at understanding the dynamics of each case studied.

Table 1 is a synthesis of the research done about the relevant factors in the understanding of the knowledge creation process associated to technological innovation.

4.1. Strategic Perspective

Before proceeding to analyze the operational dimension highlighted in this article, it is necessary to summarize the observations on the strategic dimension, fundamental to the creation of a development environment in a company.

With Author (2013), it is observed that the company has a global information and knowledge sharing tool, available to the company´s research team members. It´s a virtual platform for the management of explicit knowledge, with the possibility of having information on diverse experiences according to theme communities created by the users themselves. If an urgent question arises, it´s possible to send an *"Urgent Requests*" message to the theme team members. Such a tool can be used to search for items not available in the catalog, but available in a faraway place from where the problem is.

On the other hand, such a virtual environment does not contemplate issues related to uncodifiable individual experiences, be they tacit or acquired through practice.

The Technology and Innovation Director informs that there is no standardization in the innovation initiatives, and that innovation may sprout from different origins. However, there is a systematic discussion about future scenarios, and that is the moment for inside and outside specialists to freely participate.

Another strategic direction is to encourage the collaborative research of people from other countries and sectors of the organization, thus stimulating a creative and innovative environment.

On the theme of open innovation, the organization focuses on partnerships with universities, research centers, other large companies and even with novice entrepreneurs who may contribute strategically. There is still the typical research of the market intelligence sectors, which observes what is being done by other companies and research teams.

It is fundamental to observe the direction regarding quality and production scale: every product should be developed to meet the needs of the countries where the company is and to comply with the laws of each country.

4.2. The Dimension of Unimaginable Problems

Having these strategic considerations in mind, this item studies the operational dimension of unimaginable problems.

- A product designed for the electric power distribution sector, developed with the client.
- An integrated software system, with the possibility of connection, in real time, with sensors and actuators, to optimize resources such as energy, water, gas etc., developed with the collaboration of several countries, and with custom made finalization for each client. In Brazil, there was a partnership with a local university.
- An integrated actuation and control system of a GPS positioning equipment for use in high seas.
- An electromechanical component for large-scale production.
- A business unit to develop innovation together with partner start-up companies.

In developing the product for the first case, with the participation of the client, some predictable problems occurred, but there were others that weren´t even imagined when the product was first conceived. In this case, the product was a submersed equipment and, when positioned, it created a spiral magnetic field around it. The solution, after research, tests and simulations, generated an industrial patent and made the product a market reference. Another unimaginable problem occurred at the time the prototype was being tested in an environment that simulated the real world. At this point, the client´s technician was substituted and a new technician demanded dimensional changes in the product, which delayed delivery, increased costs and required new molds to manufacture the changed parts. In other words, new people led to new situations, producing an effective impact on the project.

Regarding the software integrated system, several problems occurred, such as: How to take energy to the tip of a perforating drill, kilometers below the earth surface? Or: how to run an electric train through an area under a conservation easement where cables aren´t allowed? One of the interviewees affirmed that many opportunities that come up during the project execution and weren´t thought of beforehand end up being neglected because of deadlines and costs.

As to the integrated actuation and control system of a GPS positioning equipment, unimaginable problems arose, which were analyzed and solved by the product development teams. The teams were made up of people from the academic field as well as from other large company, active in other economic sectors that would also take advantage of the new product.

For the development of the electromechanical component, a partnership was established with a national competitor who had specialists in the mechanical items of the product to be developed. That was an important strategy because, at that moment, when the market needed a product like the one developed with the partner company, the researched company had no available technicians.

The company being analyzed had the electromechanical technology and the laboratories for the tests. With the partnership, the product was developed and during the testing stage several unimaginable problems arose, which created a new industrial patent and a patent to protect the new product´s design. With that, the team spotted a novel use for the product – new usages in new markets, an unimaginable thing at the product conception.

The fifth case is about an organizational innovation that was entirely planned from the beginning, but that during the implementation stage had to go through unimaginable paths, given the circumstances. There was the need for new partners with new technologies and new products, which could improve the strategies of the company, but that would require some changes in the developing of some existing products. There were people who hadn´t been chosen initially to participate in the projects but, due to the unavailability of the initial team members, gave their personal contribution to the projects. Such situations corroborate the theories presented in this article. (Polanyi, 1964; Cook and Brown, 1999; Leonard-Barton and Strauss, 2001; Chagas Jr., 2008; Newell et al., 2009 and Chagas and Campanário, 2014).

Rodrigues, Heringer and França (2010) highlight the case when a product, developed by a high-technology company, operating in several countries, presented an unimaginable fault, despite the tests and simulations during the product´s development stage. A slight dimensional error,almost imperceptible, in the development of the product, when analyzed in the client´s perspective, created very relevant consequences.

5. CONCLUSION

The knowledge creation process associated to innovation in a technology-based company, when stimulated and made viable by adequate corporate strategies, can bring relevant results for the company. In the operational level of each product development and innovative process, among the several dimensions to be observed, the dimension of unimaginable problems must have special attention from managers and developers. During the product development period, or at its launching, new situations may occur, either due to technical restrictions or new problems seen by new team members, or even due to opportunities that should be considered, thus changing the initial project in a relevant way.

The researcher suggests a specific study directed to the development of complex products, according to the theories articulated by Chagas and Campanário (2014), as in the case of the development of nuclear plants, great bridges or tunnels, trains and high speed freeways etc.

ACKNOWLEDGEMENTS

Specialthanksto Katia de Brito Pereira for thesupport in thelanguageandto Thaís Pereira Stegun for thetechnicalsupport.

REFERENCES

Ashby, W. R. (1970). *Uma introdução a cibernética* . São Paulo: Perspectiva.

Barbieri, J. C., & Alvares, A. C. T. (2003). Inovações nas organizações empresariais. In J. C. Barbieri (Ed.), *Organizações inovadoras: estudos e casos brasileiros* (2nd. ed.). São Paulo: FGV Editora.

Biancolino, C. A. (2010). *Valor de uso do ERP e gestão contínua de pós-implementação: estudo de casos múltiplos no cenário brasileiro* (Tese de Doutorado). Universidade de São Paulo, São Paulo. Retrieved from http://www.teses.usp.br/teses/disponiveis/12/12136/tde-29112010-152921/

Chagas Jr., M. F. (2008). *Criação e exercício de capacitações em integração de sistemas: explorando interações entre formas de aprendizagem tecnológica - o caso do programa CBERS.* (Doctoral Dissertation). Instituto Tecnológico de Aeronáutica, São José dos Campos.

Chagas Jr., M.F.; Campanário, M. A. (2014). *Systems Architecture, Procedural Knowledge and Learning by Using: Implications on Systems Integration Capabilities.* BAR, Rio de Janeiro, v. 11, n. 1, art. 1, pp. 1-21, Jan./Mar. 2014. Retrieved from: http://www.anpad.org.br/bar.

Chesbrough, H. W. (2003). The era of open innovation. *Managing innovation and change*, *44*(3), 35–41.

Chesbrough, H. W. (2008). *Open Innovation*. Oxford: Oxford University Press.

Cook, S. D. N., & Brown, J. S. (1999). Bridging epistemologies: The generative dance between organizational knowledge and organizational knowing. *Organization science*, *10*(4), 381–400.

Dewey, J., & Bentley, A. F. (1948). Knowing and the known. Retrieved July 3, 2011, from https://www.aier.org/sites/default/files/otherpublications/KnowingKnown/KnowingKnownFullText.pdf

Dosi, G. (1988). Sources, procedures, and microeconomic effects of innovation. *Journal of Economic Literature*, *26*(1), 1120–1171.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of management review*, *14*(4), 532–550.

Flick, U. (2009). *Uma introdução à **pesquisa** qualitativa* (3a. ed.). Porto Alegre: Bookman.

Freeman, C. (1995). The National System of Innovation' in historical perspective. *Cambridge Journal of economics*, *19*(1), 5–24.

Hamel, G., & Prahalad, C. K. (2005). *Competindo pelo futuro*. Rio de Janeiro: Campus.

Hildreth, P. M., & Kimble, C. (2002). The duality of knowledge. *Information Research*, *8*(1), 8–1.

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

Kim, L. (2006). Da imitação à inovação: a dinâmica do aprendizado tecnológico da Coréia. *Revista de Economia Política*, *26*(4). Retrieved from http://www.scielo.br/scielo.php?pid=S0101-31572006000400012&script=sci_arttext&tlng=es

Kline, S. J., & Rosenberg, N. (1986). An overview of innovation. *The positive sum strategy: Harnessing technology for economic growth*, *14*, 640.

Kuhn, T. S. (2006). *A estrutura das revoluções científicas* (9th ed.). São Paulo: Perspectiva.

Leonard-Barton, D. (1995). *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*. Harvard Business School Press.

Leonard-Barton, D., & Straus, S. (2001). Aproveitando Todo o Cérebro da Empresa. In *Gestão do Conhecimento* (5th ed.). Rio de Janeiro: Campus.

Lima, E. (2010). Teorizando a partir de dados qualitativos em administração. *Revista Pretexto*, *11*(1), 73–93.

Lopes, P. P. (2009). Inovação distribuída e a distribuição da inovação. Retrieved October 6, 2009, from http://conhecimento.incubadora.fapesp.br

Maccari, E. A. (2002). *Gestão do Conhecimento em Instituições de Ensino* (Dissertação de Mestrado). Blumenau.

Maccari, E. A. (2008). *Contribuições à gestão dos programas de pós-graduação stricto sensu em administração no Brasil com base nos sistemas de avaliação norte americano e brasileiro* (Doctoral Dissertation). Universidade de São Paulo, São Paulo.

Mintzberg, H., Ahlstrand, B., & Lampel, J. (2000). *Safari da estratégia*. Porto Alegre: Bookman.

Nelson, R. (1990). O Capitalismo como motor do progresso. *Research Policy*, 193–214.

Newell, S., Robertson, M., Scarbrough, H., & Swan, J. (2009). *Managing Knowledge Work and Innovation*, (2nd ed.). New York: Palgrave Macmillan.

Nicolsky, R. (2010). Modelo dinâmico para inovações tecnológicas. In S. R. H. Parolin & H. C. Oliveira (Eds.), *Inovação e propriedade intelectual na indústria* (Vol. IV, p. 278). Curitiba: SENAI/SESI.

Nonaka, I., & Takeuchi, H. (1997). *Criação de Conhecimento na Empresa – Como as Empresas Japonesas Geram a Dinâmica da Inovação*. Rio de Janeiro: Campus.

OECD. (2005). Manual de Oslo: diretrizes para coleta e interpretação de dados sobre inovação, (3). *Retrieved* from www.mct.gov.br

Polanyi, M. (1964). The Structure of Tacit Knowing. Retrieved July 3, 2011, from http://www.missouriwestern.edu/orgs/polanyi/mp-structure.htm

Prince, T. R. (1975). *Sistemas* de *informação: planejamento, gerência e controle* (Vol. 1). São Paulo: USP.

Rodrigues, L. C., Heringer, B. H., &França, A. L. (2010). Padrões de Inovação em Multinacional de base tecnológica. *Revista Inteligência Competitiva*, *7*(3), 198–204.

Rodrigues, L. C., & Riccardi, R. (2007). *Inteligência Competitiva nos Negócios e Organizações*. Maringá: Unicorpore.

Sawhney, M., Wolcott, R. C., & Arroniz, I. (2006). The 12 Different ways for Companies to Innovate. *MIT Sloan Management Review*, *43*(3).

Schumpeter, J. A. (1984). *Capitalismo, socialismo e democracia*. Rio de Janeiro: Zahar Editores.

Schumpeter, J. A. (1985). *A Teoria do Desenvolvimento Econômico* (2nd. ed.). São Paulo: Abril Cultural.

Tidd, J., Bessant, J., & Pavitt, K. (2001). *Managing Innovation: integrating technological, market and organizational change.* (2nd ed.). UK: John Wiley & Sons.

Tigre, P. B. (2006). *Gestão da inovação no Brasil*. Rio de Janeiro: Campus.

Utterback, J. M. (1994). *Mastering the Dynamics of Innovation*. Harvard Business School Press.

Wiener, N. (1954). *Cibernetica e sociedade: o uso humano de seres humanos* (4th ed.). São Paulo: Cultrix.

Yin, R. K. (2010a). *Estudo de caso: planejamento e métodos* (4th. ed.). Porto Alegre: Bookman.

AUTHOR'S BIOGRAPHY

Antonio de S. Limongi França

Universidade Nove de Julho - UNINOVE, São Paulo, SP, Brazil.

Rua Barão do Triunfo, 142, apt. 111A, Brooklin, São Paulo, SP, Brazil, CEP 04602-000.

Professor at Vanzolini Foundation /Universidade de SãoPaulo/Sâo Paulo, Brazil, CEAI course, Strategy and Innovation Management discipline. Expert in Strategic Brand Management / Branding by the São Paulo Rotarians Foundation (MBA). Master in Political and Economic Law from Mackenzie Presbyterian University. Doctor in Business Administration/Strategies in Organizations/Innovation UniversidadeNove de Julho

Author of scientific articles, book chapters and updater of legal works. Author of *The Small and Micro Enterprises in Brazilian Law*, Jurua publisher. Graduated in Law, Faculty of Law, University of São Paulo (1985). Graduated in Business Administration from current Universidade Católica de Santos (1976).

ACKNOWLEDGEMENTS

Special thanks to Katia de Brito Pereira for the support in the language and to Thaís Pereira Stegun for the technical support.