SPATIAL AND ORGANIZATIONAL DYNAMICS

DISCUSSION PAPERS

Entrepreneurship and Organizations

Nº7

June 2011

Knowledge Management in Tourism Organisations: Proposal for an Analytical Model
Gestão de Conhecimento em Organizações Turísticas: Proposta de um Modelo de Análise
Bernadete Dias Sequeira and João Filipe de Jesus Marques

Infrastructure and Infrastructuring as a Bridge Between Information Systems Design and Organization Design
Infra-estrutura como Elo de Ligação entre o Desenho de Sistemas de Informação e o Desenho da Organização
Rodrigo Magalhães

Collaborative Methods for Busines Process Discovery
Métodos Colaborativos para a Descoberta de Processos de Negócio
Marielba Zacarias and Paula Ventura Martins

The Blessings of Vintage: Exploring Technological Change Made by Users of Discontinued Home Video Games Hardware
As Maravilhas do Vintage: Explorando a Mudança Tecnológica Realizadas por Utilizadores de Hardware de Videojogos Descontinuado
Jorge Graça

UAlg UNIVERSIDADE DO ALGARVE

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Entrepreneurship and Organizations

Texts by:
Bernardete Sequeira
João Filipe Marques
Jorge Graça
Marielba Zacarias
Paula Ventura Martins
Rodrigo Magalhães

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cieo@ualg.pt
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TABLE OF CONTENTS

Authors Presentation 5

Knowledge Management in Tourism Organisations: Proposal for an Analytical Model 7

Bernadete Dias Sequeira
João Filipe de Jesus Marques

1. Introduction 8
2. Learning Knowledge 9
3. Organisational Knowledge Management 13
4. Enabling Knowledge Management 19
5. Conclusion 29

Infrastructure and Infrastructuring as a Bridge Between Information Systems Design and Organization Design 32

Rodrigo Magalhães

1. Introduction 33
2. The Planning Bias of Traditional Organization Design Theory 34
3. The Problem with Information Systems Design 35
4. Information or Digital Infrastructures 35
5. Organization Designing and Systems Infrastructuring 36
6. A Framework for Organizational Infrastructuring 39
7. Conclusion 42

Collaborative Methods for Busines Process Discovery 45

Marielba Zacarias
Paula Ventura Martins

1. Introduction 46
2. Business Process Discovery Methods 47
3. Methodology 47
4. Mapa – Tool for Business Process Discovery 52
5. Conclusions and Future Work 54

The Blessings of Vintage: Exploring technological change made by users of discontinued home video games hardware 56

Jorge Graça

1. Introduction 57
2. Literature Review 58
3. Home Video Games Industry Dynamics and the Emergence of the Angry Orphans 62

4. Exploring the Blessings of Vintage: technological change made by users of discontinued home video games hardware 66
5. Conclusions 73
Annex A 78
Annex B 79
Annex C 83

Normas Editoriais/Editorial Norms 85/88

AUTHORS PRESENTATION

Bernardete Dias Sequeira (bsequei@ualg.pt)

Bernardete Sequeira is an assistant at the Faculty of Economy - University of Algarve. She holds a degree in Sociology from the University of Évora, an equivalent to a master's degree in management and information systems. She is a PhD candidate in sociology at the Faculty of Economy - University of Algarve. Her research interests are in the fields of the Sociology of Work and of the Organizations, Human Resource Management and research methodology.

João Filipe Marques (jfmarq@ualg.pt)

João Filipe Marques, researcher of the CIEO, holds a Degree and a Master in Social Anthropology, and a PhD in Sociology by the École des Hautes Études en Sciences Sociales of Paris. He is Assistant Professor at the Faculty of Economics of the University of Algarve and Director of the Sociology Master Program. He has been teaching Social Sciences and Sociological Theories since 1994 and is main field of research has been the Sociology of Racism and Ethnicity. He is the author of the book Du «non racisme» portugais aux deux racismes des Portugais, (Lisboa, Alto Comissariado para a Imigração e Diálogo Intercultural, 2007) as well as of several articles on the subject of racism in contemporary societies. Recently he has been teaching the course of Sociology of Tourism in the Sociology Program of the University of Algarve.

Jorge Graça (jorge.graca@gmail.com)

Jorge Graça holds a MSc. in Innovation, Knowledge and Entrepreneurial Dynamics from Aalborg University, and a BA in Economics from the University of Algarve. He worked at the Directorate-General for Budget of the European Commission, and later at the Permanent Representation of Portugal to the EU as Deputy of the Industry Department, during the Portuguese Presidency of the European Council in 2007. He was a Technology Transfer Officer at the Division of Entrepreneurship and Technology Transfer of the University of Algarve, coaching technology-based start-ups and University-Enterprise R&D consortia for several years. His research interests are the History and the Design of Technologies.

Marielba Zacarias (mzacaria@ualg.pt)

Marielba Zacarias is a Computer Engineering (1982) with a MSc degree in Systems Engineering (1996), and a PhD in Informatics and Computers Engineering (2008). She has a professional experience of over 25 year in the Information Systems field. She is now an assistant professor of Electronics and Informatics Engineering Department and member of Research Centre for Spatial and Organizational Dynamics (CIEO), at the Algarve University. Her research interests include organizational modelling and ontologies. She has published several scientific papers, participated in several international program committees and co-organized several scientific events related to these topics.

Paula Ventura Martins (pventura@ualg.pt)

Paula Ventura Martins is an assistant professor of the Electronics and Computers Engineering Department of Faculty of Sciences and Technology, University of Algarve, and she is also a member of Research Centre for Spatial and Organizational Dynamics (CIEO). She has a PhD degree in Computer Science and Engineering from IST/ULT. In 2000, she got the Master's degree in Computer Science and Engineering from FCT/UNL. She concluded her undergraduate course in Computer Science and Engineering on 1992, in the same institution. Her personal interests are Software Process Improvement, Software Development Processes, Workflows and Modelling Languages.

Rodrigo Magalhães (rodrigo.magalhaes@inov.pt)

Rodrigo Magalhães is currently Professor of Information Systems and Organization at the Kuwait-Maastricht Business School (KMBS) in Kuwait, where he previously held the post of Academic Director. KMBS is a private graduate school affiliated to the Maastricht School of Management in the Netherlands. He was formerly with the School of Management and Economics at Catholic University of Portugal, where he was responsible for the launching of the Information Management stream of the MBA programme. He holds visiting positions at the Department of Computer Science and Engineering, Instituto Superior Técnico, Lisbon, Portugal and at the Instituto Superior de Ciências do Trabalho e da Empresa (ISCTE) also in Lisbon, where he lectures regularly in postgraduate programmes. Prof Magalhães is the Editor-in-Chief of the International Journal of Organization Design and Engineering and has published extensively in the areas of information systems management, organizational change, knowledge management, organization learning, business process management, e-HRM and e-learning. He holds a PhD (Information Systems) from The London School of Economics, an MBA from Sheffield University, an MA (Information Science) from Leeds Metropolitan University, UK and a BA (Psychology) from the University of Natal, South Africa.

KNOWLEDGE MANAGEMENT IN TOURISM ORGANISATIONS: PROPOSAL FOR AN ANALYTICAL MODEL

GESTÃO DE CONHECIMENTO EM ORGANIZAÇÕES TURÍSTICAS: PROPOSTA DE UM MODELO DE ANÁLISE

Bernadete Dias Sequeira
João Filipe de Jesus Marques

ABSTRACT

Tourism is an activity-based service sector in which information and knowledge are fundamental to developing realistic strategies and business plans. This article presents a model that was developed in an investigation called "Organisational Knowledge Management in Tourism Organisations," which was part of a doctoral degree in Sociology, Faculty of Economics, University of Algarve. This study investigated how Algarve tourist organisations manage knowledge by observing how they create, retain, share and use it. This empirical research is based on a study of three cases that used documental investigation, interviews and questionnaires and the analytic model that is introduced here. We present an analytic model that identifies the different stages of knowledge management (acquisition / knowledge creation, retention / storage, transfer / sharing and use) and the management practices that facilitate it (strategic management, organisational culture, structure and work processes, human resource policies, information systems and communications, evaluation of results and relationship with the environment outside the organisation) based on learning promotion.

Keywords: Knowledge, Organisational Knowledge Management, Facilitating Practices.

RESUMO

O turismo é um sector de actividade baseado em serviços, no qual a informação e o conhecimento são fundamentais para definir estratégias e planos de negócio adequados à realidade. O presente artigo consubstancia-se na apresentação de um modelo de análise desenvolvido numa investigação designada "Gestão do Conhecimento Organizacional em Organizações Turísticas", conducente à obtenção do grau de Doutor em Sociologia, na Faculdade de Economia da Universidade do Algarve. A investigação tem como objectivo analisar como organizações turísticas no Algarve gerem o seu conhecimento, ou seja, observar a forma como criam, retêm, partilham e utilizam o conhecimento. A investigação empírica a levar a cabo basear-se-á no estudo de três casos através da investigação documental, da realização de entrevistas e da implementação de questionários, tendo como pano de fundo o modelo de análise que aqui se expõe. Nesse sentido, elaborou-se um modelo de análise que identifica as diferentes fases do processo de gestão do conhecimento (aquisição/criação do conhecimento; retenção/armazenamento, transferência/partilha e utilização) e as práticas de gestão facilitadoras do mesmo (gestão estratégica, cultura organizacional; estrutura e processos de trabalho, políticas de recursos humanos, sistemas de informação e comunicação, avaliação de resultados e relação com o ambiente externo da organização) com base na promoção da aprendizagem.

Palavras-chave: Conhecimento, Gestão do Conhecimento Organizacional, Práticas Facilitadores.

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1. INTRODUCTION

In the first half of the twentieth century, the world economy was based on industrial production. However, starting 50 years ago, the importance of the tertiary sector as a lever for economic development increased. The 1990s were marked by the dominance of the service sector over other sectors because technological development radically altered information processing, thus allowing the incorporation of large amounts of information. Thus, information and knowledge have taken on a central role in the economy in relation to capital, raw materials and even work.

The sociologist Daniel Bell, (1973), who pioneered the conceptualisation and systematisation of the concept of post-industrial society, refers to the shift from an economy based on the production of goods to an economy where services gain momentum. In this scenario, theoretical knowledge functions as the central generator of innovation and change and leads the ideas that inspire the community.

According to Kaplan and Norton (1997), one of the most radical changes in management thinking in recent years was the transformation of the role of workers from providing physical labour to performing increasingly abstract data analysis.

The traditional factors of production - land, labour and capital - have not disappeared but have become secondary. They can be easily obtained when there is knowledge. Thus, Peter Drucker (1996) also refers to a "knowledge society" as the "society of organisations" in which the purpose and function of each organisation, whether corporate or not, is the integration of expertise in tasks.

The challenge for organisations is the development of teams, collective or organisational knowledge learning and knowledge management (Kluge, Stein and Licht, 2002). These practices foster many opportunities for professional development and encourage people to collectively develop and share skills, thus encouraging cooperation in the workplace. Knowledge management is inextricably linked to organisations' abilities to utilise and combine the various sources and types of organisational knowledge to develop specific skills and innovative capacity. This knowledge can then be translated into new products, processes and market leadership (Nonaka and Takeuchi, 1997).

Thus, tourism faces a similar challenge to that faced by other service sectors. Society and markets require the rationalisation of resources and improved efficiency, which puts enormous pressure on all public and private organisations. The improvement of work processes and management of people and their knowledge, supported by modern information systems, are necessary to create the appropriate mechanisms to achieve those aims.

This article is situated in the field of research known as "Organisational Knowledge Management in Tourism Organisations" and is the final stage in a doctoral degree. This research integrates empirical research from a number of hotel organisations using the analytical model that is presented here.

"The problems of understanding what knowledge is, how it is to be justified and its extent and permanence have been the subject of vigorous philosophical debate for many thousands of years" (Spender, 2001: 35). Therefore, this article will first discuss knowledge

to clarify three theoretical approaches: the theory of knowledge, the sociology of knowledge and organisational approaches. Second, we present the analytical model, which aims to understand the structure and dynamics of knowledge management in organisations.

Thus, we present a proposal for an analytical model, still under construction, which identifies the different stages of knowledge management and management practices that use the promotion of learning to create the conditions that facilitate organisational learning.

Given the complexity of the structural contexts and decision-making and the dynamics of interaction between the organisational actors, the processes of knowledge management are quite varied. Therefore, in this model, we try to account for the multifaceted characteristics of management knowledge and its practical significance. The two major axes of the model (stages of knowledge management and practices to facilitate knowledge management) do not exist in isolation. Rather, they complement each other and are essential for a comprehensive approach to knowledge management.

2. LEARNING KNOWLEDGE

The problem of knowledge caught the attention of the pre-Socratic philosophers, Heraclitus and Parmenides as well as Sophists, Socrates, Plato and Aristotle. In modern history, the fields of knowledge and science have gained particular importance. The theory of knowledge, along with the problems of rationalism and empiricism, became a central theme only in the Modern Age.

The Theory of Knowledge investigates issues arising from the relationship between the subject and object of knowledge and the basic conditions for true knowledge. This theory, seeking "an explanation or philosophical interpretation of human knowledge" (Hesse, 1978: 25), has explored issues concerning the nature, sources and validity of knowledge. It tries to answer questions such as the following: What is knowledge[1]? How do we reach it? Can we achieve the means to defend it against scepticism? These issues are as old as philosophy. The History of Philosophy from the Greek period can be seen as a process that seeks the answer to the question: what is knowledge? However, the definition of knowledge is far from logically perfect, so there is scepticism in the pursuit of knowledge in philosophy (Nonaka and Takeuchi, 1997). This issue has led many philosophers to seek a method that establishes a "truism".

The rationalism-empiricism controversy has been one of the most persistent debates in the history of philosophy. It was overcome by the Kantian synthesis that, among the more radical positions, used pure rationalism or empiricism as pure intermediate positions and attempted to reconcile this dualism.

According to contemporary rationalism, reason plays an important role in cognitive processing, which is the main source of knowledge (Hesse, 1978). Rationalists assume that the knowing subject is active and that to create a representation of any real object is to submit it to the structure of the subject's ideas. That is, true knowledge is not a product of sensory experience, but a mental process that brings absolute truth through rational argument based on axioms (Nonaka and Takeuchi, 1997).

According to contemporary empiricism, sense experience is the source of all knowledge. Knowledge about things, even one that seeks to elaborate universal laws from experience, therefore, is only valid within the limits of the observable. Empiricists deny the existence

[1] The philosopher John Locke, in his "Essay Concerning Human Understanding" published in 1690, is a systematic approach to the issues concerning the origin, nature and certainty of human knowledge. Leibnitz, in his book "New Essays on Human Understanding, " published posthumously in 1765, sought to refute the epistemological perspective of Locke. On the conclusions reached by these two philosophers, other thinkers developed their ideas in England, including George Berkeley in his "Treatise of the Principles of Human Knowledge" in 1710 and David Hume in his works "Treatise of Human Nature" in 1739 - 40 and "Research on Human Understanding "in 1748. Also, Immanuel Kant, with the publication of his seminal book "Critique of Pure Reason" in 1781, sought to find a critical foundation of scientific knowledge of nature, which is the logical validity of knowledge (Hesse, 1978).

of innate ideas, as advocated by Plato and Descartes, and consider that the mind is empty before it receives any sensory information. Reason is merely an organisation of sensory data, and ideas or concepts of reason are simple copies or combinations of data from this experiment.

The historic debate between rationalists and empiricists led to intermediate positions that sought to overcome the limitations of both philosophical positions. So-called intellectualism, with origins in Aristotelian thought, recognises the existence of the "truths of reason" and, moreover, gives intelligence a positive function in the act of knowing. That is, reason does not contain universal truths as ideas but can reach them using particular facts that coordinate the intellect. Thus, the intellect draws together concepts of reality based on real images. "Thus, the experience and thinking exactly form the basis of human knowledge" (Hesse, 1978: 75).

There was a second attempt to reconcile rationalism and empiricism by the German philosopher Immanuel Kant (1724-1804). His critical theory used experience and thought as sources of knowledge. However, the concept of the a priori inverts the relationship between experience and thought. That is, thought is not passive before experience; it is active and consists of elements a priori knowledge, independent of experience, conceived as forms that allow for ordering the jumble of sensations in space and time (Hessen, 1978). In this view, knowledge begins with experience, but it is organised by the a priori structures of the subject. According to Kant, knowledge is the synthesis of the information in our senses (phenomenon), and our understanding produces itself (concepts) (Kant, 1997).

Comte, in his discussion of the positive method of science, added to rationalism and empiricism. He treated theory as a way to organise facts in a relevant way for scientific use (Giddens, 1998). Although Comte adopted a fundamentally empiricist point of view, systematic observation distinguishes science from other types of positive claims to knowledge. This difference is dependent on the evidence of sense perception, which is considered the basis of certainty in science (Giddens, 1998). Rationalism, in turn, only deals with the organisation of select facts into theories, and these facts establish the link with laws or universal propositions.

One objective of the general theory of scientific knowledge is situated among other possible forms of knowledge. Are there knowledge processes that use different pathways from those used by science? Some authors propose directing our intellectual faculties to the "intuition of essences" and establishing a phenomenological science beyond scientific facts (Blanche 1988). Phenomenology attempts to describe, understand and interpret the phenomena that appear to perception and proposes to end the separation between subject and object (as opposed to positivist thought of the nineteenth century). It examines reality from the perspective of the first-person. Its aim was to demonstrate that true knowledge is perceived in things themselves and is not a mere reflection of a pre-existing awareness, which determines in advance the kind of potential knowledge (Manheim, 1986), as in the Kantian approach.

The phenomenological approach to sociology was verified through the work of Austrian Alfred Schütz, who stood at the crossroads of Weber's sociology and Edmund Husserl's phenomenological philosophy (Corcuff, 2001). In Weber's sociology, the meaning and significance of things may arise from social work or when the protagonist of the action gives meaning to the subjective thought and behaviour. By understanding human and social facts, Weber developed the foundations of a comprehensive or interpretative sociology.

The Sociology of Knowledge was introduced by the German philosopher Max Scheler, in the 1920s. However, the origins of the Sociology of Knowledge are in German thought from the nineteenth century, including Marxism, Nietzsche's thought and historicism (Berger

and Luckman, 2004)[2]. The roots of the Sociology of Knowledge may be found in Marx, who argued that man's consciousness is determined by his social being. This subject included some of Marx's key concepts, including ideology (ideas that serve as weapons for social interests), false consciousness (thought that is alienated from the true social thinker) and infrastructure structure/superstructure or reification. According to Marx, human thinking is grounded in human activity (work) and the social relations produced by this activity. Thus, infrastructure is human activity, and super-structure results from the thought produced by such activity. Thus, the economic infrastructure of society determines its ideological superstructure and its legal, political and religious make-up.

It should be noted that Scheler was interested in the Sociology of Knowledge. He aimed to establish a philosophical anthropology using different perspectives that accounted for specific location, and historical and social levels (Berger and Luckman, 2004, 19). Hence, Scheler argued that the relationship between "ideal factors" and "real factors" (terms reminiscent of Marx's concepts infrastructure/ superstructure) was just an adjustment. The "real factors" regulate the conditions under which certain "ideal factors" appear in a story (Manheim, 1986), but not its content. That is, society determines the presence but not the nature of ideas (Berger and Luckman, 2004: 19).

However, the perspective of Karl Mannheim[3], viewed by many as the founder of the Sociology of Knowledge, is much broader than that of Scheler. According to Mannheim, context determines not only the appearance but also the content of ideas. Mannheim returns to historical materialism, claiming that knowledge is historically relative and socially relative; in other words, it is conditioned by certain aspects of social being, particularly social classes (Mannheim, 1986). He argues that the elements of a group cooperate and compete in organised groups that have different influences according to the position of the groups, changing societal issues and the continuity of given conditions. Thus, according to a group's desire to change or maintain such collective activity, we encounter problems, concepts and modes of thought. The competition over the construction of various modes of thought influences the emergence of new knowledge and the ways in which it develops. That knowledge controls the economic market, the course of political and social events and reveals the various interpretations of the world as expressions of intellectual groups struggling for power.

Berger and Luckman (2004) move away from Mannheim and Scheler's ideas and the neo-positivist orientation. They believe that the question of ideas, including ideology, is only part of the wider problem of the Sociology of Knowledge. This discipline should "take care of what is considered" knowledge "in society" (Berger and Luckman 2004: 26), which is what men know as reality in their daily lives. This knowledge constitutes the construction of meanings without which no society could exist.

Peter Berger and Thomas Luckman used phenomenological constructivism, clearly influenced by the thought of Alfred Schutz, to extend the Sociology of Knowledge to common knowledge (i.e., the processes of social construction of knowledge in everyday life. Thus, the sociology of knowledge must deal with the variety of empirical knowledge in human societies and the processes by which any body of knowledge is established as "reality" (Berger and Luckman, 2004). It is important to understand the processes by which human knowledge develops and is transmitted in social situations, which crystallise reality for the common man and are taken for granted.

The epistemologist Thomas Kuhn (1996) made an important contribution, but more importantly, he legitimised the social relevance of content (beliefs, values, consensus), in

[2] The book *The Social Construction of Reality* was published in 1966.

[3] Currently associated with the sociology of knowledge due to the work of Karl Mannheim, as a result of the full translation of his work into English. Scheler's work on the sociology of knowledge has never been translated. The formulation made by Manheim in the sociology of knowledge remains the reference for this subject area.

many cases a key factor for the validity of discoveries in science. According to this argument, the scientific community as a group, at certain times in its history, adopts a set of shared beliefs, values and techniques, which become the paradigm (or programme) for the acceptance of scientific knowledge.

Therefore, paradigms are reflected in organisational settings, in literature and in accepted practices and are shared by various communities that research, teach, work and comment on theories of organisations (Magalhães, 2005). In the last 50 or 60 years, there has been a shift in thinking about organisations. According to Magalhães (2005), the old paradigm behind the mechanistic metaphor is grounded in the classical theories of Taylor (1914), Fayol (1949), Weber (1947) and more recently in the systems theory of Von Bertalanfy (1950) and the theory of decision-making by Herbert Simon (1945). The new paradigm is based on explaining the complexity of the mechanisms that develop collective cognition, or organisational culture, and self-referential social systems that are in permanent state of change. The theoretical proposals of Nonaka and Takeuchi (1995) about the creation and development of knowledge management in organisations, along with those of other authors, are currently accepted by the academic community. It can be said that the new paradigms for "organisations" and "organisational knowledge" are intimately intertwined (Magalhães, 2005).

2.1 Organisational Knowledge

To define organisational knowledge, it is important to differentiate data, information and knowledge. It is not easy to disentangle these three concepts, which often are correlated and even overlap. *Data* are facts about events and objectives. They describe what happens and do not include value judgments or interpretations. According to Davenport & Prusak (2003), in an organisational context, data are often described as structured records of transactions.

The attribution of meaning to data and its relationship to a context and its interpretation transform them into *information*. According to Peter Drucker (1993), information differs from data because it has meaning, relevance and purpose. For a set of data to be *information,* there must be relationships between the data or between the data and other information. It is the result of a combination or organisation of data that allows us to draw conclusions about a particular phenomenon (Fialho and Serrano, 2003).

People continuously transform information into knowledge; they make comparisons, analyse consequences, look for connections and talk to others about the information received. These actions result in the accumulation of knowledge, which increases the individual capacity of transforming data into information to create knowledge for future action.

However, both information and knowledge are closely linked to the production context and social relationships because they are created through social interactions. Berger and Luckmann (2004) argue that people construct social knowledge, which influences their attitudes and behaviours through interaction and information sharing in a particular historical and social context.

Similarly, Karl Wiig (1999), another author who distinguishes knowledge and information, says that knowledge consists of truths, beliefs, perspectives, concepts, judgments, expectations, methodologies and *know-how*. It is organised, integrated and accumulated over long periods to be applied in specific situations. The information, in turn, consists of facts and data that are organised to describe a particular situation. Applied knowledge is used to interpret information about a situation and to manage it. In this perspective, knowledge is information applied to action and appears in individuals' routine practice and behaviour (Fialho and Serrano, 2003). Therefore, in organisations, knowledge is often embedded not only in documents or repositories but also in routines, procedures and norms (Davenport

and Prusak, 2003). It therefore has a dual nature because, in formal procedures, it is implicit and explicit in people and products.

Nonaka (1991) and Nonaka and Takeuchi (1997) recognise the distinction between tacit and explicit knowledge and draw on Polanyi's theory of knowledge, explained in his book *Knowing and Being*, published in 1969. According to Nonaka and Takeuchi (1997), there are two types of organisational knowledge: tacit and explicit. Tacit knowledge involves a technical dimension - *know-how* - and other cognitive models, beliefs and perceptions. Such models are difficult to demonstrate, but they exert a profound influence on how we perceive the world. The technical dimension includes personal skills and knowledge related to the action of an individual in a specific context, such as an art or profession, a particular technology or market or even the activities of a group or team. In turn, the cognitive dimension includes items such as intuitions, emotions, schemas, values, beliefs, attitudes, skills and "premonitions". These elements are embodied in individuals and determine how they act and behave. They are the filters through which people perceive reality.

Brown and Duguid (2001) treat knowledge in organisations as a social practice. Most of the practices in which people are involved, in particular working practices, are ultimately social practices that bring people together through interdependent activities. Thus, the available knowledge in a group, although often invisible, is collective[4] and may give rise to what Weick and Roberts (1993) refer to as aspects of a collective mind. This type of knowledge is revealed through practice rather than in the statements. It is distributed because it often requires several members of a group to perform a task. Also, it is partial because it is unlikely that any member of the group has all the knowledge. Finally, it may be improvised because each group member spontaneously adapts his activity to the others, following a basic script. Despite attempts to reduce unpredictability, not everything is predictable because workers adapt to various situations.

From the individual standpoint, knowledge originates in and is applied to the human mind. From the perspective of organisations, knowledge resides in documents, routines, procedures, practices and norms (Loureiro 2003). However, above all, knowledge is reflected in the organisational development of new products and services, in making decisions in relation to customers, in the formulation of strategies and so on. According to Nonaka and Takeuchi (1997), this knowledge is the result of the dissemination of knowledge by individual organisational structures.

3. ORGANISATIONAL KNOWLEDGE MANAGEMENT

In our literature review on organisational knowledge, we found that some authors define it as an object to be created, purchased, possessed or sold or as something like a machine, a building or another organisational asset. Other authors support this idea and focus on the process of knowledge creation. This approach leads us to the concept of knowledge management, viewed as a published and explicit knowledge that is embedded in the practices of an individual or collective organisation. From this perspective, knowledge is seen as a process and not as a product (i.e., a process that involves the individual and social processes of creativity, innovation, motivation and communication). This issue covers a broad and complex field of research.

The field of Knowledge Management is explored in several scientific areas, including Information Science, Psychology, Sociology, Business Studies, Organisation Studies, Strategic Management, Computer Science and Information Systems, among others. Under Organisational Theories, knowledge management is the organisational

[4] Indexing in the sense of ethnomethodology.

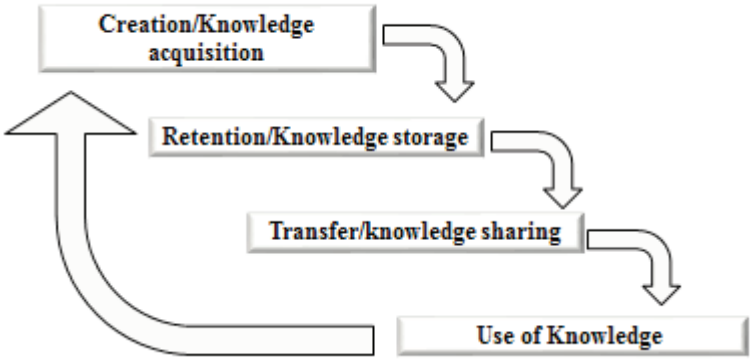
capacity to develop, innovate and enhance competitiveness. From this perspective, knowledge management is a management context where knowledge is used. Researchers such as Nonaka and Takeuchi (1997), Davenport and Prusak (1998) and Bukowitz and Williams (2002) have tried to understand the processes of organisational learning through well-defined stages, in which they analyse various management practices that improve procurement processes and the encoding, transfer and use of knowledge in an organisational context. The models designed by these authors can be termed Models of Knowledge Management.

3. 1 Processes of Knowledge Management

Research interest in the concept of knowledge management does not mean that the conceptual frameworks are clearly defined. Most theoretical approaches use multidimensional characteristics that are difficult to identify. In this sense, we tried to develop an analysis model to identify the different stages of knowledge management and the management practices that facilitate this knowledge, based on the promotion of learning because "managing knowledge is to create conditions that facilitate organisational learning "(Loureiro, 2003: 63).

The model, at the various stages of knowledge management, is based on the complementarity of several theoretical approaches to build an analytical framework that can address different processes in knowledge management, as shown in Figure 1. In addressing the practices that facilitate knowledge management, we adopted the thesis of Claudio Terra (2001) and developed it with other theoretical perspectives.

Figure 1 - Processes of knowledge management

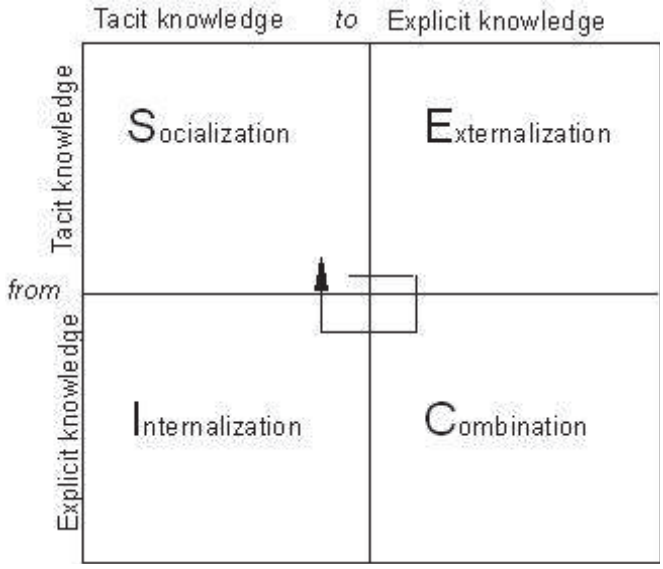


Source: Authors' (2011)

3.1.1 Creation and acquisition of organisational knowledge

Nonaka and Takeuchi (1997) are considered pioneers in research on the creation and use of knowledge in organisations. They created the analytical model of organisational knowledge creation called the "knowledge spiral", which enhances and integrates the various types knowledge. These authors showed that innovation and the creation of new knowledge derives from organisational transformation, or the conversion of tacit knowledge into explicit knowledge (Nonaka and Takeuchi, 1997: 11).

Figure 2 - Spiral of organisational knowledge creation



Source: Adapted from Nonaka and Takeuchi, (1997)

The combination of these two categories of knowledge highlights four modes of knowledge conversion (socialisation, externalisation, combination and internalisation), through which tacit and explicit knowledge spreads (Nonaka and Takeuchi, 1997).

Socialisation is the process of sharing or creating tacit knowledge between individuals through the development of shared experiences, observation, imitation and practice.

The process of explanation is the articulation and externalisation of tacit knowledge into explicit knowledge. It becomes codified and transmissible through formal language that can be easily understood by others. When it is made explicit, tacit knowledge can be shared and then becomes the basis of new knowledge.

Combination is the dynamic process of creating new tacit knowledge from explicit knowledge that already exists, giving rise to new concepts and ways of working. The combination is a process of systematisation of explicit concepts, at the organisational level more than the group level (Julian, 2009).

The main issues in combination concern the processes of communicating, disseminating and systematising knowledge. Therefore, networks and computerised data may be catalysts in this type of conversion (Nonaka, 1994).

The internalisation process is the incorporation of explicit knowledge in the form of tacit knowledge. In practice, the internalisation process has two dimensions. Firstly, explicit knowledge in the behaviours and practices of organisational members is incorporated in the form of mental models, cognitive structures or shared technical knowledge (know-how). Secondly, explicit knowledge is incorporated through the use of simulation programmes or projects that promote the various processes of learning through practice (learning-by-doing) and enable the learning of new concepts and working methods.

Each mode of knowledge conversion creates a different knowledge content. Socialisation generates what might be called "shared knowledge" because mental models or technical skills are shared. Outsourcing generates "conceptual" knowledge. Combination gives rise to "systemic knowledge." Internalisation produces "operational knowledge" about project management, production processes, new products and policy implementation (Nonaka and Takeuchi, 1997).

The creation of knowledge is thus a continuous and dynamic process between tacit and explicit knowledge. It involves fluctuations between the four modes of knowledge conversion and is like a spiral of knowledge that gradually extends the base of organisational knowledge. This process can expand to the organisation's external environment to the extent that it can interact with other organisations, leading to the creation of new knowledge.

Davenport and Prusak (1998), in turn, consider five methods for intentional knowledge acquisition, resource dedication, fusion, adaptation and knowledge networking. The most direct and usually the most effective way to acquire knowledge is to buy an organisation or to hire the individuals who own it. Increasingly, companies are acquiring others because of their knowledge. Moreover, knowledge can be leased or financed. An organisation can financially support a research institution or university in exchange for the right of priority in the commercial use of their results. Hiring a consultant to conduct a project is renting a source of knowledge. Contrary to the rental of tangible goods, knowledge implies a degree of knowledge transfer, but it represents only a small portion of the knowledge held by experts.

Another way to create knowledge is to direct resources to train units or groups with a specific purpose. Research departments are examples of this method. Mergers bring together people with different perspectives to work on a problem or project and encourage them to reach a common answer. This practice brings together a variety of talents and experience and increases the chances of a successful outcome (Davenport and Prusak, 1998). However, the "creative abrasion or merger requires some commonality" (Davenport and Prusak, 1998: 74), so group members must develop a common language to understand each other. Thus, some shared knowledge is necessary for the collaboration, such as a common object or concept to unify the efforts of the group.

Adaptations imposed on organisations, which are driven by changes in competition, new technologies and social and economic change, encourages the creation of knowledge. Informal networks of knowledge within organisations, such as communities of practice, promote the sharing of common knowledge to communicate and cooperate. The continuity of a network may well lead to new knowledge.

According to Beckman (1997), the creation of new knowledge can have many sources of inspiration and involves various activities, such as learning, creative thinking, research, experimentation, discovery, innovation, customer observation, causal analysis, benchmarking and process improvement projects. Experts' nonverbal and unconscious knowledge in specific areas is also a valuable source. Crucially, at least in today's technological environment, only humans can create knowledge.

3.1.2 Retention and storage of knowledge

Storage aims to reduce the loss of knowledge that is related to individuals' specialties and experiences in an organisation. Thus, knowledge storage seeks to represent an organisation's collective memory to facilitate its accessibility and thus transforms the assets into explicit and formalised knowledge. Both individual and team knowledge holders will add little to the organisation if there are ways to share this same knowledge (Beckman, 1997). Thus, the purpose of coding is to transform organisational knowledge into a code to make it explicit, portable, organised and as intelligible as possible to those who need it (Davenport & Prusak, 1998). According to the authors, it is necessary to follow the principles of coding to keep a certain structure of knowledge:

- Define the business strategy for the codified knowledge;
- Identify the existing knowledge as a way to achieve business objectives;
- Assess knowledge in terms of usefulness and appropriateness for codification;
- Identify a means of coding and appropriate distribution.

The mapping of the sources of organisational knowledge is an important part of the encoding process and can be developed through technology. The development of a knowledge map involves locating important knowledge in the organisation and publishing a list or table showing where to find it (i.e., people, documents and databases). A knowledge map may also function as an inventory and can be used to assess the stock of organisational knowledge and identify its strengths and weaknesses. Patents and the textual representation of a process or product developed by experts and inventors, reports and other structured documents are forms of codified explicit knowledge.

The codification of tacit knowledge in organisations is often impossible to reproduce in a document, which reduces, generally, the location of the knowledge to one person and provides an incentive for the owner to interact with others. Although it is difficult to codify tacit knowledge, this effort may be profitable for the organisation because the loss of those who hold the knowledge threatens the intellectual capital of the organisation. Thus, the organisation should seek to develop strategies to disseminate this knowledge. Thus, an organisation can target its knowledge processing into two broad classes: integrative (structured repositories for managing explicit knowledge) and interactive (allows interaction to integrate tacit knowledge) (Davenport & Prusak, 1998).

According to Terra (1999), every worker should contribute to the knowledge base and strategic knowledge of an organisation through appropriate processes and supporting technologies. A shared classification of information between areas, regions and departments is essential in facilitating collaboration, but it is not sufficient for the full use of information systems. There must be a policy to develop skills in using information technologies, with a particular focus on new, Internet-based technologies. These tools can promote virtual collaboration, research, access and sharing through the publication of information in a web environment.

3.1.3 Knowledge transfer and sharing

Sveiby (1998) states that a unique characteristic of knowledge is that the more it is shared and used, the more valuable it becomes. Davenport and Prusak (1998) argue that knowledge is transferred in organisations, regardless of whether the management process is conscious. According to the authors (1998, 107), the "spontaneous and unstructured transfer of knowledge is vital to the success of a company." However, specific strategies to encourage knowledge transfer are necessary for organisations that prioritise the creation and management of knowledge.

Davenport and Prusak (1998) identified some processes that promote the transfer of knowledge. To encourage the sharing of tacit knowledge among workers, the authors, like Nonaka and Takeuchi (1997), emphasise the system of staff rotation, which enables workers to understand the development of new products and / or services. However, the authors caution that methods of knowledge transfer must be compatible with organisational, and even national, culture. Davenport and Prusak (1998) consider that spaces for knowledge transfer are another way of transferring knowledge. Bars, cafes or restaurants in an organisation allow conversations to occur between employees and are places where "people are wondering about on-going projects, exchange ideas and ask advice on how to solve problems" (Davenport and Prusak, 1998: 110). It is likely that these group settings generate more creative solutions than isolated workers can, fully occupied with their individual tasks. Other ways to promote knowledge sharing are places and occasions for employees to interact, including walking, face-to-face meetings, fairs and forums.

The transfer of tacit knowledge generally requires more intense personal contact. This transfer may occur through partnerships, orientations for younger employees or training involving the transfer of tacit and explicit knowledge.

Information technology may also be an infrastructure for the transfer of tacit knowledge. Possible strategies include intranets, databases that link up workers who wish to share information, knowledge maps, videoconferencing systems for teamwork and video or CD-ROM recordings of the experiences of senior workers.

A common language is an important aspect in the success of any proposed knowledge transfer (Davenport and Prusak, 1998). People who share a common culture communicate better and transfer knowledge more effectively than those who do not.

Resistance to change and the need for mutual trust are equally important. Physical proximity promotes a common language and mutual trust. According to the authors referred to above, the transfer of knowledge involves the transmission and assimilation of knowledge. The mere existence of knowledge transfer does not necessarily mean that knowledge will be absorbed or that changes will occur in organisational behaviour, which is how knowledge is actually used. However, there are several factors that lead to the non-use of knowledge: distrust of the source of new knowledge, pride, stubbornness, lack of time, lack of opportunity or fear of risks. People tend to resist any change that requires the abandonment of skills, on which their competence and well-being at work depend.

Davenport and Prusak (1998) report that knowledge transfers must account for "transfer speed, i.e., the speed with which knowledge moves the organisation" (1998: 124) and the viscosity (i.e., the richness or thickness) of the knowledge transferred[5]. These two factors help to determine the efficiency and utilisation of organisational knowledge. However, the authors point out that speed can decrease viscosity, so it is important to reconcile these two factors.

Information should also be shared with external agents, due to the growing interdependence of partners, suppliers and customers. Obviously, this process requires a pre-definition of what can and should be shared externally. The protection of sensitive information by password mechanisms, encryption and restrictions on the distribution, circulation and printing of files are part of large organisations' knowledge management (Terra, 2007). The existence of (safe) virtual spaces [6] to exchange information and knowledge with various external agents (suppliers, partners, customers and others) tends to improve communication and increase trust and agility. These spaces can also boost innovation and improve services to customers. Achieving value through these relationships leads an organisation to invest in better management for the exchange of information and knowledge.

3.1.4 Use of knowledge

After locating and obtaining knowledge, an organisation faces the challenge of applying it to specific situations to meet the demands of its customers (Bukowitz and Williams, 2002). At this stage, the central issue is the innovative application of knowledge to create greater value for the customer.

Innovation refers to how an organisation combines information in new ways to create alternative solutions to problems. "The organisation may provide the means to enhance creative thinking, but the key is to establish an environment where creativity, experimentation and openness to new ideas are encouraged" (Bukowitz and Williams, 2002).

The use stage of knowledge complements knowledge sharing, which will only reach its maximum value if it is applied in a specific situation. Applying knowledge implies mobilising it to make decisions, perform tasks, solve problems, research ideas and learn. Therefore, the organisation must understand the objectives of its users and their context. Experts from different fields should add to the knowledge repository and provide support for employees through formal training, advice and instructions to improve workers' expertise and performance (Beckman, 1997).

[5] These factors are particularly influenced by the method of transfer. For example, knowledge conveyed through an orientation process or learning will have more viscosity than knowledge obtained through a database (Davenport and Prusak, 1998).

[6] Examples of virtual spaces for cooperation: digital library, list of contacts, internal networks, forums, systems and reporting mechanisms and even workflow.

The challenge is to integrate learning into people's work. Peter Senge (1998) has focused on this issue; he states that the key issue is to make learning happen and generate profound changes in the ways people think and interact. The five components (which he describes as subjects) of instruction that provide organisational learning when developed together are the following: systems thinking, personal mastery, mental models, shared vision and team learning.

This process resists short-term thinking and encourages a structured debate that has long-term benefits.

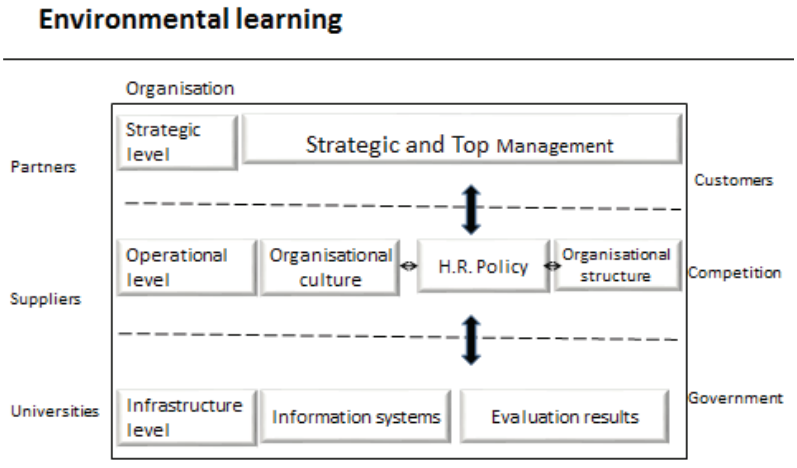
Undoubtedly, some organisations have been effective in creating or acquiring new knowledge. However, they are less capable in applying knowledge to their practices. Without making the necessary changes to their working methods, these organisations will be unable to create organisational learning. Continuous improvement requires effective engagement with learning.

4. ENABLING KNOWLEDGE MANAGEMENT

Little and Ray (2005) reported that the scholarly and practical interest in knowledge management began with the convergence of different perspectives: information management, organisational learning, strategic management, innovation management evaluation and management of intangible assets.

In this line of thought, Terra (1999), in his doctoral thesis, identified several practices (or enabling conditions) that are associated with innovative learning organisations[7]. The author concluded that knowledge management involves the adoption of management practices that are compatible with individual learning processes and the systemic combination of efforts in various organisational dimensions, including strategy, human resource policies, organisational culture, organisational structure, information systems, evaluation of results and the external environment[8].

Figure 3 - The seven dimensions of knowledge management



Source: Adapted from Terra (2001)

[7] The author sought to draw a cognitive map of the "enabling conditions" and the management practices of companies that take an innovative or proactive management of knowledge. After an exhaustive review of the literature, the author developed a model called the model of the seven dimensions of knowledge management, relating to different areas of management, including the practices that facilitate the process of knowledge management. The model was tested in 587 Brazilian companies.

[8] This approach is associated with the five organisational conditions or management practices that, according to Nonaka and Takeuchi (1995), facilitate the knowledge conversion modes, including organisational intention, autonomy, fluctuation and creative chaos, redundancy and a variety of other requirements.

4. 1 Strategy and Top Management

According to current theories of strategic management, knowledge in organisations is a key factor in transforming strategic imperatives into final results. Knowledge is understood as the only factor that can ensure lasting success in terms of effectiveness and market differentiation (Magalhães, 2005). It is, in effect, a strategic imperative.

Furthermore, Nonaka and Takeuchi (1997) argued that the most critical element of an organisational strategy is defining the kind of knowledge to be developed and its implementation in a system of management. The strategic objective, termed by the authors "intention," is the most important criterion for evaluating knowledge. The formulation of an organisational intention, when communicated, stimulates the commitment of individuals. They can reorient their thinking and behaviour with a collective approach that is based on the organisation's core values and, in particular, knowledge creation.

In knowledge management, there must be a consensus on an organisation's skills and abilities to facilitate the development of business strategies in line with them. Thus, top management should define the knowledge areas in which employees of the organisation should focus their learning efforts (Terra, 2001). It is important that organisational units know what information and knowledge they need to acquire, manage and disseminate to achieve their goals.

Thus, Terra states that knowledge gaps should be identified systematically and strategically to align knowledge assets and organisational processes with actual needs. Gaps in knowledge may include team skills and abilities, external information about markets, industries, trends and areas of expertise (internal and external) (Terra, 2007). The dimension "knowledge" should be incorporated into the strategic planning of the organisation, including, for example, highlighting actions to improve specific skills, hiring employees with profiles, experience and strategic skills and encouraging the sharing of best practices, protection and retention of knowledge and strategic skills. This strategy guarantees that key skills will be available in the future and that key knowledge is widely used in the organisation.

Leaders play a central role in setting challenging goals and creating an organisational culture that is focused on innovation, experimentation, learning, long-term results and the optimisation of various organisational areas (Terra, 2001). Leaders who communicate and share information and knowledge demonstrate that this attitude is valued in the organisation. It is essential that managers are available and collaborative and that they listen, encourage their teams to share knowledge and show their concern for employee development.

4. 2 Organisational Culture

Organisational culture can be defined as a set of core values and standards of behaviour that govern interactions and work in organisations (Schein, 1999).

According to Davenport and Prusak, "the adoption and application of new knowledge can be slow and arduous, and the success rate is highly influenced by company culture" (1998: 125).

Bukowitz and Williams (2002) state that the promotion and enhancement of knowledge sharing establishes an atmosphere of confidence and encourages contributions to organisational knowledge.

The feeling of trust between the workers in an organisation stimulates innovation and willingness to take risks and creates a more cooperative environment (Terra, 1999).

To encourage the sharing of knowledge is important to have a clear understanding, based on a set of standards that incorporates the expectations of knowledge sharing, to promote a reciprocal agreement between the individual and the organisation and between individuals themselves.

If workers perceive that the organisation wants to take ownership of their knowledge without any kind of return, they tend to feel threatened and uncooperative about sharing knowledge.

In the context of knowledge management, trust between people is related to the level of competence of each individual, willingness to share information expressed by colleagues, constructive criticism and the perception that the disagreements are resolved in a transparent and professional way (Terra, 2007). Sometimes it is necessary for workers to observe people who have new knowledge before they accept it (i.e., to learn who they are, their qualifications, whether they are trustworthy) (Davenport and Prusak, 1998).

Organisations can provide many tools to promote the use of information for innovation and creative thinking. However, the most important strategy is to establish an environment that encourages creativity, experimentation and openness to new ideas (Bukowitz and Williams, 2002). In other words, lifelong learning must be valued in words and actions (Terra, 2001); organisations must demonstrate that they value time spent in training, seminars, workshops, reading or even in programmes for e-learning during working hours. On the other hand, an environment conducive to learning makes employees pro-business in their learning strategies and personal improvement, which is embodied in changes in behaviour and results (Terra, 1999). Firms also create incentives to share knowledge by investing in technologies that facilitate communication, information sharing and personal contact between honest people. However, as Davenport and Prusak (1998) pointed out, the tools of information technology are necessary for the transfer of tacit or explicit knowledge in large enterprises, "but the values, norms and behaviours that constitute the corporate culture are the main determinants of the successful transfer of important knowledge" (1998, 117). Bukowitz and Williams (2002) reinforce this idea by noting that, although powerful network technologies make it theoretically possible for everyone to contribute knowledge, in practice, sharing *know-how* is subject to various complications and cultural barriers.

According to Terra (1999), the incentive to experiment and the freedom to try and fail are crucial in an organisation focused on innovation. However, we expect people to follow well-established innovation processes (with time and opportunities to share opinions and gather partial results) to minimise possible errors.

The freedom to act creatively opens the way for new solutions that provide new and better results. Regardless of whether people see themselves as creative, they are free to act on their ideas, and an organisation can encourage this kind of freedom. "When people are able to 'think different' their understanding of how the organisation creates value becomes multifaceted rather than limited (Bukowitz and Williams, 2002, p. 127).

Obviously, when there is more participation, processes are more confused, and the selection of contributions is more complicated. However, the potential for new and good ideas increases. Thus, the process of creativity is essential to create space and time for experimentation (Terra, 2001) and allows creative ideas to flourish, and it does not disrupt the functioning of the organisation when it is intentional. If everyone always acted freely, organisations would not meet their objectives. Thus, some organisations establish formal processes of suggestions for improvements, and other have standard procedures for feedback on the results of creative ideas, innovative actions and knowledge sharing through the public recognition and / or prize awards.

Terra (1999) notes that organisations that value "new ideas" show great openness to humour and jokes because relaxed and tolerant environments allow creative questioning about reality, competitors, the production process and customers' needs and desires.

The transfer of knowledge and information between various corporate areas and, for different units of work, individuals is the pooling of knowledge (Terra, 1999). The same author (2001) also emphasises that teamwork allows the exchange of experiences and helps

people to look at situations with a broader perspective and think more systematically. In contrast, Peter Senge (1998) argues that a systemic way of thinking allows us to see the underlying structures of complex situations, understand the system responsible for problems and analyse important problems regardless of organisational boundaries. According to Terra (1999), the organisations that lead knowledge management realise the importance of systems thinking and the relevance of having workers who think beyond their areas and work processes and seek resolutions together.

4.3 Structure and Organisational Processes

The permeability of ideas is fundamental to the use of knowledge (Bukowitz and Williams, 2002). In this regard, new organisational structures such as network enterprises, self-organising teams and informal structures reflect an increasing need for the rapid and unimpeded flow of knowledge. Models of mechanistic or bureaucratic organisations have become inadequate to meet the challenges that organisations face. Multidisciplinary teams with people from various departments are essential to meet these challenges, which go beyond organisational routine (Terra, 2001). Those teams, which break down hierarchical and operational boundaries, require organisational and individual flexibility. Organisations with more flexible structures allow a better use of expertise and experience (Terra, 1999).

Nonaka and Takeuchi (1997) suggest that organisations can deal with complex environments by developing a horizontal and flexible structure that connects the different areas of the organisation through a network of information and / or the frequent restructuring of organisation.

According to Terra (2001), organisations that stand out in terms of knowledge management use temporary and long-range teams that work on innovative research projects on products, processes or relationships with customers. These teams respond to environmental restrictions, and, thus, small rearrangements occur frequently.

The companies that rely on knowledge management usually have informal meetings outside the workplace to conduct brainstorms (Terra, 1999) because workspaces are believed to influence creativity, learning and the climate for innovation.

This type of organisation also uses communities of practice and learning, which include a significant number of people. The purpose of communities of practice is to create virtual or face-to-face collective learning around specific areas of knowledge (Nonaka and Takeuchi, 1997; Bukowitz and Williams, 2002; Terra, 2001).

Decision-making has shifted from the exclusive domain of senior executives to a distributed domain of line managers. However the flow of information is not always equally distributed. For the use of knowledge to be effective, it is important to treat information as an open resource that flows freely through the organisation (Bukowitz and Williams, 2002) to give decision-making power to people who have more knowledge and / or a specific competence for a task. Thus, it makes sense that decisions are taken at the lowest level possible to streamline the decision-making process and minimise bureaucracy (Terra, 2001).

4.4. Policies and Practices in Human Resource Management

According to Cascão (2004), Human Resource Management should play a facilitating role in knowledge management. Likewise, Terra (2001) states that the role of Human Resource Management is the creation, distribution and storage of knowledge through various policies and practices. It is through human resource policies that organisations clarify the kind of people, skills and attitudes they wish to attract.

Recruitment and selection is sometimes referred to as a strategic role for Human Resource Management[9]. These processes must be rigorous to evaluate not only the skills and abilities of candidates for a job but also the cultural appropriateness of their values related to sharing information and knowledge. Organisations should pursue diversity by recruiting professional profiles (either external or internal to projects) to enhance creativity (Terra, 2001). People with different backgrounds, experiences, formal education and culture bring different perspectives to solve problems and create new insights.

In career management, it is important to provide employees with different perspectives and experiences. Mobility and turnover make people the main vehicle for exchanging information and establishing links between different areas of the company. This experience enables individuals to learn about the organisation from different perspectives, creating fluid organisational knowledge (Nonaka and Takeuchi, 1997). Turnover, according to the authors cited above, fosters redundancy[10], which promotes the organisational knowledge spiral. In addition, careers consist of experiences in different areas and functions that enhance people's creative potential and their contacts with people from different areas of the organisation and various fields of knowledge (Terra, 2001; Nonaka and Takeuchi, 1997). Thus, these employees understand the organisation's systemic weaknesses and strengths and can usually adjust to the unexpected demands of new projects without requiring long periods of formal training.

A culture based on meritocracy is important for organisations concerned with knowledge management. They must develop a broad and comprehensive performance evaluation that measures contributions to learning and organisational knowledge, skills and specific outcomes in terms of innovation, efficiency and value, perceived by internal and external customers (Terra, 1999).

The sharing of knowledge may be a criterion for performance evaluation, for example, through the relevance and frequency with which employees contribute to the databases of best practices, discussion forums and participation in communities of practice.

The effort to promote knowledge sharing is essential for training organisation members, such as new employees, to use the systems for knowledge dissemination. Thus, an organisation focused on knowledge management should plan human resource development training that includes internal, external and on-the-job training for the development of skills and technical expertise, both for its staff and according to the needs of the organisation (Terra, 2001).

Training should be strongly associated with the strategic needs of the organisation. That is, an explicit organisational strategy, the identification of the skills needed for its implementation and a subsequent breakdown by function or department level clarify what skills each individual should develop (Terra, 2001; Ceitil, 2002). Thus, to create knowledge, organisations should encourage the commitment of their employees by formulating an organisational intention (Nonaka and Takeuchi, 1997). Training plans must develop technical and behavioural skills relevant to the results expected by the organisation.

Terra (2001) highlights that it is prudent for an organisation to avoid significant losses of employees with key knowledge. The longer an employee stays in a company, the higher his productivity and the more specific his knowledge. Companies that maintain low turnover have an advantage in creating knowledge that needs long maturation time. However, this fact does not prevent an organisation from maintaining an active policy of staff renovation by removing underperforming people and attracting human resources with new insights and knowledge.

[9] The reasoning behind this perspective assumes that cognitive ability, creativity and individual motivation and the ability to work as a team, although they can be improved and facilitated by an organisation, are personal characteristics that individuals develop throughout their lives and are hardly modifiable.

[10] The existence of information beyond the immediate operational needs of the members of the organisation allows new information from different perspectives.

The association of remuneration with a position is not a good measure because people need to show versatility in increasingly integrated teamwork and projects. Pay based on skills removes the primary focus on past performance and accounts for workers' flexibility to deal with future challenges. In fact, the employee "need not have a boss telling you how to perform your work - have a client that expects him to be able to plan and organise their own work" (Stewart, 1999: 82).

Organisations can also institutionalise ways to reward and recognise outstanding contributions and results, including symbolic moments of recognition and awards, particularly in public (Terra, 2001). Similarly, the distribution of profits among employees and engagement in business may contribute to a sense of common responsibility, fostering attitudes of collaboration and knowledge sharing between different areas of the organisation.

According to Davenport and Prusak (1998), one of the challenges of knowledge management is to ensure that knowledge sharing is more profitable than its closure. However, many initiatives related to knowledge are based on the utopian premise that people share knowledge without thinking about their potential gains or losses. However, in reality people rarely give something valuable (including knowledge) to others without expecting something in return. According to Terra (1999), it is important to maintain networks of contacts with former employees because these networks retain knowledge and can be an excellent source of business opportunities that lead to new employees and even potential partners.

Another way to foster learning through increased contacts and interactions within and outside the organisation is to encourage the active participation of individuals and teams in events and professional associations relating to their areas. In these events, individuals take on leadership positions and interact with their peers, both internally and externally.

According to Cascão (2004), human resource management will have to be innovative and decisive to face one of the biggest challenges in its history: the sharing of knowledge and skills. Performance motivation alone is no longer enough, and promoting knowledge sharing is crucial.

4. 5. Information Systems and Communication

The link between information technology, knowledge and organisational performance is clear. Technologies provide access to diverse sources of specialised information and improve our ability to analyse, manage and apply this information to work (Serrano and Candido, 2003).

The purpose of information and communication systems should be to apply timely, reliable, accurate and relevant information where it is useful. Vagueness, low accessibility or a lack of information can be costly to organisations in terms of duplicated effort, missed opportunities and dissatisfied customers.

Bukowitz and Williams (2002) report three types of disorders in accessibility of information in organisations:

- Dysfunction of information accessibility from top to bottom, usually related to safety issues or other concerns related to their misuse.

- Transorganisational dysfunction, when the different functional groups (e.g., departments, business units or process teams) refuse to share information, creating organisational cocoons.

- Dysfunction of the bottom up, when the supervisors block access to important information for decision-making. This dysfunction may happen more often when individuals are only rewarded for reporting good news and select only a certain type of data to give to executives. Furthermore, (Nonaka and Takeuchi, 1997) databases, methods of classifying information, web-based tools, intranets and the Internet support phase combination (i.e., the systematisation of concepts at an organisational level) because they allow the exchange and dissemination of knowledge among various sections, departments and organisational units.

Systems should be developed to ensure that information systems[11] are relevant and allow for the identification, access, organisation and selective distribution of information appropriate to the work of each employee of the organisation. These systems should use different perspectives: individual, team, project, organisation and intra-organisational (Terra, 2001). A system of user-customisable information is useful when searching for information and allows the individual to receive information in the format and timing suited to his needs.

A constant concern for leaders in knowledge management is to make information systems friendly (Terra, 2001) by taking into account organisational goals, best practices for use, characteristics of internal and external audiences, situations of use and the limits of existing technology.

However, these strategies alone are not sufficient for the information systems to be completely used. Organisations should develop skills and competencies to use information technologies, especially new Internet-based technologies that facilitate virtual collaboration, research, access and publishing (Terra, 2007). Given the growing interdependence of relations with partners, suppliers and customers, information should be shared with outsiders. Obviously, this openness requires a pre-definition of what can and should be shared externally. The transfer of knowledge is desirable and necessary for the development of organisations. However, imitation by competitors should be avoided (Serrano and Candido, 2003).

Organisations with advanced processes of knowledge management have a major incentive to document knowledge and know-how (Terra, 2001). In fact, these groups determine the procedures related to codification and knowledge sharing. The intranet, extranet and even the site are key channels of contact with customers, partners and suppliers. In this regard, the organisation must consider the effective use of these channels, which require human, financial and time investments to remain up to date. The most relevant information must be encoded and organised in virtual spaces for general access and not on individual computers or specific areas of the organisation. Importantly, knowledge management is primarily a matter of people (Terra, 2001). Useful technologies for knowledge management are those that integrate people (Serrano and Candido, 2003) and overcome the boundaries between business units to prevent the fragmentation of information and to create global networks for sharing knowledge.

The challenge of information technology is to identify, develop and deploy technologies and information systems that promote organisational communication and the exchange of ideas and experiences that facilitate group participation and the renewal of informal networks. Thus, the role of information technology is to develop collective knowledge and learning and facilitate the sharing of problems, perspectives, ideas and solutions.

4.6. Outcome Assessment

An important aspect of knowledge management for practitioners and researchers has been the creation of an organisational theory to include intangible variables. Terra (2001) highlights the need to measure results from various perspectives (financial, operational, strategic, knowledge acquisition), which allow us to evaluate the relations between different organisational areas and processes. Robert Kaplan and David Norton created the Balanced Scorecard (BSC), which has been developed and refined since 1992. These authors seek a comprehensive overview of an organisation that can monitor financial performance and the activities that lead to such results, such as customer relations, innovation, learning and internal business. This approach allows a greater openness to knowledge management (Bukowitz and Williams, 2002).

[11] Portals, document management, Website, groupware, etc.

The BSC management model aims to clarify organisational vision and strategy by explaining them in terms of cause and effect through four perspectives: financial, customer, internal processes and learning and growth. They describe the logic of this relationship with a strategic map, in which strategic objectives are broken down into indicators and performance targets. Action plans are essential for achieving every goal and describe strategic initiatives so that all "knowledge workers" understand their operational responsibilities and work for the results expected by the organisation (Kaplan and Norton, 1997).

According to Kaplan and Norton (1997), the role of workers has changed, and suppliers have the ability to perform increasingly abstract data analysis. This view is supported by several authors, including Drucker (1994), who refers to knowledge workers, and Sveiby (1998), who sets out the differences between the industrial paradigm and the paradigm of knowledge. Stewart (1998) also describes workers' knowledge. Edvisson and Malone (1998) and Sveiby (1998) argue that people are the only active agents in organisations. Thus, all assets and infrastructures (tangible or intangible) are the result of human actions, depending ultimately on the people there. Thus, Kaplan and Norton (1996) describe learning and growth as the foundation of every organisation's strategy, which should create infrastructures to enable the achievement of the other three dimensions of the model. The authors (2004) present the three types of capital that determine the value of intangible assets, organised into six objectives:

i) Human capital

- Strategic competencies, skills, talent and knowledge to perform the activities required by strategy;

ii) Information capital

- Strategic information, availability of information systems, infrastructure and knowledge management applications needed to support the strategy;

iii) Organisational capital

- Culture: awareness and internalisation of the mission, vision and common values needed to implement the strategy;
- Leadership: The availability of qualified leaders at all levels to drive the organisation in implementing the strategy;
- Alignment: alignment of goals and incentives with the strategy at all levels;
- Teamwork: sharing knowledge and resources for people with strategic potential.

Thus, the BSC is seen as a management system that can improve critical areas such as innovation in products, processes and customer and market development. It aims to implement organisational vision and strategy through the articulation of strategic objectives for long-term and short-term actions (Kaplan and Norton, 1997). Thus, the BSC tracks performance and strategic alignment using past financial data and introducing guidelines for future performance (Amaral and Pedro, 2004)

In 1997, Karl Erik Sveiby proposed adding a new group of elements to the balance sheet[12]. The author created the Intangible Assets Monitor, which aims to let managers experiment with new measures to evaluate intangible assets, which are increasingly important in the knowledge economy.

According to Sveiby (1998, p. 14), "while intangible assets may seem invisible, they can actually be discerned with ease, using for this, the following categories to classify them: employee competence, internal structure and external structure."

[12] The author studied how to manage and track business - based on knowledge - they have their production based on the traditional model, but only on knowledge and creativity of their employees. This work has provided a rich and global vision to assess the potential of the business.

Employee competence is the ability to place the organisation's staff in a variety of situations and create tangible and intangible assets, including skills, education, experience and values.

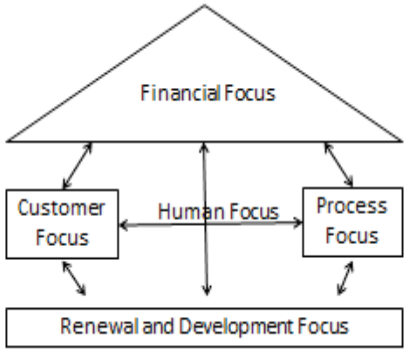
Internal structure is the existing knowledge in the organisation, which includes patents, designs, concepts, organisational culture and information systems. This knowledge is usually created by developers and owned by the company. Thus, the interaction between competence and internal structure determines an organisation's performance mode.

Knowledge that is created by the relationships between a company and its external agents is called the external structure. It consists of items that are difficult to manage and evaluate, such as relationships with customers, suppliers, image and reputation. From this perspective, investments in external structure are generally not as safe as those made in the internal structure because their value depends on how the entity meets the expectations of external agents.

Assessment is not a substitute for strategy; it is a reflection of strategy and a tool for its implementation. "At best, it works as a nervous system. It keeps the company in harmony with the reality of strategy in the extremities" (Bukowitz and Williams, 2002: 234) with customers, employees, suppliers, regulators and the community. At worst, it becomes an obstacle to change when information is not provided about the real state of the organisation (Bukowitz and Williams, 2002). The core of a knowledge management project is not the control of organisational knowledge sharing. Rather, it works as a strategic resource for the organisation.

From the experience of the company Skandia, an insurance industry based in Sweden, Edvinsson and Malone (1998) report on the intellectual capital model presented in the "Skandia Navigator." This model presents a broad list of performance measures for intangible assets.

Figure 4 - Navigator of Skandia



Source: Edvinsson e Malone (1998)

The model is characterised by five areas of focus: financial, customer, process, renewal and development and human (Edvinsson and Malone, 1998). In the opinion of the authors, organisations should focus on these areas, which are the source of intellectual capital. However, the epicentre of Skandia Navigator is its people, and financial capital is the commercial result of value created from intellectual capital. The navigator also integrates a temporal dimension with past, present and future axes. The financial focus is on the past, but the customer focus is centred on the human dimension. The processes are based in the present, and renovation and development position the organisation in the future.

Thus, in this model, intellectual capital is measured by 111 indicators, derived from a preliminary list of 164 indexes (91 based on intellectual activities and 73 in traditional

measures), covering the five foci: (1) financial, (2) customers, (3) processes, (4) renewal and development and (5) human. This quintet forms the structure of the report on intellectual capital. Edvinsson and Malone (1998) believe that companies have the capacity to monitor 111 indicators through a computerised information system.

Terra (2001) states that an organisation needs to perform both quantitative and qualitative evaluations to determine whether it is achieving its objectives (i.e., strategic level, customer level, employees, financial, operational and the creation of intangible assets)[13].

Information technology and communication provide ways to evaluate specific and detailed information about use (frequency of use, type of user, type of content and applications accessed) (Bukowitz and Williams, 2002). Other typical measures include time spent by task, relevance, updates, information accuracy and usability. According to Terra (1999), the relative size of learning, knowledge sharing and capacity building can include the results of various departments, areas and business units. Today, organisations spend as much time evaluating results in terms of skill development, organisation, divisions, departments or individuals as they do on evaluating financial and operational results. This shift requires detailed monitoring of key competences through formal and periodic reviews of initiatives related to employees' learning and skill development. Assessment in organisations is important because it allows them to detect and highlight areas for improvement.

4.7. Learning with the Environment

The blurring of organisational boundaries, as evidenced by increased collaboration with customers and suppliers, has come to define new forms of competition and innovation based on using know-how to create value (Bukowitz and Williams, 2002).

Customers (particularly the most important and profitable ones) can be significantly involved with an organisation in areas such as strategic planning, product development and feedback on products and services. Learning with customers can occur through various formal and informal mechanisms, such as focus groups, formal interviews and customer communities (Terra, 2001).

Employees' knowledge of marketing, sales and service often contribute to databases of information about customers and competitors, such as customer profiling systems for sector analysis, data on competitors and benchmarking. Organisations have well-developed systems and allow access to customer data in aggregate form or otherwise, both for front-line employees and the management, which follows the evolution of customer relationships.

According to Terra (2001), an increasingly important issue in supplier evaluation relates to the work abilities revealed by these systems, which measure the achievement of common goals through the collaborative approach based on information and knowledge sharing and contribution to innovation. Hence, capacities for innovation, collaboration and interest in ethical knowledge sharing are important criteria for selection and maintenance suppliers.

Today, it is difficult for one organisation to provide all the components of products and services that customers need and to develop products in isolation. This issue is due to the dispersion of knowledge, so it is essential that an organisation can manage partnerships with other organisations (Terra, 1999). To meet this challenge, organisations have formal training programmes, which provide the skills and competencies required for effective partnerships. They follow methods that aim to ensure the achievement of expected results. Some organisations, the leaders in knowledge management, have areas devoted to relationships with universities and research institutions (Terra, 2001). This type of initiative

[13] Specific examples include: customer loyalty and satisfaction indexes, organisational climate and employee satisfaction, as well as measures of efficiency and effectiveness in various central processes of the organisation.

aims to ensure that organisations are aware of emerging ideas in critical areas. According to Terra (2001), the decision to make alliances is often related to strategic decisions and learning. Thus, in formal alliances, there are precise definitions of how intellectual assets should be managed between the parties (access, sharing, ownership, etc.).

Organisations that compete effectively have a good understanding of their sectors, markets and competitors; they strive to capture, organise and disseminate information about the environment and competition (Terra 2001). This information may be acquired (secondary sources) and / or internally developed by teams of analysts.

Importantly, organisations absorb tacit and explicit knowledge from multiple sources, even external ones (e.g., its suppliers, partners and customers), through interactive processes. "Increasingly, organisations will build their intellectual capital through relationships - with employees, suppliers, customers and the communities with which they interact and even with competitors (Bukowitz & Williams, 2002: 27). Achieving value through these relationships, forces an organisation to invest in better environmental management.

5. CONCLUSION

Knowledge management incorporates individual, group and organisation levels. It is part of a multidisciplinary and systemic approach and involves a dynamic interaction between the various subsystems of an organisation. Knowledge management is articulated through an institutional approach that seeks to understand the influence of socially constructed cultural elements on the relationships in an organisation.

Organisational learning was discussed above through the various perspectives in the literature. We aimed to find a better understanding of this new organisational approach and identify key areas currently considered essential for effective knowledge management. Thus, approaches to knowledge management focus on organisational processes related to the creation, retention, transfer and use of organisational knowledge and highlight the importance of the management practices that facilitate them.

We presented an analytical model that identifies the different stages of knowledge management (acquisition / knowledge creation, retention / storage, transfer / sharing and use) and the management practices that facilitate it (strategic management, organisational culture, structure and work processes, human resource policies, information systems and communication-measuring results and relationships with the environment outside the organisation). We tried to take into account the multifaceted characteristics of knowledge management and its practical significance.

The two major axes of the analytical model (stages of knowledge management and practices to facilitate knowledge management) do not exist in isolation; they are complementary, and both are essential for a comprehensive approach to knowledge management. The dimensions of analysis are interconnected because the various practices of knowledge management go beyond the categorisation established here.

For example, strategies to retain knowledge through information technologies involve changes in organisational processes. These changes depend on the efficient operation of activities linked to the cultural and behavioural aspects of knowledge sharing. These factors must be taken into account throughout the investigation.

Thus, knowledge management is a set of processes that, through the dissemination of knowledge, maintains or improves the performance of organisations. These processes are influenced by variables such as culture, strategy, structure, technology, management type, resources and work processes. The interplay of these variables requires coordinated action to translate knowledge management into positive results for organisational performance.

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INFRASTRUCTURE AND INFRASTRUCTURING AS A BRIDGE BETWEEN INFORMATION SYSTEMS DESIGN AND ORGANIZATION DESIGN

INFRA-ESTRUTURA COMO ELO DE LIGAÇÃO ENTRE O DESENHO DE SISTEMAS DE INFORMAÇÃO E O DESENHO DA ORGANIZAÇÃO

Rodrigo Magalhães

ABSTRACT

This paper discusses infrastructure as a bridging mechanism between organization design and software engineering. By focusing attention on the properties and characteristics of information infrastructures as socio-technical systems, organization designing is presented as an activity equivalent to infrastructuring. In parallel, information systems design also stands to benefit from the intellectual platform known as work-related infrastructure, mainly due the capacity afforded by such a platform to make work-related connections and dependencies visible. The paper proposes a framework which enables the distinction between three layers of the organizational infrastructure (infrastructural background status, work development and design-in-use) and two modes of organizing (planning and situated). The distinction between infrastructural background and work development highlights the effects of the organizational legacy on all forms of work development, thereby informing information systems and organization design, at the macro level. The distinction between work development and design-in-use, which arises from another novel concept – *points of infrastructure* – brings in a host of a new opportunities in terms of improvements to organizational and information systems effectiveness.

Keywords: Infrastructure, Infrastructuring, Information Systems Design, Organization Design.

RESUMO

Neste artigo é focado o conceito de infra-estrutura enquanto mecanismo de ligação entre o desenho organizacional e a engenharia de software. Através de uma chamada de atenção para as propriedades e características das infra-estruturas de informação enquanto sistemas socio-técnicos, o desenho organizacional é apresentado como uma actividade equivalente à "infra-estruturação". Paralelamente, o desenho de sistemas de informação também pode beneficiar da plataforma intelectual conhecida como a "infra-estrutura de trabalho", em especial devido à potencialidade apresentada por uma tal plataforma para tornar visíveis as ligações e as dependências existentes nos processos de trabalho. O artigo propõe um modelo que faz a destrinça entre três níveis de infra-estrutura organizacional (o estatuto infra-estrutural de fundo, o desenvolvimento do trabalho e o "desenho-em-utilização") e duas formas de conceptualizar a organização (organização-planeamento e organização-situação). A distinção entre o estatuto infra-estrutural de fundo e o desenvolvimento do trabalho traz para primeiro plano o impacto da herança organizacional sobre todas as formas de desenvolvimento do trabalho – um contributo importante quer para o desenho organizacional quer para o desenho de sistemas de informação. A distinção entre o desenvolvimento do trabalho e o conceito

de "desenho-em-utilização", a qual ocorre por via de um outro conceito novo – pontos de infra-estrutura – traz consigo um role de novas oportunidades para melhorar a eficácia do desempenho quer dos sistemas de informação quer da organização em geral.

Palavras-chave: Infra-estrutura, Infra-estruturação, Desenho dos sistemas de informação, Desenho organizacional.

JEL Classification: M19

1. INTRODUCTION

Organization design and information systems design are topics which usually do not go together. The theoretical and methodological approaches belong to different disciplines – organization design follows the precepts of organization theory while information systems design has traditionally been shaped by computer science. However, although not yet recognised by the mainstream literature, organization design is tightly linked to the organization's information and software infrastructures.

With the growth of the industrial organization and the emphasis on industrial regulation and later deregulation, until the 1980s the economic environment was dominated by structural rules. Since then, the growth of infrastructural capabilities has been the driver of the business environment, firstly with organizational digital networks becoming commonplace, followed by the spread of the World Wide Web and more recently by the mushrooming of mobile telecommunications. In fact, current corporate information infrastructures, which are mostly made up of rules imposed by the software, are the result of the merger of the electronic society of the 21st Century with the organization designs inherited from one hundred years of organizing activity, in the previous century. The outcome of this merger is the emergence of an unimaginable degree of complexity and a very substantial loss of managerial control over organizational infrastructures (Ciborra et al, 2000).

In this paper we explore the concepts of infrastructure and infrastructuring as a theoretical framework which has recently been proposed as an alternative tool for information systems design (Pipek and Wulf, 2009) and propose that the same theoretical framework might also underpin a new approach to organization design. We posit that (1) as a noun, organization design can be conceptualized as the materialization of the information infrastructure in the form of the organization's processes (including all strategic and operational routines and procedures); (2) the concepts which define an information infrastructure have many similarities with the notion of organization design, linking both artifacts and immaterial elements; (3) as a verb, organization design is as process for changing or bringing about improvement to the work infrastructure, a process akin to infrastructuring (Pipek and Wulf, 2009).

The paper is organized as follows. A brief overview of the historical development of research into organization design focussing on the so-called information processing view opens the paper. The literature on infrastructure and infrastructuring is reviewed next, leading to the key objective of the paper, i.e. proposals towards a methodological framework based on infrastructure theory and which might be used in both information systems design and organization design.

2. THE PLANNING BIAS OF TRADITIONAL ORGANIZATION DESIGN THEORY

Organization design, in essence, can be regarded as the ensemble of the artifacts created by management to mediate between the interests of stakeholders (mainly the shareholders) and the day-to-operations of the organization. Behind such artifacts are definitions of the levels of responsibility, authority and accountability, definitions of the nature and extent of formal rules and procedures, definitions of task-related units and processes, definitions of human resources policies, including incentive systems and finally, definitions regarding the requirements, flows and quality of information processes needed to link of all the above (Kimberly, 1984).

The field of organization design has been dominated by two major concerns over the last fifty years. The first deals with the contingent nature of the activity of organizing, that is, the way in which the environment, technology, size or managerial choice affect the shape of the organization. The second concerns the shape itself or the types of organizational configuration which emerge as a result of the contingency factors. Contingency and configuration are thus two sides of the same coin, as summarized by Snow et al (2006):

- The organization is conceptualized as a system or configuration whose major components include strategy, people, structure, and management processes.
- Overall organizational performance is heavily dependent on the quality of the internal alignment of the organization's components as well as the external fit between the organization and its environment (i.e. strategy-structure-environment fit or congruence).
- The process of achieving fit is dynamic, and both the organization's internal and external alignment must be continually monitored and adjusted.
- All of the basic organizational configurations have particular strengths and limitations, there being no all-purpose organization design.

Although the so-called configurational approach is still found in all the mainstream textbooks, it has experienced only a moderate amount of development since the 1980s (Snow et al, 2006). This is due to a number of reasons, one of the most important being the fact that this research tradition has, since its early days, badly neglected implementation issues (Kilman et al., 1976). Traditional organization theory held that the activity of designing organizations (and their supporting systems) was clearly a top-down endeavour. In other words, the planning, building and implementing of management systems, as well as all the operating rules which allow any organization to function, is carried out starting from the functional requirements at the top of the organization and cascading down to the lower levels. Such requirements varied according to the type of environment, type of production technology or size of the enterprise and were influenced, to some extent, by internal political coalitions and power struggles. We will call this the *planning mode* of management and organizing (Johnston and Brennan, 1996).

The *situated mode* of management and organizing holds very much the opposite, i.e. organizations are not designed but are in a continuous process of being designed. Bounded rationality, rules of thumb and emergent events make it impossible to freeze the organization's design at any point in time and consign it to a state of perpetual flux (Morgan, 1997). Although the situated mode of organizing makes sense and explains many of the organizational phenomena which the planning model has difficulty in dealing with, the truth of the matter is that environmental conditions and managerial choice still dictate many of their basic design features. Planning models of organization design such as those proposed by Miles and Snow (1978), Nadler and Tushman (1997) or Simons (2005) explain only how the organization *should* function and not how the organization *does* function.

Hence, what is required is a framework which will combine both the planning mode and the situated mode of organization design. Such integration would be of great use in bridging the gap in the development approaches and methodologies adopted by managers and organization specialists on one hand, and computer scientists and software engineers on the other hand.

3. THE PROBLEM WITH INFORMATION SYSTEMS DESIGN

Information systems design entails the methods, tool and techniques involved in applying computer-based artifacts to organizational processes. Generally known as information systems development methodologies, they vary considerably in approach, some emphasizing the study of the data that the system will handle, others oriented towards the investigation of the processes to be applied to the data, and a third group focusing attention on the events which initiate decision processes and data transformations (Avgerou and Cornford, 1993). Most methodologies are organized around the notion of information systems life cycle (ISLC), which vary in terms of the number and types of recommended steps. The basic steps of a typical ISLC are (1) Definition, which includes initiation, planning, requirements determination (i.e. analysis) and design; (2) Construction, which includes programming and/or the acquisition of software and testing; (3) Installation (or Implementation), which includes changeover, training and evaluation; (4) Operation, which includes maintenance, enhancements and further evaluation.

As step number zero in all information systems design methodologies designers have to define a design scope. Doing this requires the designation of what is internal (i.e. things to design) and what is external (i.e. things to take into account) to the design process. Such decisions are often not part of the design methodologies and are taken implicitly by the designers. Implicitly, designers decide which features of the organizational process should be considered and which should be ignored. This is prone to error and may require corrections at a later stage. In the system definition stage, the determination of requirements from users is a crucial step. However, time and again it has been shown that eliciting requirements from users is also error prone due to the fact that it is difficult for users to be fully aware of their own work procedures. In the operations phase, post-implementation failures are often linked to a poor fit between technological design and organizational reality, which in turn leads to problems in subsequent attempts to re-design or re-engineer.

The problems briefly listed above underscore the fact that information systems are part of work infrastructures (Pipek and Wulf, 2009). Work infrastructures have a number of unique characteristics, for example they are mostly *invisible-in-use*. This is the reason why users are often unaware of their own work procedures, making the task of requirements elicitation a problematic one. Work infrastructures are highly *interconnected* and *complex*, containing a wide variety of automated and non-automated information processing artifacts. This accounts for the difficulty in determining accurately what is internal and what is external to the design process. Work infrastructures are also *uniquely versatile*, meaning that they can be used for many purposes in addition to the original end for which they created. This characteristic has an impact on post-implementation attempts to re-design or re-engineer due to the unanticipated changes made to the utilization of the system.

4. INFORMATION OR DIGITAL INFRASTRUCTURES

The study of work-related infrastructures has gained popularity in the information systems discipline as a means to give researchers a better grip on the concept of *information infrastructure*

(Ciborra et al, 2000; Hanseth, 2004; Hanseth and Lundberg, 2001; Pipek and Wulf, 2009; Star and Ruhleder, 1996; Star, 1999; Star and Bowker, 2002). Such study has also enabled a better understanding of the fact that an information infrastructure is not only made up of hardware and software artifacts, but comprises also the people who use the infrastructure. But, what is an infrastructure? The *Merriam-Webster Online Dictionary* (2010) gives the following definition of infrastructure: "1. the underlying foundation or basic framework (as of a system or organization); 2. the permanent installations required for military purposes; 3. the system of public works of a country, state, or region; *also*: the resources (as personnel, buildings, or equipment) required for an activity". When thinking about any large public infrastructure such as, for example, the rail network, they exhibit all of the characteristics of the traditional definition of infrastructure. The railways are a foundational service for the movement of people in any society; they are usually stable structures, with regular routes, timetables and prices; they are a resource that can be shared by different operators offering different services, such as cargo or military use; and railway tracks and rolling stock must have standard features, otherwise it will not be possible to operate with the same equipment across the network. Hence, the physical characteristics of infrastructures are fairly easy to understand and analyze.

When trying to apply such static characteristics to dynamic information infrastructures, things are more problematic. As highlighted by Dahlbom (2000), applying the traditional thinking of public infrastructure to information technology infrastructures can be seriously misleading, given that information technology needs to be understood as a flexible means of communication by which social structures are formed and re-formed, rather than being a productive foundation. Pipek and Wulf (2009) point out that information infrastructures are reflexive, in the sense that all improvements to the infrastructure are developed and processed within the infrastructure as information. Tilson et al (2010) argue that digital infrastructures cannot be defined as a set of functions (as in the case of specific systems) or through strict boundaries (as in the case of specific applications). Rather, they are a new type of IT artifact, deeply embedded in social processes with dynamic, relational and long-lasting characteristics. Hanseth and Lyytinen (2010: 4) define them as follows:

> "digital infrastructures are shared, open (and unbounded), heterogenous and evolving socio-technical system (which we call installed base) consisting of a set of IT capabilities and their communities: user, operation and design communities"

According to Star (1999), infrastructure is a relational concept, "becoming real infrastructure in relation to organized practices" (Ibid, p. 380). In other words, infrastructure cannot be defined independent of its use, acquiring different meaning according to the way it is put to use. Infrastructure becomes whatever is perceived as infrastructure by its users. Hanseth and Lundberg (2001) discuss "work oriented" infrastructures as being "highly complex and specialized practices whose properties are largely hidden for those who are not members of the community" (Ibid, p. 365). Work oriented infrastructures must be differentiated from universal service infrastructures which provide a universal service to all citizens, such as the power grid, the telecommunications network or the motorway system. Pipek and Wulf (2009: 455) define work infrastructure as the "entirety of devices, tools, technologies, standards, conventions and protocols upon which the individual worker or the organization rely to carry out the tasks and achieve the goals assigned to them".

5. ORGANIZATION DESIGNING AND SYSTEMS INFRASTRUCTURING

The following are the properties which define an infrastructure (Star, 1999). Taking design as a set of holistic properties belonging to every organization, we can see an interesting

correspondence between the two concepts (i.e. between infrastructure design and organization design).

- Embeddedness. Infrastructure [organization design] is embedded, meaning that it is sunk into other structures, social arrangements and technologies.
- Transparency. Infrastructure [organization design] is transparent to use, meaning that it does not need to be assembled for each task, but invisibly supports such tasks.
- Learned as part of membership. This means that one learns to use the infrastructure [organization's design] by using it.
- Links with conventions of practice. Infrastructure [organization design] both shapes and is shaped by the conventions of a community of practice.
- Reach and Scope. Infrastructure [organization design] extends beyond a single event or one-site practices.
- Embodiment of standards. Infrastructure [organization design] takes on transparency by plugging into other infrastructures or tools in a standardized fashion.
- Built on an installed base. Infrastructure [organization design] does not grow *de novo*.
- Becomes visible upon breakdown. Infrastructure [organization design] becomes visible when it breaks.
- Not amenable to be changed at once or globally. This means that infrastructure [organization design] is fixed in modular increments, with change taking considerable time and negotiation.

Although the fit is not perfect, we can see that each of the nine points applies to some extent. The fit becomes even better when complemented by the following statement by Star (1999:382): "nobody is really in charge of infrastructure". Indeed, we have to acknowledge the fact that in organizations nobody is in charge of organization design. Design is simply a set of superstructural and infrastructural properties which allows the organization to fulfill its purpose.

Pipek and Wulf (2009) elect to talk of infrastructuring as a creative activity which is aimed at the improvement of work infrastructures. Furthermore, these authors clarify that such an activity can be described as "design" (Ibid, p. 457), understanding design as any transformational or change-inducing activity that individuals or groups perform with the intention to have long term effects. The change activities that those authors address in their paper refer to programming, configuring and using collaborative infrastructures, although stating that they "remain open with regard to other design domains" (Ibid, p. 457). Insofar as many ongoing changes in organization design are enabled by concurrent changes in work-related infrastructures, it can be assumed that information infrastructuring activities also underpin organization design activities. In order to explain and support such an assumption, we have to delve for a moment into Pipek and Wulf's (2009) theory of infrastructuring.

Firstly, in developing their approach, these authors use the expressions information systems infrastructure and work infrastructure interchangeably:

> "We believe information systems to be a very special type of infrastructure with a set of problems and opportunities that cannot be found in traditional infrastructures (…) However we consider the following characteristics specific to work infrastructures:
>
> - A unique versatility. The infrastructure can be used for many purposes in many work environments (…)
>
> - Reflexivity. Information systems as a work infrastructure can be seen as reflexive in two ways. First the IS work environments of designers are part of the same global infrastructure as those of users and second, all the improvements to the global infrastructure are developed within that infrastructure. More fundamentally, large and important parts of

> that infrastructure (i.e. software) can be processed within the infrastructure as information (Ibid, p. 449)"

In addition, Pipek and Wulf (2009) make a number of different points regarding IT-based work infrastructures, which highlight the similarities between these and the organization's design and for that reason are worth pursuing. Mostly, the points are directed at information systems design methodologies, but seem highly applicable to organization design. The authors claim:

> "The invisibility of work infrastructure makes it hard for users to be fully aware of their own work procedures, making it difficult for designers to elicit requirements" (Ibid, p. 449)

This observation applies to the implementation of any change to the work task of individual workers, whether it involves the changeover to an automated system or not.

> "Design methodologies require designers to define a design scope. Doing this requires defining what is internal (things to modify/design) and what is external (issues to consider) to a design process. Parts of the work infrastructure will be excluded from the design, but the complexity of the work infrastructure makes this a difficult and error-prone process that may require corrections later" (Ibid, p. 449)

Again, the problem of boundary definition which the authors are referring to is germane to the implementation of any organizational change. For example, when implementing a new reward system, deciding which parts of the organizational infrastructure should be included and which should be excluded could be a error-prone process.

> "Work infrastructure help highlight aspects of design methodologies that have less to do with designers/developers and their design process, and more to do with how the technologies undergoing design, and the design process itself, are embedded in an existing work environment" (Ibid, p. 449)

In organization design the situation is the same, once created everything becomes part of a whole and it becomes very difficult to carve up the design into neat sections for purposes of implementation or change.

> "The (non-)physicality of an infrastructure leads to additional degrees of freedom whose regulation needs to be negotiated and acknowledged by all actors (for example, air traffic routes)" (Ibid, p. 453)

Like an infrastructure, the organization's design also has no substance and although there is a structure which imposes rules and procedures, the ultimate direction of the organization is also the result of negotiation and bargaining amongst stakeholders.

From the quotations above, it is clear that most of what is said about the information systems infrastructure as a work infrastructure applies to the organizational infrastructure as a whole. This means that given the fact that most of the organization's information flows are now-a-days supported by software infrastructures, the information systems infrastructure and the organizational infrastructure tend to become one-and-the-same.

Lastly, Pipek and Wulf (2009) make an important distinction between *design-before-use* and *design-in-use* which roughly corresponds to the distinction we have made earlier between the planned action and the situated action models of management. Design-before-use is related to the classic notions of infrastructure which is planned and designed by specialists to be used by unspecified users. Design-in-use is put forward as an extension of the concept of user participation utilized in information systems design. Seen through the view point of work infrastructure, design-in-use goes beyond the classic divide between designers and users and "demand opportunities to renegotiate the border between what remains the same and what is changed when designing information systems; to renegotiate who changes aspects

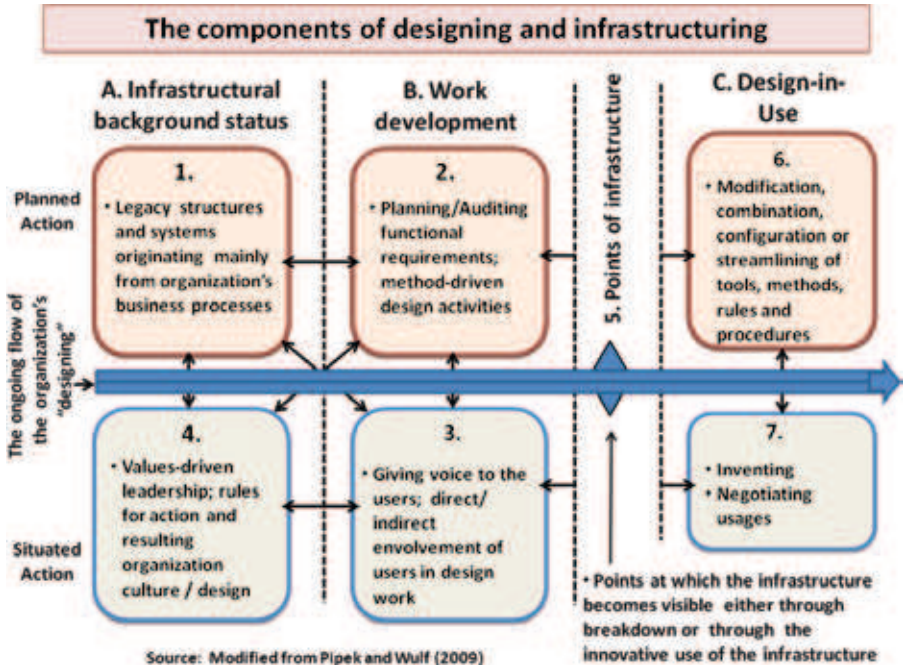
of information systems; and to renegotiate when these aspects are changed (before use vs. during use)" (Ibid, p. 452).

From the standpoint of organization design, we have exactly the same situation, i.e. we have the formal side which elicits requirements, plans organizational structures/procedures and draws a variety of representations (models) of the organization's reality. On the informal side, we have the situation-after-design, with people interacting in emergent ways and in accordance with varying contexts; local learning taking place in a situated fashion; and organizational change proceeds not according to the plan, but as a consequence of the combined force of cultural habits and political interests.

6. A FRAMEWORK FOR ORGANIZATIONAL INFRASTRUCTURING

In this section we propose a methodological framework (see Figure 1) based on the model put forward by Pipek and Wulf (2009) for information systems design. If one agrees with the notion that organization design is made up of information processing artifacts (organizational structures, policies, procedures, computer-based systems) and information processing activities (interacting, communicating, reporting, making decisions), we submit that the organization's design can be construed as a sociomaterial (Orlikowski, 2007) work-related infrastructure. This is in line with Pipek and Wulf's (2009) assertions that information and software are infrastructural materials and that their framework includes other artifacts which may not be part of the hardware and software infrastructure.

Figure 1



In adapting Pipek and Wulf's (2009) framework we are mindful that (1) the phenomenon of organization design includes but is not restricted to information systems design and (2) organization design infrastructures include not only new artefacts (mostly computer-based) but also non-computer-based artefacts which have been around for many years and need as much attention as the newly implemented ones. The framework is divided up into seven components arranged according to a matrix featuring three columns, corresponding to three layers of the infrastructure and two rows, corresponding to two contrasting

modes of organizing action – planned and situated. There is an extra row called "points of infrastructure", which does not stand for an infrastructural layer, but is a type of event which is highly relevant for the ongoing development of the infrastructure. These seven components produce and reproduce the organization's overall infrastructure. The model represents a recursive and holistic system, in the sense that the each individual component learns from inputs sent and received to and from other individual components thereby making this a learning system.

Starting with the layers of the infrastructure, they are (A) Infrastructural background status; (B) Work development and (C) Design-in-Use. The layers go from a strategic and cultural high level of abstraction (level A) to an operational, hands-on, practical level of daily execution (level C). Level B refers to the activities which are the consequence (and later on the cause) of level A. The activities in level B are more concrete than those in level A, but less concrete than those in level C. As regards the stances or modes of organizing, the planned model includes all the activities which are necessary to plan in order to set up any part of the organization's structure (vertical or horizontal). The situated mode includes the myriad of unplanned or emergent events which shape the organization's design but which are not possible to freeze at any point in time.

Box 1 contains the organizational legacy (Prahalad and Krishnan, 2008). Legacy is a part of all infrastructures and comprises a mix of policies, procedures and systems, as well as people. The bulk of an organization's infrastructural legacy is ingrained in its work flows, which have developed over the years with successive generations of reorganization sometimes led by software implementation. It represents also the existing business model which, in turn, is a cause and a consequence of the organizational legacy. Box 2 represents all the method-driven activities used either by strategic or operational business planners or by software engineers in preparation for new work development or redesign/ reengineering of existing work. Functional requirements (both strategic and operational) are surveyed, structural arrangements (both vertical and horizontal) are planned, along with policies and procedures; finally, activities (processes, tasks and jobs) are designed, either manually or with the support of computer-based tools. Planners plan, designers design and users are assumed to use the artefacts in the way that they were meant to be used. Broadly speaking, boxes 1 and 2 correspond to the traditional view of organization design.

The situated view of infrastructure, in the bottom half of the figure, ushers in the users' viewpoint. Infrastructure is not only what planners and designers say infrastructure should be but it is also the multitude of perceptions of users about the infrastructure. This is where social science research techniques come in to help unearth the immaterial elements of the infrastructure. Box 3 contains the users' involvement in design methodologies, either as part of the preparation of work development or a reaction to the implementation of new designs. Users may be asked to participate directly in work development activities or they may participate indirectly, for example by taking preparatory training or simply by resisting change. Box 4 contains the leadership action which is necessary to drive the activity in boxes 1, 2 and 3. It contains the generative rules which feed on leadership values, as well as the organizational contexts created by the application of the rules. Such contexts are cultural in nature and they constitute the immaterial part of the organization's design.

Ciborra and Failla (2000) provide an excellent example of the development of a large corporate infrastructure which correspond to the cycle represented by the boxes 1-2-3-4 in Figure 2. The case is about the implementation of a world-wide CRM infrastructure at IBM started in the early 1990s, arising as response to the major business downturn the company experienced in the late 1980s. The very ambitious project was aimed at the reengineering of all the major processes linking the company to its customers and was thus labeled "the new plumbing at IBM". Ciborra and Failla (2000) make a distinction between

two stages in the implementation process, similar to the distinction made in Figure 1, under the *planning* and the *situated* modes of organizing. They call the two stages "mechanistic" and "adaptive". The first entailed the straightforward application of the CRM model and the second involved the learning and the adaptation of the people to the new processes, but also some adaptation of the new infrastructure to the old processes. They highlight the importance of the organizational legacy and conclude that although the implementation of the CRM infrastructure was a success to a large degree, the old IBM culture of a "well managed centralized bureaucracy" was still present. The case ends with a question about the transition between the old "formative context" and the new culture of decentralization and process orientation. Ciborra and Failla (2000: 123) ask "should IBM governance mechanisms be adjusted to this permanent transition, instead of being aligned towards an end state that will never be obtained?" The answer to this question goes to the heart of organization design theory and clearly highlights that adjustable governance mechanisms, rather than fixed design dimensions, are the appropriate response to the requirements of organizational agility.

The cycle represented by the boxes 1-2-3-4 represents one part of the creation and development of an organization's infrastructure. What is missing from this cycle is *what happens next*, that is what happens in the myriad situations where the plans do not produce the intended results or when the results exceed the intention of the plans. In terms of an action methodology for organization design, the additional steps which allow dealing with (i.e. systematically searching and managing) breakdowns or innovative uses of the infrastructure are crucial. Breakdowns are the causes of error, inefficiencies and loss of value which plague all types of organizational designs. Innovative uses of the infrastructure are the opportunities presented by the new organizational capabilities (both human- and technology-related) which are very often not recognized by management. This gap has been filled by the conceptual device put forward by Pipek and Wulf's (2009) and named *points of infrastructure*. The point of infrastructure is the point in time when the infrastructure becomes visible to its users. It occurs because of two reasons: a breakdown in the infrastructure or the local resolution of a "reverse salient" (Star and Bowker, 2002).

A breakdown is experienced when users perceive a significant incongruence between the level of service expected from the infrastructure and the actual service received from the infrastructure. In terms of organization design, there are breakdowns all the time. Some are more obvious in view of the fact that they are related to the materials aspects of the infrastructure and others are more difficult to detect given that concern the immaterial, mostly people-related aspects. However, what is important is that traditional organization design theory has no mechanisms for dealing with breakdown, in a systematic fashion. The same is true of mechanisms for dealing with innovative uses of the infrastructure. A "reverse salient" is a notion put forward in sociological research to signify the point in time when the potentiality offered by the infrastructure is met by the decision to adopt a local practice. Such a decision may, in turn, change the original intention of the infrastructural arrangements.

In a real organization, there will be many points of infrastructure occurring on a regular basis. What organizations need to do is to create policies and procedures for dealing with such events and for turning them into infrastructuring or designing opportunities: "infrastructuring activities inform a search for possible points of infrastructure that will evoke an improvement of work infrastructure" (Pipek and Wulf, 2009: 460). Once a point of infrastructure is identified, an opportunity is then created to engage in what Pipek and Wulf call *design-in-use*. Design-in-use is a useful distinction from design-before-use, the traditional conception of organizational design, whereby design is carried out by professional designers

of artefacts to be used by unspecified users. In the diagram in Figure 2, design-in-use is labelled as boxes 6 and 7.

Pipek and Wulf (2009) provide examples of points of infrastructure as breakdown as well as innovative uses of the information infrastructure. In a case about the introduction of a groupware infrastructure in a German state government, these authors report on the changes occurring to an existing typing pool as one of the results of the new groupware artifact. They explain that the existing division of labor in document production which involved dictating and typing plus its associated artifacts, such as computers with text processing software and internal courier service presented an opportunity for making the usage of the groupware immediately beneficial. Both document production and document exchange would be made dramatically faster by the introduction of the groupware application, however the way that the data was exchanged between the people who produced the documents and the typing pool still had to be negotiated. Without such process of negotiation there would have been a breakdown in the infrastructure between these two groups of people, in spite of the improved technological capabilities. The process of negotiation, which led to the development of new conventions of practice, was labeled Pipek and Wulf (2009) as *design-in-use*.

Two more examples taken from the same case refer to the usage of the new groupware infrastructure by individuals. The first instance relates to the reduction in the number of typists in the typing pool due to the voluntary adoption of text editing practices by the authors of the documents. Given the new capabilities afforded by the groupware, document originators decided that it was quicker to make minor changes to the documents themselves than to send the documents back to the typing pool. This is an example of an innovative use of the information infrastructure. The second instance relates to an action of counter-implementation adopted by one of the remaining typists as a measure to protect him/herself from the possibility of job loss. Against the policy, the typist in question decided to store a number of document templates in his/her personal workspace and to make them available only upon request. The outcome of this action was a breakdown in the infrastructure whenever the typist was on leave. Once again, the measures taken to counter such action constitute examples of *design-in-use*.

In all the examples above it can be seen that *design-in-use* steps are no more and no less than steps in organization designing. The information infrastructure would not function properly without the *design-in-use* steps but, on the other hand, it was the information infrastructure which drove the changes in the first place and forced the organization's design to follow.

7. CONCLUSION

In this paper we have argued that two independent research traditions – information systems design and organization design – can benefit from the adoption of a common intellectual platform – the organization's information infrastructure as well as its infrastructuring processes. In the design and development of both information systems and the organization, designers are always faced with an installed base with many invisible elements. Unlike a building or a bridge, where most of the infrastructural components are visible, an organization's (mostly information-based) infrastructure is largely invisible. This accounts for many of the failures or limited success of projects of organizational change, which includes the implementation of both information systems design and organization design.

Organizational infrastructures are, of course, very different from public infrastructures, for example for the provision of water or electricity. In organizations the problem is not as simple as fixing a ruptured pipe or a faulty high-voltage cable. The problem, in organizations, involves intensive human participation and problem-fixing cannot be done without the

cooperation of organizational members. However, unlike the electricity company with its emergency brigades ready to assist and fix breakdowns, organizations usually have neither such mechanisms nor the procedures for dealing with the redesign that should follow a breakdown. Thus, there is a need for a framework of organization design which includes, under the same ontological foundation, not only planning, development and routine maintenance activities, but also mechanisms to cope with breakdown or non-standard use as well as post-implementation design.

Talking about the problems associated with managing corporate infrastructures, Ciborra (2000) has recommended that "instead of worrying about under-management and trying to regain control through approaches that prove from the outset to be too simplified, why not play with the idea of a different partition between the limited scope for our management of the infrastructure and the scope for the infrastructure to manage us". We suggest that the new partitioning proposed by Ciborra is to be found in the concept of *point of infrastructure*, which creates a demarcation between the infrastructure in regular operation and those parts of the infrastructure that need some sort of attention. Most parts of the organizational infrastructure work uneventfully, just like an elevator, 24 hours a day, seven days a week. After they have been planned, designed and implemented, organizational processes will work as they should. After going live, only a relatively small part of the infrastructure will requires the organization's attention, either in terms of fixing a breakdown or taking advantage of an innovative use of the infrastructure.

Points of infrastructure and design-in-use are two of the concepts highlighted in the framework proposed in this paper. Inspired on Pipek and Wulf (2009), the model explains how the organizational infrastructure can serve as a bridge between information systems and organization design. It follows the recommendation by Snow et al (2006) regarding the need for an organization design theory that integrates concepts and approaches from organizational change. In addition to the concept of infrastructure, the model introduces the notion of infrastructuring (or designing). The relationship between these two concepts is autopoietic (Maturana and Varela, 1980), meaning that in the process of infrastructuring the infrastructure produces the components which reproduce itself.

Summing up, the proposed framework makes the distinction between three layers of the organizational infrastructure (infrastructural background status, work development and design-in-use) and two modes of organizing (planning and situated). The distinction between infrastructural background and work development highlights the effects of the organizational legacy on all forms of work development, while the distinction between work development and design-in-use brings in a host of a new opportunities in terms of improvements to organizational effectiveness. Finally, the model bridges also between the planning and situated modes of organizing, thus suggesting new ways to integrate *hard* engineering methods with *soft* behavioural approaches.

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COLLABORATIVE METHODS FOR BUSINES PROCESS DISCOVERY

MÉTODOS COLABORATIVOS PARA A DESCOBERTA DE PROCESSOS DE NEGÓCIO

Marielba Zacarias
Paula Ventura Martins

ABSTRACT

Information flows across the organization are complex and procedures employed to understand, share and control organizational knowledge and experiences should be properly supported by collaborative environments. Nevertheless, few collaborative methodologies had been proposed to describe and evolve business processes. Existing tools don't provide the right methods for business processes discovery, modelling, monitoring and improvement. In the future, business processes models should be the result of cross-team and cross-departmental collaboration, with involved business people sharing their personal knowledge and formalizing it.

This discussion paper focuses on collaborative process discovery methods, tools and the importance to integrate local information into coherent and sound process definitions. Business Alignment Methodology is a methodology that provides guidance about how organizational practices and knowledge are gathered to contribute for business process improvement against current Business Process Modelling approaches.

Keywords: Business Process Discovery, Collaborative Work, Methodology, Modelling.

RESUMO

A complexidade dos fluxos de informação organizacionais e os procedimentos aplicados na compreensão, partilha e controlo do conhecimento e experiência organizacional deverão ser suportados de forma apropriada por ambientes colaborativos. Porém, as propostas existentes sobre metodologias colaborativas para a descrição e evolução de processos de negócio são muito limitadas. As ferramentas actuais não providenciam os métodos apropriados para a descoberta, modelação, monitorização e controlo de processos de negócio. No futuro pretende-se que os processos de negócio resultem de colaborações entre diferentes equipas e departamentos, em que os actores organizacionais partilham e especificam formalmente o seu conhecimento individual.

Este artigo apresenta um método e uma ferramenta colaborativa para a descoberta de processos de negócio, bem como a importância de integrar informação individual e colectiva em descrições de processo coerentes e robustas. A Metodologia para o Alinhamento de Negócio, em oposição às abordagens correntes para a modelação de processos de negócio, é uma abordagem que descreve a forma de capturar conhecimento organizacional de forma a contribuir para a melhoria dos processos de negócio, a partir de prácticas de trabalho individual e colectivas.

Palavras-chave: Descoberta de Processos de Negócio, Trabalho Colaborativo, Metodologia, Modelação.

JEL Classification: Z19

1. INTRODUCTION

The business world is continuously changing and is now aware of the need to improve interactions employee-employee and employee-client. Now organizations feel the urgent need to share, communicate and improve business processes descriptions that uncover such interactions. Information flows across the organization are complex and procedures employed to understand, share and control organizational knowledge and experiences should be properly supported by collaborative environments (Althoff, Bomarius, & Tautz, 2000).

An adequate supporting system requires attention to continuous changes and business process descriptions should emerge and evolve based on knowledge sharing within an organization (Mengoni, Graziosi, Mandolini, & Peruzzini, 2011). The time that senior managers defined and controlled business process models is coming to an end. In the future, business processes models should be the result of cross-team, cross-departmental and cross-organizational collaborations, with all the involved operational actors sharing their personal knowledge and formalizing it.

There is a vast literature about principles and theories behind collaborative processes and tools (Huettner, Brown, & James-Tanny, 2007). However, few collaborative tools had been specifically proposed to describe and evolve business processes. Existing tools don't provide the right methods for business processes discovery, modelling, monitoring and improvement. They don't allow gathering current experience and knowledge for business processes discovery and improvement purposes. They don't support the underlying collaboration mechanisms of operational actors that enable them to cope with changing contexts or react to existing problems. These are the main reasons for high rates of failure and disappointment in many approaches, methods, and techniques used for Business Processes Management (BPM).

There are several problems associated to current BPM approaches, such as: (1) existing BPM approaches are based on the top-down paradigm; (2) knowledge acquisition and modelling are time consuming activities; (3) existing BPM approaches don't provide means to react to change; (4) existing BPM mechanism don't allow identifying business practices which are diverging from its base business process description.

Business Alignment Methodology (BAM) is a methodology for business process improvement that sets out principles and strategies for improving the quality of business processes. This methodology provides guidance about how organizational knowledge and work practices are gathered and discussed to improve business process. BAM encompasses the following phases:(1) Business Process Discovery, (2) Business Process Supervision and (3) Business Process Analysis and Improvement.

A key driver of BAM, concerning business process improvement, is the ability to facilitate the alignment of business processes and daily work practices. In this regard, this paper focuses on the process discovery phase, particularly on the collaboration processes and tools that allow integrating local information about work practices into coherent and sound process definitions. A brief discussion of existing approaches for business process discovery (Ghose, Koliadis, & Chueng, 2007) allows identifying weaknesses and proposing improvements included in this methodology. One of the contributions of this paper is to present a new collaborative tool to support the process discovery phase through the annotation and discussion of business process descriptions among all operational actors somehow related with such processes.

The remainder of this paper is organized as follows; section 2 presents the state of the art about business process discovery methods. Section 3 briefly describes the phases of the proposed methodology, emphasizing on the business process discovery phase. Section 4 presents MAPA, a tool for Business Process Discovery. Finally, Section 5 concludes and introduces future work.

2. BUSINESS PROCESS DISCOVERY METHODS

Traditional Methods to discover business process requirements include: an initial meeting, interviews, questionnaires, observation and ethnography. However, these traditional methods are usually costly, take a great amount of time to complete and introduce a high percentage of human error (Houck, 2007). There are several reasons why traditional BPM approaches do not achieve expected goals:

- Top-down approach that provides a broad organizational perspective, however with lack of detail.
- Different people have different viewpoints and it is difficult to achieve shared process definitions.
- Organizations structures, rules and practices are constantly changing, it is important to provide mechanisms to align business process descriptions with actual structures, rules and practices.

Ethnography represents a form of descriptive observation where researchers embed themselves into a work (Ritter, Lyons, & Swindler, 2007). Within this field, a number of strengths and weaknesses have been identified. The strength of these insights is that they reflect actual work practices. Observation also uncovers features of the work that are not obvious to participants because they are deeply embedded in what they do on a day-to-day basis. The weaknesses are due to the fact that the wealth of information that is contained within an ethnographer's notes is highly unstructured and personalized. Recently, several authors have proposed automated process discovery techniques (Aalst et al., 2007; Houck, 2007). Nevertheless, these techniques are restricted to records created by Process-Aware Information Systems (PAIS), which are not always available.

From our perspective, Business Discovery (BD) requires hybrid techniques to detect process problems and the root causes for these problems (Houck, 2007). Interviews allow gathering viewpoints from selected key actors, while collaborative methods allow discussing such viewpoints among a larger number of actors enabling asynchronous discussions that reduce the need of face-to-face discussions. Regarding business processes, main benefits of collaborative tools are: uncovering several viewpoints of the same activities, an enhanced visibility of business processes to operational actors and deeper analysis of business processes.

It is important to emphasize the difficulties common to ethnography and collaborative methods. In particular, when it comes to bridging the gap between business and IT view on business processes, results from these methods may have to be processed and structured to develop more accurate business models. We consider that a good collaborative tool that provides structured data of business processes for IT engineers should allow to discover, share, analyse and improve business process descriptions from non-structured and personalized information. Whereas the proposed approach allows non-structured annotations and discussions as well as personalized information, it provides the means to enable accurate, precise and structured representations of business processes.

3. METHODOLOGY

It is argued that existing business process (BP) methodologies do not offer the necessary flexibility or agility that new approaches require. Process-centric approaches tend to emphasize process (workflow, decision, information, activities) as the dominant dimension (Hollingaworth & Services, 2004), but an activity-agent-product centric approach must also capture aspects about interactions between human, activity and informational components. Recent research in BPM pays more attention to flexibility as a way of coping with the

unpredictability of business processes (Mutschler, Weber, & Reichert, 2008; Reichert, Dadam, Jurisch, Kreher, & Goser, 2008). Based on this new context, BAM methodology represents a multidisciplinary approach that allow business analysts to improve business processes discovery, monitoring and analysis, paying attention not only to process but to product, information and human dimensions through work practices.

Although business processes do involve different actor perceptions, this flexibility is important to adjust business processes in response to changes in the organization, in order to reach a global view of the real organization. BAM approach addresses the impact of individual knowledge, collaboration and knowledge sharing from a business perspective by examining actions at individual, group and organizational levels. To assists business analysts in creating, sharing and learning business process, the methodology proposes a two-dimensional approach. The two dimensions, Practice and Process (figure 1), will ensure the proper structure to articulate individual, group and organizational knowledge with business analyst knowledge acquisition. The Practice dimension explores day-to-day work based on practitioners descriptions. The methodology proposes to assist organizations in its efforts to assess and manage problematic situations of specific daily practices, and develop and implement solutions that help manage these problems. The Practice dimension covers real information needed to systematically support or reject many of decisions about the business process models. In the Process dimension, business analysts based on information of the Practice dimension formulate business process reviews and iterative business process improvement efforts.

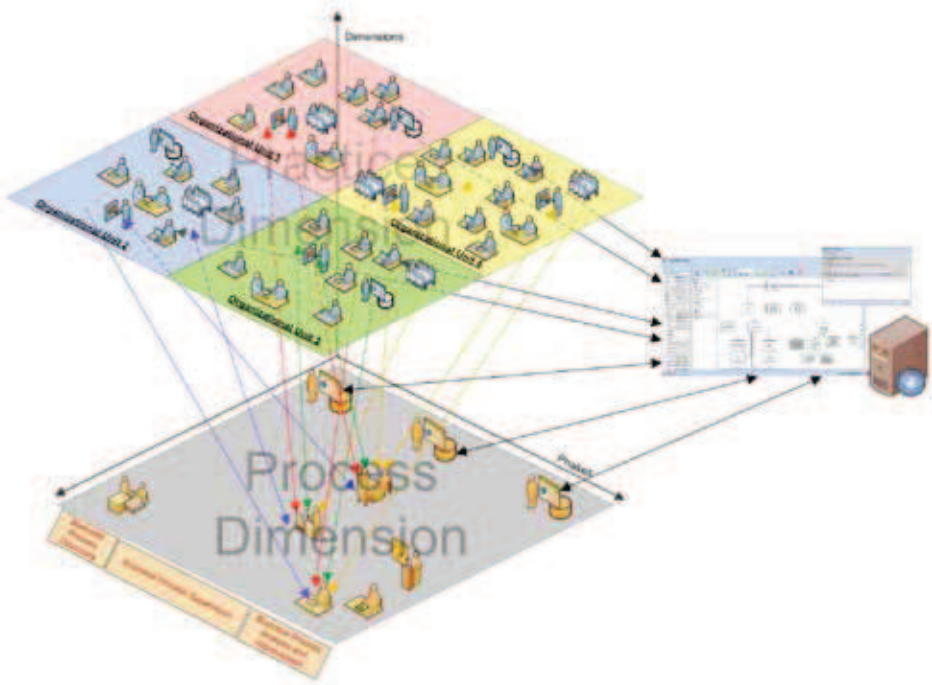

Figure 1 - Business Alignment Methodology

The present approach integrates collaborative methods into a methodology that allow discover and improve business descriptions. There are three phases outlined in the methodology: (1) *Business Process Discovery*, (2*) Business Process Supervision* and (3) *Business Process Assessment and Improvement*. *Business Process Discovery* phase main goal is an initial process specification through interviews and collaborative methods. *Business Process Supervision* phase involves provides assurance that daily practices follow the base business

process model or reveals the need to take corrective actions because real activities performed by operational actors are different from those specified in the business process model. In *Business Assessment and Improvement* phase, initially, business analyst and managers analyse real business performance and produce assessments focused on business processes issues, respectively. After that, the results gathered during assessments enable improvements and consistent refinements of the base business process model creating a new version. Each phase includes specific working methods and goals that are presented in the following subsections.

Since the focus of this paper is on business process discovery methods, we only describe in detail the business discovery phase. The other two phases only have a brief description of methods and goals.

Phase I - Business Process Discovery

The first goal of a *Business Process Discovery* (BPD) is just to get personal descriptions of business processes. Operational actors have knowledge of their actions, nevertheless their knowledge is personal and to a certain extent tacit, hence it is hard to formalize. In fact, most organizations simply do not know their end-to-end processes accurately or in detail, since their process knowledge is tacit and decentralized (Verner, 2004).On the other hand, organizational knowledge crosses functional divisions and outside the organization (clients, suppliers). Therefore, organizational processes embody specific accumulated knowledge that is not confined to particular individuals or groups. This knowledge, which is explicit, must be transmitted but this is not enough. Business process modelling approaches should consider the effect of continuous business processes improvement as a reaction to fast-changing environments in the business world.

BPD phase aims at developing an organizational profile of people, activities, technology, and information in order to understand business processes. This phase includes two main sub-phases: (1) *Learning (Eliciting) Business* (LB) and (2) *Modelling Business* (MB). *Learning Business* is knowledge acquisition, a set of tasks that can be the most time consuming portion of BPD. Some of the major considerations include the choice of the methods to use for acquiring specific types of knowledge (Koschmider, Song, & Reijers, 2010). In order to serve this purpose, the methodology will not consist only on translating natural language descriptions of business processes but also includes guidance in the form of instructions, templates and examples. Modelling Business consists in an intensive interaction between actors of the two dimensions, operational actors and business analysts.

Learning Business

Initially, the sub-phase *Learning Business* includes interviews where the business analyst interacts with operational actors as key to the success of business discovery. At an organizational level, the methodology proposes to assist organizations in their effort to assess and manage problematic situations based on daily actions and implement solutions related to these problems.

Table 1: Learning Business Process guidelines

Guideline	Description
Goal	Find out organization's needs regarding business discovery, analyse and understand problems with senior managers, and define an initial business process view.
Purpose	The business analyst finds current process practices to include in an initial business process description.
Method	Initial meetings with senior managers mainly covered questions about the organization's mission and goals. Also important was information retrieved through interviews and questionnaires. The organization also delivered several documents relevant for an initial development process definition. A kick-off meeting mainly covered a description of the collaboration process and a presentation of a process draft.
Actors	Business Analyst and operational actors.
Activities	Kick-off meeting, interviews and questionnaires. Business process specification.
Milestones/Outputs	Organization's goals list and initial. Business process specification.

The BAM methodology was designed for explicitly addressing the social dynamics of business process specification. It is based on social interactions as proposed in a two-dimensional space. The Practice dimension covers information needed to systematically support or reject many process decisions based on the result of daily experiences. The exact process representation concerns activities, resources, decision points and work flows (topology). In the Process dimension, business analysts capture best practices from the practice dimension that leads to business process reviews and improvement. The dynamic interplay between these two dimensions (practice and process dimensions) shows the synergy between activities performed by key operational actors and activities described by business analysts involved in BPD. Table 1 outlines the guidelines regarding method, actors, activities, milestones and goal.

Modelling Business

After an initial business process definition, business analyst starts modelling business processes. The sub-phase *Modelling Business*, from the knowledge management point of view, involves several stakeholders (business analyst, process owner, organizational unit responsible and operational actors) into four interrelated activities: (1) model construction; (2) model revision and evaluation and (3) model approval (table 2). Model construction is an activity that transforms tacit and implicit knowledge and specific contextual situations into more structured and documented forms. The model revision and evaluation activity results from a critical review of existing knowledge about business processes.

All participants may present alternative proposals that result from associating different facts and new meanings. The updating process provides support to business process model discussions and negotiations to correct represented activities and other aspects. Finally, the model approval activity concludes the interaction process and collaboration among the parties involved in a business process model specification by approving or rejecting the model.

The model revision and evaluation activity will use the annotation as a mechanism to capture the updated proposals made by business actors. Annotations are used mainly to make proposals to correct the model (corrective maintenance), to capture changes in

action or interaction contexts (adaptive maintenance), to make free comments that could anticipate problems (preventive maintenance) and promote continuous process improvement (perfective maintenance). If business actors detect any misalignment between the model and their knowledge of activity current states-of-affairs, they can make a textual or graphic annotation with the correction proposal.

Booth dimensions (practice and process) involve the same actors (business analyst, organizational unit responsible and operational actors). Organizational unit responsible has modelling responsibility of the practices within his organizational unit. At process dimension, modelling responsibilities should be attributed to process owners. All actors have annotation and reviewing rights over practices of their organizational units. Nevertheless, they also have rights to annotate and review processes related with their work.

Table 2: Modelling Business Process guidelines

Guideline	Description
Goal	Support business process model discussions and negotiations to improve an initial proposal.
Purpose	Obtain a business process model accepted by operational actors.
Method	The business analyst constructs and initial business process model, which triggers business process model changes based on annotations of involved operational actors. The phase ends the approval of a final version of the business process model.
Actors	Business Analyst, Organizational Unit Responsible and operational actors.
Activities	Model construction, model revision and evaluation model approval.
Milestones/Outputs	Business process models.

Phase II — Business Process Supervision

In the *Business Process Supervision* (BPS) phase, formal control mechanisms are designed in order to ensure that operational actors carried out real business activities as described by business models. Control mechanisms consist of three main activities: (1) compare real business activities with base business models (2) annotations/reviews and (3) identify new business descriptions.

Each annotation/review should be adding or validating new features to improve the business process. During this phase, the organizational unit responsible and operational actors will analyse improvements against oldest daily practices. In this context, operational actors will become more and more confident on suggestions of the business analyst. From iteration to iteration, confidence will increase and results will start appearing.

The milestone that marks the end of this phase and the beginning of the *Business Assessment and Improvement* phase is crossed when business analysts and operational actors agree that: business process model describe the detailed behaviour that address real needs, major problems have been solved, business process practices provides some useful value to the organization and these practices are stable enough to implement a new and improved business process version.

Phase III — Business Process Assessment and Improvement

Business Process Assessment is a mean for organizations to identify their strengths, weakness, existing improvement activities and key areas for improvement. It enables organizations to determine the current state of their business processes and to develop improved models. In

the begin of the Business Process Assessment and Improvement (BPAI) phase, the business analyst analyse change proposals and through a comparison between base business process models and proposed changes, a new set of models is build to correct work that is not proceeding well, by showing where adjustments need to be made. In the end, the results gathered during assessments enable improvements and consistent refinements in order to produce an improved set of business process models. This phase ends when all the involved actors agree that: the objectives set during BPD (and modified throughout the second phase) have been met; and especially if all participants are satisfied with the new business process model version. BAM directs attention to organization's needs for communication, coordination and collaboration within and between operational actors and business analysts. The methodology is about how business processes are represented and how business analysts acquire and use knowledge to improve business process. BAM methodology includes model and control activities that intend to develop and implement organizational business processes (process dimension). Nevertheless, control activities also include monitoring and tracking of day-to-day work (practice dimension).

4. MAPA – TOOL FOR BUSINESS PROCESS DISCOVERY

To support the Process Discovery Phase, we used a tool named MAPA Discovery (Monitoring and Annotation of Processes and Activities) (Castela, Dias, Zacarias, & Tribolet, 2010). MAPA features are:

- Graphical Business Process Editor
- Support for annotations, revisions and approval of business process diagrams
- Different levels of granularity
- Configuration of access rights and notifications
- Allowing annotations of diagram elements
- Version and Annotation History

MAPA complements traditional graphical business process edition capabilities with generic features of collaborative tools (comments and discussions) and requirements specific to collaborative business process modelling by embedding a annotation-review-approval process named PROASIS (Castela, Zacarias, & Tribolet, 2010) where annotations, revisions and approvals are performed by users with specific responsibilities within each process. PROASIS identifies four organizational roles (annotator, reviewer, approver and modeller) and four types of actions (annotation, review, approval and modelling). Modellers create and update activity or process diagrams using standard graphical edition features. Annotators are operational actors with rights of making annotations on process elements (activities, information flows or other actors), process fragments or processes as a whole. Annotations are (1) change proposals or (2) arguments regarding perceived errors or lacking details. In MAPA, annotations are used mainly to make proposals to correct models (corrective maintenance), however, they can be used also to capture changes in (adaptive maintenance), to make free comments that could anticipate problems (preventive maintenance) and promote continuous process improvement (perfective maintenance).

Reviewers are actors with rights to comment supporting (agree) or counter-arguing (not agree) such annotations by making revisions of the annotation. Each annotation initiates a discussion thread around the annotation subject that is replied through one or several revisions. Approvers are actors with rights to end discussion threads by approving or discarding the proposal or argument contained in the initial annotation. Once approved, modellers proceed to make the changes or corrections on the corresponding diagram. Once modellers

complete approved modifications, a new version of the model is created and annotations, revisions and approvals are cleared. However, this previous version is not deleted. Instead it is shown as part of the diagram history. Each annotation, revision and approval triggers e-mail notifications to all actors associated to the corresponding indicating the process, type of transaction and actor who performed it. According to PROASIS, MAPA should provide two perspectives; (1) Process and (2) Organizational perspectives.

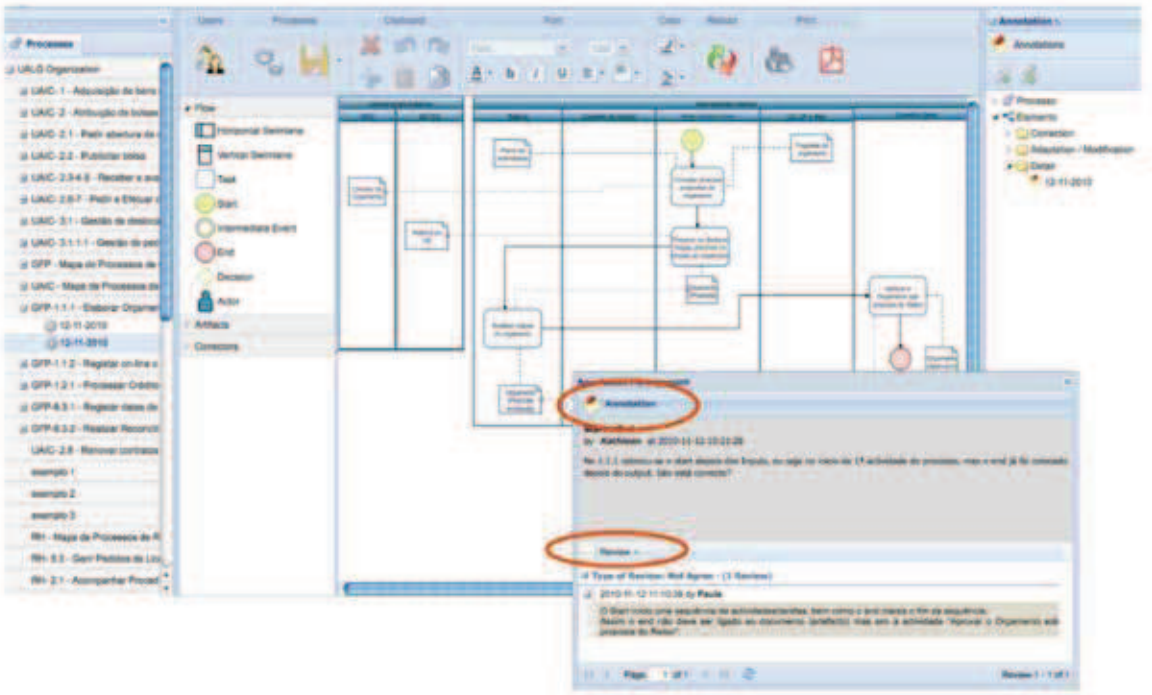

Figure 2 - The MAPA tool

The process perspectives encompasses two main different views; (1) Execution View and (2) Process Owner View. The execution view aggregates the activity and its context (used and produced documents, information systems, previous and subsequent activities, annotations, etc.). The process owner view shows process descriptions and its history. It also shows the organizational units crossed by the process. The Organizational perspective encompasses two main views (1) Organizational unit where the actor works, and (2) Organizational unit headed by the actor. This view also shows the processes where the organizational unit participates. However, the current version of MAPA only includes the Process Perspective and Process Owner view.

Figure 2 depicts an image of the MAPA interface. The top area includes some standard editing commands. In that area, the tool includes two essential buttons: users and processes. The processes button allows creating new processes or new processes versions. The users button allows configuring users rights regarding processes. Users are associated to processes through roles (annotator, modeller, reviewer and approver). The left side of screen shows the list of processes that the particular user has modelling, annotating, reviewing or approving rights. The process list shows not only the current process version but also previous versions. The window over the diagram shows one annotation and review of the process in the main window. The right side area shows all the annotations and reviews of a particular model version. Central area is reserved for a standard process edition task.

5. CONCLUSIONS AND FUTURE WORK

This paper described a methodology for Business Process Improvement with focus on Business Process Discovery phase, particularly on collaboration methods and tools support. Incorporation of multiple viewpoints into the business modelling process also contributed to learn and change business processes specifications. Embedding a annotation-review-approval process named PROASIS, MAPA tool improve participation, providing a structured support to disseminate business process models, express opinions and negotiate perspectives.

The proposed methodology is the result of several case studies for business process improvement. However, a pilot case study regarding collaborative process modelling was conducted using the MAPA tool. Preliminary results show that it stimulated the involvement of all actors (business analyst, organizational units responsible and operational actors) in validating (and thus updating) the enterprise model, aligning it with the reality in an interactive and shared way. So, annotations and reviews fit the requirement of being a suited mechanism to generate, debate and insight about the organization in order to propose changes and improve the organizational business model.

In the future, we will focus on incorporating new functional requirements in the MAPA tool in order to: (1) model daily actions (practice model) and (2) align practice model (practice dimension) with business process models (process dimension). Future work will also include new efforts to gather empirical data on its use that will help refine the methodology.

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THE BLESSINGS OF VINTAGE: EXPLORING TECHNOLOGICAL CHANGE MADE BY USERS OF DISCONTINUED HOME VIDEO GAMES HARDWARE[1]

AS MARAVILHAS DO VINTAGE: EXPLORANDO A MUDANÇA TECNOLÓGICA REALIZADAS POR UTILIZADORES DE HARDWARE DE VIDEOJOGOS DESCONTINUADO

Jorge Graça

ABSTRACT

The paper analyses the relation between use and technological change, emphasising three points that are not usually mentioned in the literature: the need to study technologies and products beyond the typical Product Life Cycle model, the need to study the role of users as agents of technological change, and the need to study technology "in use", and not only new and upcoming technologies.

Based on those premises, an empirical study of the home video games industry was conducted, combing qualitative and quantitative research activities through the "crystallisation" technique. The qualitative component was used to analyse online communities of users that perform technological changes to discontinued home video games hardware (modders) and their activities. The qualitative component comprised an online questionnaire to 20 users.

Results confirm that "old" technologies continue to exist and to be improved long after they are discontinued, due to users' technological changes. These technological changes are complex processes, done through incremental steps, on an individual learning by doing basis, within a context of information sharing, and support within the communities. Although relevant from a technical point of view, the outcomes do not feedback into the innovation processes of companies.

Keywords: use, technological change, angry orphans, technological obsolescence.

RESUMO

O artigo analisa a relação entre o uso e mudança tecnológica, enfatizando três pontos que normalmente não são citados na literatura: a necessidade de estudar as tecnologias e produtos para além do típico modelo do ciclo de vida do produto, a necessidade de estudar o papel dos usutilizadores como agentes da mudança tecnológica, e a necessidade de estudar a tecnologia "em uso", e não apenas tecnologias novas e emergentes.

Com base naquelas premissas, foi realizado um estudo empírico sobre a indústria de videojogos, combinando actividades de investigação qualitativas e quantitativas, combinadas através da técnica de "cristalização". A componente qualitativa foi utilizada para analisar comunidades online de utilizadores que realizam mudanças tecnológicas em hardware de videojogos descontinuado (modders) e as suas actividades. A componente qualitativa compreendeu um questionário online a 20 utilizadores.

[1] This paper is the result of a Master thesis dissertation published at Aalborg University under the title: Between the Winner's Curse and the Blessings of Vintage – Exploring technological change made by users of discontinued home video games hardware. Available at http://bit.ly/jEabT2.

Os resultados confirmam que tecnologias "velhas" continuam a existir e a ser melhoradas muito depois de serem descontinuadas, devido às mudanças tecnológicas operadas pelos utilizadores. Essas mudanças tecnológicas são processos complexos, realizadas através de passos incrementais, numa base individual de aprender fazendo, num contexto de partilha de informação e apoio dentro das comunidades. Apesar de relevantes do ponto de vista técnico, os resultados não são incorporados n os processos de inovação das empresas.

Palavras-chave: uso, mudança tecnológica, angry orphans, obsolescência tecnológica.

JEL Classification: O33

1. INTRODUCTION

This paper is motivated by three related observations. First, some people keep using the "old" products, despite the appearance of all sorts of new and revolutionary state-of-the-art technologies that usually provide additional advantages. Technologies do not merely fade away, but continue to be improved and to shape the technological landscape long after their supposed obsolescence, often against newer rivals.

To frame this observation, in Section 2.1, two fundamental shortcomings in the Product Life Cycles related literature are explored: it closes the question of technological limits at an early stage, and the period of time when a product remains in use after withdrawal is disregarded, leaving the analysis of what occurs with products and technologies after they reach the maturity or declining stages out of the scope.

Second, people have the creative capacity to come up with ways of using old products that were not envisaged by their original creators. Users act as agents of technological change, reinterpreting "old" technologies, and finding new ways of using them for purposes that were not thought of when they were designed.

To frame this observation, in Section 2.2, the literature on technological change, understood as an advance in knowledge embodied in new designs for existing products or, made by the users is explored.

Third, technologies and products do not just disappear. They continue to exist and to be used long after they reach the maturity and declining stages predicted by the PLC model.

To frame this observation, in Section 2.3, the literature calling for the analysis of the technology in use is reviewed, expanding the notion that many technologies thought of as "old" remain in use for longer than the accounts based on the mainstream mental picture allows.

Based on those three approaches, the main objective of this paper is to explore the characteristics of technological changes made by users of discontinued home video game consoles.

Section 3 presents the home video games industry dynamics that contribute to the creation of the "angry orphans" (David, [1987] 2005) of this industry, i.e. the many users of hardware that was discontinued, who still use it and act on it by performing technological changes. This group constitutes the target of Section 4, where the empirical study is presented.

Section 5 presents the main conclusions and proposals to improve existing literature and possible research tracks for similar studies.

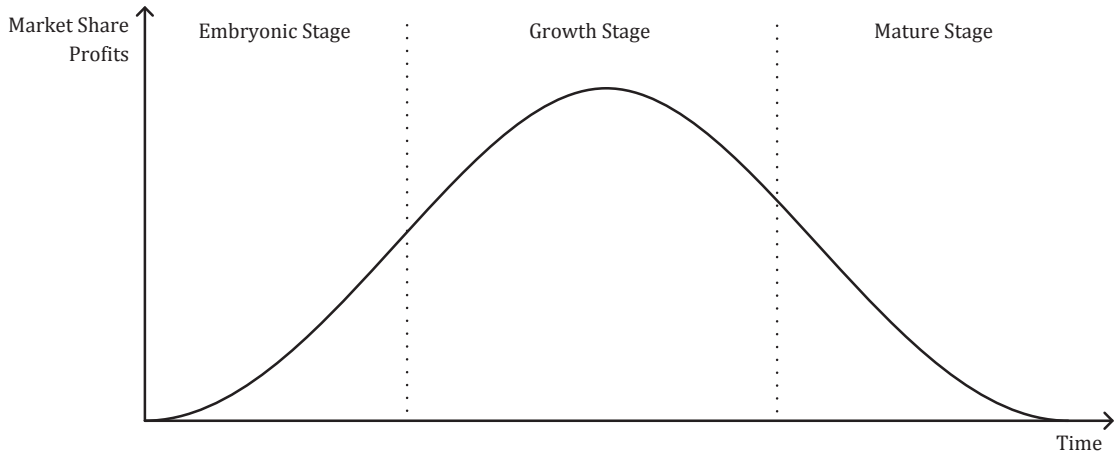
2. LITERATURE REVIEW

This section reviews and challenges the literature the related to the Product Life Cycle model. Next, the literature on the role of users as agents of technological change is presented. Finally, a review of the literature arguing for the study of technology in "use" is made.

2.1. Beyond the Technological Limits of the traditional Product Life Cycle model

The Product Life Cycle (PLC) model was originally developed as a tool for firms to understand and take advantage of the evolution patterns in new industries both in domestic (e.g., Levitt, 1965, Dean, 1976), and international markets (e.g., Vernon, 1966) within three stages: exploratory or embryonic, intermediate or growth, and mature (Figure 1).

Figure 1 – Product life cycle



Source: own elaboration, based on Levitt (1965)

Later, Utterback and Abernathy (1975, 1978) developed a stage model of the evolution of innovation patterns along the PLC to describe the properties of markets (industries) in terms of number of firms (entry and exit patterns), rate and type of innovations (new or improved products), market shares, and profits along a period of time – a fundamental insight that depicting the interplay of product and process innovation at different moments (Figure 2)

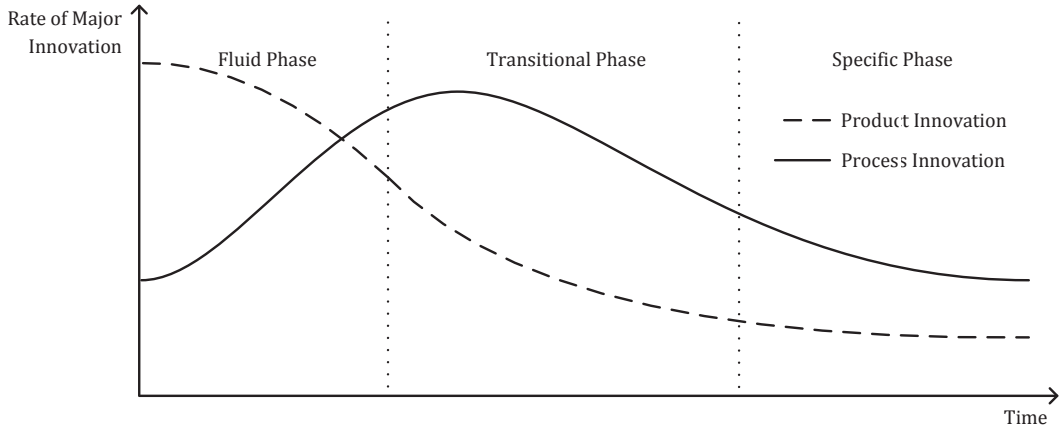
> *[...] initially the market grows rapidly, many firms enter, and product innovation is fundamental, and then as the industry evolves output growth slows, entry declines, the number of producers undergoes a shakeout, product innovation becomes less significant, and process innovation rises* (Klepper, 1997).

When product innovation is relatively more intense, firms try to explore the new technology in different ways. The technology branches off, yet within certain boundaries, because there are physical constraints to the level of experimentation a technology can undergo – the technological trajectory (Dosi, 1982). This is usually depicted as an S-shaped curve, a complementary analytical tool to the PLC (Figure 3)

> *[...] in the early stages of a technology, the rate of progress in performance will be relatively slow. As the technology becomes better understood, controlled, and diffused, the rate of technological improvement will accelerate. But in its mature stages, the technology will asymptotically approach a natural or physical limit such that ever greater periods of time or inputs of engineering effort will be required to achieve improvements* (Christensen, 1997, p. 39).

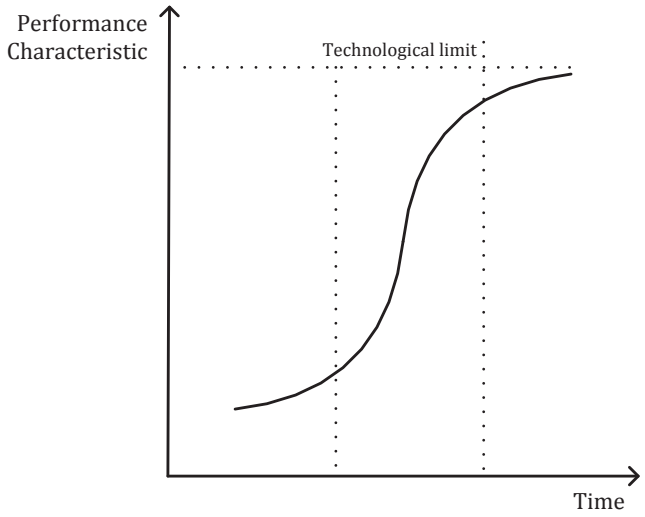
Thus in the early stages of development, a technology operates below its potential. Over time, performance improves at a faster pace in result of users' and designers' accumulated experience (learning). In any case, technological improvement becomes increasingly harder to achieve, as a technology approaches its limit, given for instance constraints in the amount of available knowledge, engineering and financial effort, competition with other technologies, and physical characteristics. This behaviour was found in a number of technologies, ranging from microprocessors and computer hard drives, to fertilisers, light bulbs, and jet engines (Asthana, 1995).

Figure 2 – Rate of product and process innovation



Source: Utterback (1994, pp. 82-83)

Figure 3 – Technology s-curve



Source: own elaboration

The PLC patterns are also recurrent in a wide range of industries and products. Utterback (1994, pp. 1-21) accounts found these pastterns in the typewriting industry in the US. Klepper (1997) describes similar findings in the US automobile industry. Clements and Ohashi (2005) and Altinkemer and Shen (2008) in the home video games industry.

Sufficient as the evidence demonstrating the PLC's significance to explain the industry's dynamics may be, the model presents two fundamental shortcomings from the perspective of this study. It closes the problem of the technological limits at an early stage, and the period of time when a product remains in use after withdrawal is disregarded, leaving the analysis of what occurs with products and technologies after they reach the maturity stage out of the scope

Empirical evidence demonstrates that in some circumstances technologies can be pushed further to transcend the limits, according to the idea that "old" technologies continue to be improved, postponing the time when they become "clearly outmoded" (Rosenberg, 1972).

Utterback (1994, pp. 145-166) describes the improvements caused by successive discontinuities in the ice and refrigeration industry in the US. Christensen (1992) suggests that incumbents in the disk drive industry were able to outcompete established firms, based on the capability of taking both the existing technologies, and the ones resulting from the need to push the conventional limits of physical laws to the market.

Particularly interesting is Henderson's (1995) analysis of the photolithographic alignment technology, showing that the limits of a technology are influenced not only by the structure of the dominant design, and the approximation to the imposed by the laws of physics. They also depend on the evolution of key complementary technologies, and more importantly, on the needs and preferences of the users.

These cases suggest that the PLC model depicts only a part of the complete cycle. Technologies may continue to exist and remain in use long after reaching the maturity stage, challenging the technological limits predicted by the S-curve, and the "tragic fate" of being condemned to disappear at some point.

2.2. Users as agents of technological change

Users are not mere passive consumers of technologies, something anticipated in the previous section in connection with their importance in the expansion of technological limits. Users play a role not only in the consumption, but also on the modification, domestication, design, reconfiguration and resistance to and of technologies, bringing to bear on them purposes other than those originally intended by the designers and marketers (Oudshoorn and Pinch, 2003).

Particularly interesting for this study is the last perspective where users are considered agents of technological change, a perspective put forward by Kline and Pinch (1996) in the extension of the scope of users' interaction with technology within the Social Construction of Technology (SCOT) framework. Analysing the adoption of the car in the United States in the first half of the twentieth century, by then a technology with rather stabilised meanings and uses in urban communities, they found that in rural areas users introduced a series of modifications to adapt the car to the needs of rural life, customising the machines to do things like grind the grain, plough the fields, or carry the produce to town, which could not be done had they not acted on the technology and reinterpreted its' use.

Similar findings are reported in a study about the users of the TRS-80 computer (Lindsay, 2003). Released in the late 1970s, the TRS-80 was still being kept alive by its existing users almost 25 years after it was discontinued in 1984. Much beyond its expected obsolescence, and with all kinds of support withdrawn by the manufacturer, users took on the roles of designers, producers, marketers, and technicians – agents of technological change – 'further developing the technology' (Lindsay, 2003, p. 29).

The conceptualisation of users as agents of technological change is linked to the works of von Hippel (1988), and Rosenberg (1982) in the realm of Innovation studies. Von Hippel's main point is that the llargest share of the innovation process is often carried out by the user, who 'recognizes the need, solves the problem through an invention, builds a prototype,

and proves the prototype's value in use'; the commercial application and diffusion are then carried out by the manufacturer (von Hippel, 1988, p. 25).

Rosenberg (1982, pp. 120-140) recognises that the feedback from the experience of use into the design and way of operating products – learning by using – takes place through small and gradual changes that eventually add up leading to changes in design, and productivity, and where 'the participation of the user in the process of making technological improvements is one of the critical features'.

A particularly important perspective for this study is that users act as agents of technological change contributing to the development of "old" technologies. By attributing new meanings to a technology that has long been discontinued, users drive a "double life" of technologies

> *[...] home personal computer use has ended up being largely for non-utilitarian purposes; early cassette recorders were intended to be used for playing pre-recorded tapes, but were generally used for recording from records; scratch music involves moving a record deck backwards and forwards at discos; video is used to make films as well as to watch them at home, and even within the home, use goes beyond the designers' intentions in that video is used predominantly to 'time shift' television [...]* (Mackay and Gillespie, 1992).

Furthermore, as shall be seen in the home video games industry case, such contributions often come from groups of enthusiasts and hobbyists

> *One of the remarkable characteristics of technological improvement over the past century or so has been the role played by enthusiasts and hobbyists. The irony of this is that it has typically been in technological realms of great complexity that such individuals have had their greatest influence. E.g., automobile, wireless telegraphy transformed into "radio", and the personal computer* (Friedel, 2007, p. 513-514).

2.3. Towards an analysis of technology in use

Technologies do not appear from vacuum, they are preceded by a history. However, Lindqvist (1994) criticizes the rather narrow approach to the history of technology – which seems particularly concerned with the initial periods of rapid technological growth, disregarding the whole "technological landscape", i.e. the ensemble of all existing technologies at any given time.

A perspective shared by Edgerton (2007, pp. xiv-xv)

> *Innovation-centric history focuses on the early history of some technologies which become important later. The history of invention and innovation needs to focus on all inventions and innovations at a particular time, independently of their later success or failure. It needs to look too to invention and innovation in all technologies, not just those favoured by being well known and assumed to be the most significant.*

In the same line, Rosenberg (1982, p. 19) notes that historians of technology, and economists alike, seem fascinated with things that change rapidly, rather than with things that simply exist and remain

> *[...] many historians, even economic historians, have focused their attention overwhelmingly upon one aspect of the question of technical progress: "Who did it first?". [...] Such questions are, indeed, important to the history of invention. Much less attention, however, if any at all, has been accorded in the productive process. Indeed, the diffusion process has often been assumed out of existence. This has been done by identifying the economic impact of an invention with the first date of its demonstrated technological feasibility or – what is hardly the same thing – the securing of a patent.*

What is more, 'the human-made world, the environment in which we form and experience our social relations, is almost completely shaped by "old age" technologies that have reached a state of maturity or decline' Lindqvist (1994, p. 276), reflecting that technologies remain in use after their supposed obsolescence, as discussed above

> *We still have buses, trains, radio, television and the cinema, and consume ever-increasing quantities of paper, cement steel. The production of books continues to increase. Even the key novel technology of the late twentieth century, the electronic computer, has been around for many decades. The post-modern world has forty-year-old nuclear power stations as well as fifty-year-old bombers. It has more than a dash of technological retro about it too: it has new ocean-going passenger ships, organic food and classical music played on "authentic" instruments* (Edgerton, 2007, pp. xi-xii).

The importance of the horse increased during World War II when the German army deployed many of the more than 3 million horses it possessed in battlefield operations; or in Cuba in the 1990s, when in the aftermath of the Soviet bloc collapse, the government established an animal traction programme to recover the agricultural sector from the shortage of Soviet and East European agricultural machinery supplies (Edgerton, 2007, pp. 35-36).

Those examples show that technologies do not merely fade away, they also struggle for survival, often against superior rivals, and show their historical importance at later stages (Lindqvist, 1994, p. 275-277). Furthermore, most inventions only acquire true economic importance many years after they are invented and widely diffused, and as seen before, not necessarily for the purposes they were thought of in the first place (Edgerton, 2007, Chp. 1, Oudshoorn and Pinch, 2003).

However the standard mental image mentioned above leads to an exaggeration of the importance of the initial growth stage in technology studies. Consequently, a wealth of the technological landscape has been left "undiscovered". Therefore, Edgerton (1999) argues for accounts of technology based on use.

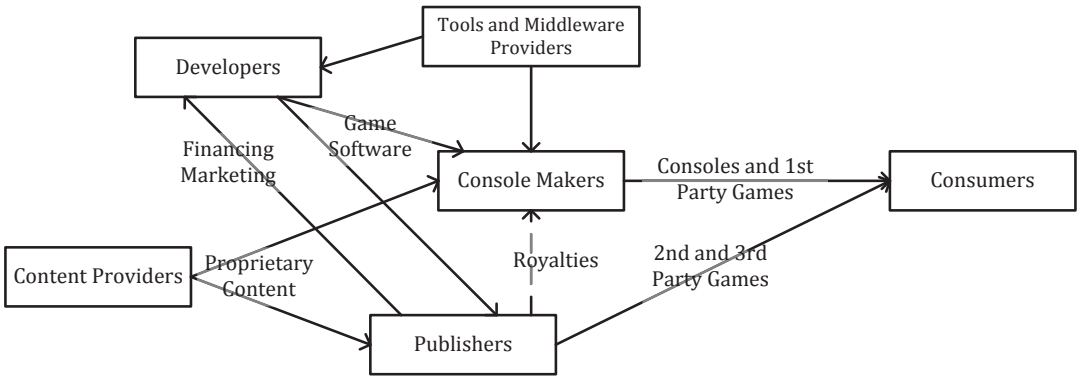
3. HOME VIDEO GAMES INDUSTRY DYNAMICS AND THE EMERGENCE OF THE ANGRY ORPHANS

Due to the existence of network effects in the home video games industry, a system has intrinsically no value if no software can be purchased or rented to be used in it[2]. Software and hardware are complementary, which is confirmed by several empirical studies (e.g., Gallagher and Seung Ho, 2002, Schilling, 2003, Clements and Ohashi, 2005).

In addition to the technical performance, the two other cornerstones for the success of a home video games platform are the ability to expand the installed base of users (direct network effects) and the availability of software (indirect network effects). To achieve this, manufacturers establish *de facto* standards that on the one hand lower the transaction costs of the producers in the ecosystem (Figure 4), and on the other increase buyers' switching costs.

[2] Early hardware manufacturers controlled the development and production of both hardware and software, a trend that changed in the late 1970s, when some companies started developing and producing hardware and software independently. This transition is the reason why the term system is used to describe the first generation home video games hardware, conveying the message of a complete and immutable hardware and software set; and the term platform is adopted from the second generation onwards to convey the message of a business catering two or more distinct groups establishing complementary relations, where hardware and software coexist in separate, but complementary ways. The term console is used indistinguishably.

Figure 4 – Home video games industry ecosystem



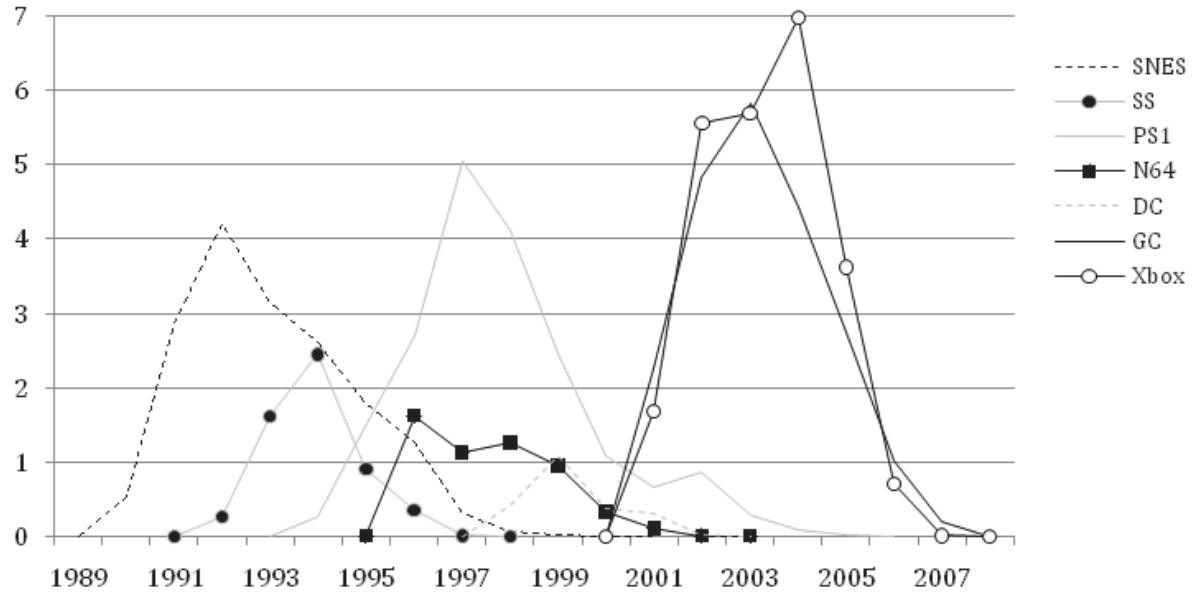
Source: Evans et al. (2006, p. 147)

Next we elaborate on the aspects of the home video games industry which are crucial to understand the emergence of angry orphans, which will be the focus group of the empirical study: the characteristics of the technology life cycle, the development of architectures and dominant designs, the disregard of backward compatibility, and strategies that increase consumer lock-in.

3.1. Technology life cycle

The technological evolution of home video games hardware is characterised by seven intertwined waves of technological innovation (see Annex A). New entrants have often outcompeted established players – each new console attempts to improve the previous technology. A multitude of incompatible systems is available on the market at any point, stimulating intense inter- and intra- generational rivalry due to the short product life cycle of the hardware (Clements and Ohashi, 2005) (Figure 5).

Figure 5 – Product life cycle for selected consoles 1989-2008 (sales volume in millions in America, Europe, Japan and Australia)



Source: own elaboration based on monthly data from VGChartz, retrieved online 26 April 2010 at www.vgchartz.com.

The technological leadership rivalry pattern is recurrent, but it is often the case when the most successful systems are the ones coupled with hit games. It was the case with the *Atari 2600* and the *Nintendo Entertainment System* (NES). Both platforms remained in the market long after competitors came up with technologically superior consoles, mostly because they had build impressive game libraries with hit titles, creating large installed bases of users. This reverts to the network-based characteristics of the home video games industry where the complementarity of hardware and software creates direct and indirect effects that draw users to or repel them from a platform.

3.2. Architectures and dominant designs

During the first and second generations of home video games there was high technological experimentation, which eventually eased in latter generations, as the technological trajectories became more explicit. While it took 20 years to establish the second dominant design, the third dominant design was established only 6 years after (see Annex A).

3.3. Backward compatibility

Backward compatibility has not been an important feature of the video games industry. As software (games) of previous consoles cannot be played in newer or competing models, companies fight a "full-blown standards war" to impose their latest models every five years, approximately the length of a generation (Gallagher and Seung Ho, 2002).

There are two reasons why backward compatibility may not be important. First, it does not necessarily contribute to the success of a platform. The *Atari 5200* was compatible with the vast game library of its highly successful predecessor *Atari 2600*, but this did not prevent it from achieving limited sales success. Second, a console can be successful even if not compatible with its predecessors. Nintendo made the Super Nintendo Entertainment System (SNES) deliberately incompatible with NES' outstanding game library, but even without that leverage, the SNES became one of the most successful platforms of the fourth generation.

Nevertheless, the *Playstation* series shows that backward compatibility can be advantageous for both manufacturers and consumers. This may be one of the reasons why in later generations intra-platform backwards compatibility is a recurrent feature. Inter-platform compatibility remains inexistent.

3.4. Consumer lock-in

In industries where network effects play an important role, manufacturers seek the smallest initial advantage that caters positive feedbacks and confers larger advantages in the future (Shapiro and Varian, 1999). In the home video games industry that advantage usually lies on the new entrants' side, who achieve initial lead through aggressive pricing strategies to rapidly build a large installed base, and allows them to appropriate the most benefits from selling games for a platform thereafter.

While low hardware price is necessary to start the adoption process of a console, software availability and variety are necessary for it to continue. Clements and Ohashi (2005) suggest that once a platform provider establishes an installed base, it encourages software entry and variety to signal a strong commitment that there will be continuous maintenance of the platform in the market, which in turn attracts more users.

3.5. The emergence of the (not so) angry orphans

The characteristics of the technology life cycle, the development of architectures and dominant designs, the disregard of backward compatibility, and consumer lock-in are factors that play in favour of platform providers, but are contrary consumers' interests.

Because the life cycle of a console is relatively short, and there is intense rivalry between companies to establish a *de facto* standard, there is frequent console turnover (Clements and Ohashi, 2005). This competition means that consumers are prone to be captive of a platform and can be induced to pay more than they should for the software. Coupled with limited backward compatibility this means that gamers have a sort of Trojan horse in their living rooms that contributes to increase lock-in in a specific model.

Therefore, many users of older platforms become victims of the "competitive gale" and are left outside the new prevailing network standard, and become "angry orphans" (David, [1987] 2005). They are *angry* because they made sunk investments in hardware whose maintenance and further elaboration was or will soon be discontinued, so they are or will soon became *orphans* of support from hardware and software manufacturers. Consumers get apparently "stuck" with a piece of obsolete technology because a substantial part of the value of the consoles is lost, e.g. in terms of direct and indirect network effects.

However, some "angry orphans" find another "life" in the discontinued hardware, which emerges from both the emotional side of video gaming, and the online communities of orphans that are established around the use of discontinued hardware.

3.5.1 An emotional experience

Video gaming is an emotional experience (Järvinen, 2009, Perron, 2005), developing during the action of gameplaying, but likely to stay with users for a long period, also because people have been playing video games for more than a decade on average (ESA, 2009, p. 3-4). Tthese are the reasons why the retrogaming movement that 'revisits the history and evolution of classic or "old school" video and computer games, appreciating the innovations of the past' (Rehak, 2008) is increasingly popular today.

Furthermore, the use of objects that became symbols of the past, such as vintage video game consoles, carries an aura of prestige, and is connected to a certain type of subculture and way of living

> *There is, in general, no social prestige in employing a technology that has reached a stage of maturity or decline. However there is often high social status in employing either a technology that is in its initial stage of growth or – paradoxically – a technology which has already declined and been by and large abandoned. It is, for example, prestigious to write either on a portable word-processor or with a fountain pen. A ball pen, le dernier cri in the 50s, lends little glamour to its present owner. [...] To flaunt a nylon shirt was the dream of us all during the initial growth stage of the synthetic fibre industry, but today it is a symbol of the nerd* (Lindqvist, 1994, p. 284).

Gamers look back to the past of video games with nostalgia, so when this emotional side of use develops, they do not necessarily feel "angry" about being orphaned and owning obsolete video game consoles that have been discontinued. They find themselves part of a vintage subculture adamant of the music and graphic design of older games that keeps the "old and orphaned" consoles alive and bustling.

3.5.2. Online communities

The growth of online gaming, and the pervasiveness of the Internet, created a proliferation of websites, groups and forums dedicated to video games. While some have a commercial purpose, many are set up in a spontaneous and collaborative manner by video game fans, and used for fan-based game production, or exchange of information regarding technical aspects and gameplay, for instance.

Users of discontinued video game consoles have also established their own online communities of enthusiasts and hobbyists. In particular, the orphans of the home video

games industry that act as agents of technological change gather online, as a subculture of appreciators of modifications of obsolete (vintage) home video games hardware. These users reinterpret and act on the hardware, contributing to the extension of its life cycle after it has been discontinued by the manufacturers. They find new creative ways of improving the hardware and using it for purposes that were not thought of originally.

In the next section we evidence the results of the "blessings" arising from the vintage video game consoles, reporting the findings from the empirical study conducted on those users and communities, in the exploration of technological change made by users of discontinued home video game consoles.

4. EXPLORING THE BLESSINGS OF VINTAGE: TECHNOLOGICAL CHANGE MADE BY USERS OF DISCONTINUED HOME VIDEO GAMES HARDWARE

The home video games industry's angry orphans acting as agents of technological change, are generally called "hackers", a term designating someone who builds, rebuilds, modifies and creates hardware or software, with a view to expand their capacities, give them new features or make them do something they were not intended originally.

Our concern was specifically the case of hardware modifications, an activity known as "modding". Hence, the (not so angry) orphans of the home video games industry are referred as "modders', and the modifications also called "mods".

4.1. Methodological Approach

The study was based on qualitative and quantitative procedures, combined through the "crystallisation" technique as the writing process unfolded (Richardson and St. Pierre, 2005, Janesick, 2000).

Grounded Theory was used in the qualitative part of the study (Goulding, 2002, Strauss and Corbin, 2008). Besides being an approach especially indicated in cases where new knowledge is sought in an area where few or no previous data is available, it also allowed a closer interaction with the reality and experiences of the home video games industry's orphans, through the analysis of the meanings of their words, thoughts and opinions.

Modders usually accompany a modification with a more or less detailed technical description of the process, so the qualitative data resulting from this research track included technical descriptions, photos, and comments of the modders and others in reaction to the modification projects. The data focused essentially the technicalities and uses of the modifications.

The analysis of that data alone would result in a narrow scope of the findings centred on technical aspects. Hence, to give consistence, objectivity and broaden the scope of the qualitative analysis' findings, the study also included a quantitative online survey, of aspects deriving from the qualitative analysis: the context and motivations of technological change (e.g., video gaming habits, motivations, constraints to the technical changes and the demographics of modders).

Qualitative and quantitative data were then compiled into a coherent whole as the analysis progressed and crystallised during the writing process, which was therefore also used as a method of inquiry (Richardson and St. Pierre, 2005).

4.2. Data Collection

The empirical data was collected from the "virtual" communities (databases and websites) where the modders publish the results of their modification projects:

- Retrothing.com. Website dedicated to vintage gadgets and technologies.

- Instructables.com. Collaborative community where members upload and download instructions of how to make different sorts of DIY projects.
- Engadget.com. Web magazine covering mostly new, but also vintage gadgets and consumer electronics.
- Hackaday.com. Website dedicated to the publication of a variety of technology hacks.
- Benheck.com. Website of a recognised consoles modder, where other users also share their projects.

Cases were selected on the basis of a set pre-established criteria, to insure that only real cases of technological change, made by "angry orphans" were selected:

- Involve technological change, defined as an advance in knowledge embodied in new designs of home video games hardware.
- Use hardware that had been discontinued at the time of the modification.
- Use at least one piece of original hardware, although other items might have been used or added in the modification process.
- Be made by a former or current user of video games, regardless of the platform.
- Be finalised and proven to be operating.

This procedure resulted in a sample comprising 70 cases, made by 59 different modders (Annex B). 50 of those users were contacted directly, either by e-mail or messages in the forums and websites, requesting the participation in the survey. The questionnaire was created using Google Docs Form, and all the questions made compulsory, except for the personal details of the respondents (Annex C).

The questionnaire was made available online through April 2010, and a total of 20 valid answers were received, representing a response rate of 40%, corresponding to 24 cases in the sample.

4.3. Results

4.3.1. The Orphans

Respondents of the questionnaire were 27 years old on average, and only 10% were women, indicating that older people might prefer to keep playing vintage video games in their original condition and not "destroy" them by doing such modifications. This feeling of "preservation" is actually quite common, and can be grasped in the comment to a modification that involved the removal of all the components of a NES, whose shell was then used to house a DVD player (case 59):

> *I would do the same thing, except my now-21-year-old NES still works, and I have no intentions of breaking it.*

The majority of respondents was located in North America, indicating that these "virtual" communities have strong geographical rooting. This is not surprising, taking into account that the United States is the largest market for video games, where the industry also started, and therefore where it is expected that more orphans exist.

4.3.2. Characteristics of Technological Change

The coding process (Strauss and Corbin, 2008, pp. 159-60) resulted in a typology comprising five categories along which technological change was analysed (Table 1):

- Object. The part(s) of the hardware being modified.
- Process. The process(es) used in the modification.
- Outcome. The type of final product of the modification process.

- Interaction Set-Up. The hardware set-up resulting from the modification.
- Purpose. The use of the outcome.

Table 1 – Categories of technological change made to discontinued home video game consoles

Category	Characteristics	
Object	Console	
	Controller	
	Data Support	
Process	Substitution	
	Addition	
	Removal	
Outcome	Within Original Hardware	
	New Piece of Hardware	
Interaction Set-Up	New	Link to other technologies
		Function independently
	Same	Same console
		Older console
		Newer console
Purpose	New Use	
	Same Use	

Source: own elaboration, based on Annex B

These categories, and some of the most significant relations between them are explored next.

Object

We considered as object of modification any part of the hardware (console and controllers), and the games' physical data support (e.g., cartridges). The console and the controllers were the preferred parts, which might have to do with the fact that they offer more possibilities to act upon – they are more complex, and incorporate more circuitry, whereas the physical data support, cartridges in all the cases, basically consist of a microchip installed on a small circuit board inside a plastic casing.

Table 2 – Object of technological change made to discontinued home video games hardware

Object			Nr. of Cases	%
Console	Controller	Data Support		
+	+	+	0	0%
+	+	-	5	7%
+	-	+	0	0%
-	+	+	0	0%
+	-	-	28	40%
-	+	-	26	37%
-	-	+	11	16%
		Total	**70**	**100%**

Note: + yes; - no.

Source: own elaboration, based on Annex B

Process

The modifications were made using three types of processes (Table 3):

- Substitution of at least one component of the original hardware by another, performing the same function (used in 51% of the cases);
- Addition of at least one new component to the original hardware, performing the same or another function (used in 84% of the cases);
- Removal of at least one component from the original hardware (used in 91% of the cases).

Table 3 – Processes of technological change made to home video games hardware

Process			Nr. of Cases	%
Substitution	Addition	Removal		
+	+	+	28	40%
+	+	-	0	0%
+	-	+	8	11%
-	+	+	26	37%
+	-	-	0	0%
-	+	-	5	7%
-	-	+	3	4%
		Total	**70**	**100%**

Note: + yes; - no.

Source: own elaboration, based on Annex B

Only a minority of the modifications was achieved by using just one process. Substitution of never occurred in isolation, because to keep the systems working, when a component is taken out, another needs to be added (37%), substituted (11%), or both (40%).

Hence, two or three processes were usually necessary to conduct a modification, which together with the preference for modifying the more complex parts of the hardware mentioned above, leads to the conclusion that these technical changes involved some degree of complexity. This apparent complexity would lead to the assumption that modders' individual skills play an important role in the modification process, but the survey showed that the education background was not deemed to be a strong contribution to the success of a modification. Modifications are done through small incremental steps, involving learning by doing – 75% of the respondents referred that individual learning (by doing) is very helpful to the success of a modification, and most of the times without establishing any rules prior to the modification. The words from one of the modders sum-up these aspects (case 46):

Most of the time, I made the steps up as I went and worked on trial and error.

A complementary observation is that contrary to what would be expected, playing video games for many years (knowing a technology by using) does not seem a decisive factor in the success of modifications.

Outcome

This category can be interpreted as the "location" of the physical outcome of the modification (Table 4). In most cases, the outcome remained within the physical boundaries of the original hardware (e.g., a SNES cartridge transformed into a USB hub (case 31)), but

modifications did also result in the production of a new piece of hardware (e.g., the "Super Genintari", a console made from parts of 4 different systems (case 62)).

Table 4 – Outcomes of technological change made to discontinued home video games hardware

Outcome	Nr. of Cases	%
Within Original Hardware	54	77%
New Piece of Hardware	16	23%
Total	**70**	**100%**

Source: own elaboration, based on data from Annex B

The fact that less cases resulted in a new piece of hardware, is an indication that modders try to preserve the "looks" of the original hardware, pointing to the influence of the emotional attachment to video games and their appreciation as symbols of the past.

Interaction Set-Up

Home video game systems usually interact with another technologies (e.g. a TV), and so do the technologies it incorporates interact with each other, what was called the "interaction set-up".

The analysis points to the fact that the modifications aimed at changing the original interaction set-up (Table 5), and contrary to what happens with the process, these goals seemed to be well defined beforehand – 75% of the respondents mentioned that "to fulfil a special need" is an important or very important motivation to conduct a modification.

Modders seem to know what they want to achieve with the technological changes, although as seen before, they do not know best way to do that, as expressed in a comment to a modification (case 5)

My head hurts just thinking through all the glitchy possibilities.

Table 5 – Interaction set-up results of technological change made to discontinued home video games hardware

Interaction Set-Up		Nr. of Cases	% of Category	% total
New	Link to other technologies	25	53%	36%
	Function Independently	22	47%	31%
Same	Same console	18	78%	26%
	Older console	2	9%	3%
	Newer console	3	13%	4%
Total		**70**	**-**	**100%**

Source: own elaboration, based on data from Annex B

The new set up can, on the one hand, link the old hardware to a technology it did not before the modification (e.g., a NES cartridge transformed into the casing for an external hard drive (case 15)). On the other hand, the outcome can function as an independent system without any connection to an external technology whatsoever (e.g., various cases of hardware transformed into handheld systems ("portabilisations" – cases 11, and 35, for instance).

Table 6 – Relation between the interaction set-up and the outcomes of technological change made to discontinued home video games hardware

Interaction Set-Up		Outcome			
		Within Original Hardware		New piece of hardware	
		Nr. of Cases	%	Nr. of Cases	%
New	With Other Technologies	25	69%	24	69%
	Function Independently	11	31%	11	31%
Same	Same console	13	72%	5	100%
	Older console	2	11%	0	0%
	Newer console	3	17%	0	0%

Source: own elaboration, based data from Annex B

Table 6 points to the fact that modders like to keep playing vintage video games. They act on the discontinued consoles to maintain the original interaction set-up, i.e., to be able to play. This was evidenced in the survey, where 60% of the respondents claimed to be currently playing the consoles they modified before. Nonetheless, the fact that the original interaction set-up can also be changed indicates that these orphans also look for other purposes to the hardware, as discussed below.

Purpose

This category clarifies the redefinition or not of the meaning of the discontinued consoles, that is, if and how are modders reinterpreting its uses. Modifications either maintained the original use of the discontinued hardware, or on the contrary, made it do something to which it was not originally intended (Table 7).

Table 7 – Purposes of technological change made to discontinued home video games hardware

Purpose	Nr. of Cases	%
New Use	33	47%
Same Use	37	53%
Total	**70**	**100%**

Source: own elaboration, based on data from Annex B

Modders are thus not necessarily reinterpreting the use of the hardware when they modify it, although the results of the questionnaire point to the fact that finding other uses for the hardware was an important or very important motivation to carry on modifications to 65% of the respondents.

5.3.3. Characteristics of the Communities

This section outlines the characteristics of the online communities. The "submersion" in the realm of the modders resulted in an understanding of the community context within which the technological changes analysed in the previous section takes place.

Rules

Communities function mostly on the basis of rules tacitly accepted by the modders. Acknowledgement is given to modders that have done the same or similar modifications before. Only positive and constructive comments are allowed, to help improving each others' projects, so negative comments are not accepted, as expressed in the response from a member of a community to an unpleasant comment (case 17):

> *I can see YOU aren't a hardcore nerd, or you would see that taking two obsolete electronic devices and sticking them back together is cool.*

Prior to engaging in a project, modders usually search for the existence of similar projects to the ones they have in mind, to assess the originality of an idea, because they define the goals of a modification beforehand.

Individual process, shared outcome

Modding seems an utterly individual activity, although its results are disseminated within the community. Only one of the cases in our sample was conducted by two persons, and in a particular context, since it was made for academic purposes (case 49). The individual character of the process is not motivated by the competition among modders, as mentioned by 55% of the respondents.

Furthermore, only 15% of the respondents referred that the influence of others was helpful or very helpful in the modification process, and 60% mentioned that the cooperation with other people doing modifications is only somehow helpful, or not helpful at all, emphasing the importance of "learning by yourself" mentioned above.

Ideas and projects are freely shared within the communities, and modders are keen on showing their achievements, because reputation also plays an important role. Recognition from peers is somehow important or important for 75% of the respondents, and projects are often published in more than one site.

Entertainment with no commercial purpose

Modding is an activity run mostly as a hobby with non-commercial character. It is an important phenomenon from a technical perspective, but it is also the mere result of individual attempts to act over technology, with no further ambition of reaching the economic relevance of innovations. 70% of the respondents of the survey mentioned that making additional income is not one of the motivations. 85% referred that being entertained for some hours is an important or very important motivation.

The effects of technological change have relevance to define the "life" of the communities, but no economic impact. No cases were found where technological changes feedback into the economy, as described by von Hippel (1988) and Rosenberg (1982, pp. 120-140).

However, there are examples of manufacturers that build on the retrogaming phenomenon, releasing new versions of vintage software and hardware. This is a small-scale phenomenon, although a sign that manufacturers regard the markets for vintage products as not "dead" yet.

Technical communities

Although orphans come together in thematic communities, they unite fundamentally due to the technical aspects of modding in general, and not necessarily because of a shared appreciation for vintage video games. 75% of the respondents referred that internet resources are deemed to be helpful or very helpful in the modification process. Nonetheless, 75% of the

respondents also claim that overcoming the lack of technical support from the manufacturer in not an important motivation to conduct the modifications.

Orphans enjoy modding in general. 80% of the respondents claimed to modify other types of products, new or old, as diverse as telephones, clocks, turntables, amplifiers, vintage woodworking machines, toys. This indicates that technological changes made to vintage video games hardware are a part of a larger community involved in modding in general, an idea reinforced by some respondents' comments saying they modify "anything worth a try to fix or make better" or "anything to make it more interesting".

The driver for the modifications in not necessarily the emotional attachment to vintage/retro objects, modding is an activity motivated by the appreciation of doing technological changes to objects in general.

5.3.4. Use and Technological Change

What was discussed in the previous sections converge in three central ideas regarding the connection between technological change and use.

First, old home video game consoles are still in use, even after they were discontinues or are thought of as obsolete. The mere existence of a sample of cases of technological change proves that discontinued home video game consoles are still in use, in line with the idea that technologies do not just disappear completely discussed before.

Second, users act as agents of technological change on that hardware. All the respondents claimed to have played video games (regardless of the format) at least once in their lives. This confirms that the use of home video games seems to be a precondition for its modification later on. However, that does not necessarily mean the use and modding of the same models – from the 90% of the respondents that claimed to have played home video game consoles before they started modding, only 22% used to play the models they came to modify later on, and 72% both the models they modify and models other than the ones they modify. This is yet as another expression of the emotional side of video games, confirmed by the fact that emotional attachment to video games was deemed to be an important or very important motivation to start a modification for 75% of the respondents.

Third, and in consequence of the previous, users are thus responsible by the technical change that is at the basis of the extension of the life cycle of video games hardware after it is discontinued. These orphans are therefore challenging the technological limits of the hardware. 60% of the respondents felt motivated to conduct modifications by the thrill of the technical challenge itself, but challenging the limits of the hardware and improving its performance are not deemed strong motivations, although these are two clear conclusions from the analysis of the characteristics of technological change.

5. CONCLUSIONS

The hobbyists that perform technological changes to discontinued home video games hardware come together in online communities in a spontaneous way, although influenced at an early stage by the dynamics of the home video games industry, when they become orphaned. Short product life cycles, combined with intense rivalry between *de facto* standards lead to high console turnover. Limited inter- and intra-platform backward compatibility, combined with manufacturers' strategies aimed at increasing consumer switching costs contribute to consumer lock-in. Many users are thus left in the position of "angry orphans", because some elements of the industry's ecosystem cease to be available at some point, e.g., support from hardware and software manufacturers.

However, those users who gather in online communities, developing an alternative support network, and find renewed value in the outcome of their modifications – they are comfortable with the old. They do not necessarily feel "angry" by still using "old" or "obsolete" hardware.

Technological change tends to be a complex activity, done through small incremental steps, on an individual learning by doing basis. By acting on the technology in such manner, orphans have two main purposes: to improve the hardware so they are able to play the same games they did before, or use it in new ways. The process is individual, yet there is a constructive context of information sharing, and support from the community, which motivates the modders, and contributes to the continuous improvement of their skills, the quality of their projects, and to build reputation within the community.

The emotional attachment to video games is another important driver of the modifications, yet many orphans engage in technological changes to vintage home video game consoles because they usually do them to other products as well. Thus, these users enjoy being part of this subculture, on the one hand because of the blessings of the emotional side of vintage video games, and on the other because they appreciate the technical challenge of modifying things.

However, the outcome of those technological changes does not feedback into the innovation processes of companies. Their scope is relevant from a technical point view, but confined to an individual sphere that skips the logic of the market. This sort of technological tinkering conducted by hobbyists has proven essential in the development of the electric guitar, for instance (Waksman, 2004), however in the home video games industry, although there are some companies reviving past hardware and software, they do not incorporate the results of the activities described in this study in their processes yet.

The study confirmed that, "old" technologies continue to exist and to be improved long after they reach their supposed technological limits, and that users are responsible by the extension of both the period in which they are in use and their physical limits. In face of this evidence, the product life cycle literature should some allow leeway to recognise that in some cases there is a subsequent phase to the maturity stage, in which products and technologies are still in use, and furthermore being improved, but no longer actively marketed.

This study demonstrates the importance of analysing technology in use, and is a valid contribution to the understanding of this reality, and the relation between use and technological change. The reflexive debate about the outcome of this work resulted in two ideas for improvement: the exploration of the analysis from the perspective of the leaning economy, and the broadening of the scope of the study, to include other industries or products.

The analysis might seem to advocate for a "culture of the old", relegating a cornerstone for economic progress in the learning economy: the need to renew competences, and rapidly learn new things, while forgetting old knowledge that gets in the way of learning new ways (Lundvall and Archibugi, 2001).

That was not the case. Implicit in the analysis is that the orphans that conduct technological changes on vintage home video games might not be forgetting everything, but even so, they actually leave their options open to develop new knowledge. Although those technological changes do not achieve the economic relevance of an innovation, they certainly represent some level of technical originality, and a contribution to the advancement of technological progress, the nuance being that the new knowledge is created based on "old" things that are thought of as obsolete.

Hence, it would have been interesting to probe into the analysis of the relation between "old" things that linger on for a long time and the extent to which users of such orphaned technologies create new knowledge based on them when conducting technological changes.

Finally, the scope of the study could be broadened, so the same analysis would be used as a template to explore other industries or products. This ambition is feasible, and can produce a wealth of results to the understanding of use in connection with technological change.

It would be interesting to conduct a comparative study of discontinued products and technologies including similar cases, where users take on the role of agents of technological change, and simultaneously look at other cases, where users do not technically act on the technologies. "Angry orphans" occur in other types of industries and products – what happened to typewriters, cars, washing machines, PDAs, VHS recorders that are no longer on the market, but surely still being used?

Such study would capture the extent to which technological changes to discontinued products is a general pattern or not, and render a deeper understanding of different dimensions of analysis and characteristics of such products and users.

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ANNEX A – Release and discontinuity dates, and technical specifications of selected consoles

Generation	Console	Manufacturer	Time-Span		Media	Operating Performance		
			Release Date (US)	Discontinued	Media	CPU Speed (MHz)	CPU Bits (Width)	RAM
1st (1972-1976)	Odyssey	Magnavox	1972	Mid-1975	-	n/a	-	-
	PONG	Atari	Jan. 1975	1977	-	n/a	-	-
	Telstar	Coleco	Jun. 1976	n/a	-	n/a	-	-
2nd (1976-1984)	VES (Channel F)[DD]	Fairchild	Aug. 1976	1978	Cartridge	2	8	64 KB
	Studio II	RCA	Jan. 1977	1979	Cartridge	1.78	8	4 KB
	2600 (VCS)	Atari	Oct. 1977	Jan. 1991	Cartridge	1.19	8	128 b
	Astrocade	Bally	Feb. 1978	1984	Cartridge	3.58	8	4-64 KB
	Odyssey[2]	Magnavox	1978	1983	Cartridge	1.78	8	64 b
	Intellivision	Mattel	Dec. 1979	1984	Cartridge	0.5	16	7 KB
	Arcadia 2001	Emerson	Mar. 1982	1983	Cartridge	3.58	8	1 KB
	ColecoVision	Coleco	Sep. 1982	1984	Cartridge	3.58	8	8 KB
	Vectrex	Milton Bradley	Nov. 1982	1984	Cartridge	1.5	8	512 b
	5200	Atari	1982	1984	Cartridge	1.79	8	16 KB
3rd (1985-1991)	NES	Nintendo	Oct. 1985	1993	Cartridge	1.79	8	8 KB
	Master System	Sega	Jun. 1986	1990	Cartridge	3.6	8	128 KB
	7800	Atari	Jun. 1986	Jan. 1992	Cartridge	1.79	8	4 KB
4th (1989-1997)	TurboGrafx-16	NEC	Aug. 1989	1995	Cartridge	3.6	16	8 KB
	Sega Genesis	Sega	Aug. 1989	1997	Cartridge	7.61	16	64 KB
	Neo Geo AES	SNK	1990	1997	Cartridge	12,5	16	64 KB
	Super NES	Nintendo	Sep. 1991	1997	Cartridge	3.58	16	128 KB
	NEC TurboDuo	NEC	Oct. 1992	1995	Cartridge CD-ROM	7.16	8	64 KB
5th (1993-2001)	IM	3DO	Oct. 1993	1996	CD-ROM	12.5	32	3 MB
	Jaguar	Atari	Nov. 1993	1996	Cartridge	26.6	64	16 MB
	Neo Geo CD	SNK	1994	n/a	CD	14	16	64 KB
	Saturn	Sega	May 1995	1998	CD-ROM	2x28	32	2 MB
	PlayStation[DD]	Sony	Sep. 1995	2000	CD-ROM	33.9	32	2 MB
	Nintendo 64	Nintendo	Oct. 1996	2001	Cartridge	93.75	64	4 MB
6th (1999-present)	Dreamcast	Sega	Sep. 1999	Mar. 2001	GD	200	128/64	16 MB
	PlayStation 2	Sony	Oct. 2000	-	DVD	300	128	32 MB
	GameCube	Nintendo	Nov. 2001	Nov. 2007	GC Disc	485	128	40 MB
	Xbox[DD]	Microsoft	Nov. 2001	Mar. 2009	DVD	733	128	64 MB
7th (2005-present)	Xbox 360	Microsoft	Nov. 2005	-	CD/DVD	3.2 GHz	-	512 MB
	PlayStation 3	Sony	Nov. 2006	-	CD /DVD	3.2 GHz	-	513 MB
	Wii	Nintendo	Nov. 2006	-	Wii Disc GC Disc	729	-	88MB

Note: DD – Dominant Design; n/a – not available; - Not Applicable.

Source: data compiled from Kent (2001). Gallagher and Seung Ho (2002), Schilling (2003), Clements and Ohashi (2005), Evans et al. (2006), Wolf (2008), and All Game at www.allgame.com, Classic Gaming at www.classicgaming.gamespy.com, Old Computers Museum at www.old-computers.com, Retro Gaming Consoles at www.retrogamingconsoles.com, Retrothing at www.retrothing.com, What Console at www.whatconsole.co.uk, Tieto Kone Museo at www.tietokonemuseo.net, The Video Game Museum at www.vgmuseum.com.

ANNEX B – Case Study Description

Cases		Console(s)				Modification Categories															
						Object			Process			Outcome		Interaction Set-Up					Purpose		
														New		Same					
Nr.	Description					Console	Controller	Data Support	Substitution	Addition	Removal	Within Original Hardware	New Piece of Hardware	Link to Other Technologies	Function Independently	Same console	Older console	Newer console	New Use	Same Use	Description
1	Atari 2600 Joystick TV Remote Control	A 2600					x			x	x	x		x					x		Remote Control
2	Atari 2600 Game Wallet	A 2600						x			x	x			x				x		Wallet
3	Bankzilla	A 2600	A 7800			x			x	x	x	x				x				x	Video Games
4	Atari 2600 Cartridge Wallet	A 2600						x			x	x			x				x		Wallet
5	Circuit Bent Nintendo Famicoms	FAM				x				x		x		x					x		Make Music and Video
6	NES in a Cartridge	NES						x		x	x	x		x					x		Video Games
7	Portable NES	NES						x	x	x	x	x			x				x		Portable Video Games
8	NES Remote for Apple	NES					x			x	x	x		x					x		Remote Control
9	Atari 2600 Portable	A 2600	PSOne			x	x		x	x	x		x		x					x	Portable Video Games
10	Atari 5200 Cartridge iPod Dock	A 5200						x		x	x	x		x					x		iPod Dock
11	Portable SNES	SNES				x	x		x	x	x		x		x					x	Portable Video Games
12	Portable Colecovision	CV				x	x		x	x	x		x		x					x	Portable Video Games
13	Portable Gamecube	GC	PSOne			x	x		x	x	x		x		x					x	Portable Video Games
14	NES AdPad	NES					x		x	x	x	x				x				x	Controller
15	NES Cartridge External Hard Drive	NES						x		x	x	x		x					x		External Drive Casing
16	NES Controller Cellphone	NES					x			x	x	x		x					x		Mobile Phone
17	NES Cartridge PDA	NES						x		x	x	x		x					x		PDA
18	NES Controller Wallet	NES					x			x	x	x			x				x		Wallet

Note: A 2600 - Atari 2600; A 5200 - Atari 5200; A 7800 - Atari 7800; CV - Colecovision; FAM - Nintendo Famicom; GC - Nintendo GameCube; NES - Nintendo Entertainment System.

Continue on the next page

Source: own elaboration

(Cont.)

Cases		Console(s)				Modification Categories																
						Object			Process			Outcome		Interaction Set-Up					Purpose			
														New		Same						
Nr.	Description					Console	Controller	Data Support	Substitution	Addition	Removal	Within Original Hardware	New Piece of Hardware	Link to Other Technologies	Function Independently	Same console	Older console	Newer console	New Use	Same Use	Description
19	NES USB Controller	NES					x		x	x	x	x		x						x	Controller
20	NES Controller with LEDs	NES					x			x		x				x				x	Controller
21	Atari 2600 Joystick with LEDs	A 2600					x			x		x				x				x	Controller
22	NES Cartridge Powered Speakers	NES						x		x	x	x		x					x		Speakers
23	Nestune	NES	FAM			x			x	x	x	x		x					x		Make Music and Video
24	NES Advantage Guitar Pedal	NES					x			x	x	x		x					x		Guitar Pedal
25	Bent NES	NES				x				x		x		x					x		Video Synthe-siser
26	NES Controller Bike Flasher	NES					x			x	x	x			x				x		Bike Flasher
27	NES Cartridge Clock	NES					x			x	x	x			x				x		Clock
28	NES Lunchbox	NES				x					x	x			x				x		Lunchbox
29	NES PC	NES				x			x	x	x	x		x					x		PC
30	NES Controller PC Card Reader	NES					x			x	x	x			x				x		PC Card Reader
31	SNES Cartridge USB Hub	SNES						x		x	x	x		x					x		USB Hub
32	Sega Master System controller to Atari 7800	SMS	A 7800				x		x		x	x					x			x	Controller
33	NES USB Controller With Games	NES					x			x	x	x		x						x	Video Games
34	GameCube with LCD	GC				x				x		x			x					x	Video Games
35	DreamCast Portable	DC	PSOne			x			x	x	x		x		x					x	Portable Video Games
36	Geosis	AES	SG			x			x		x	x				x				x	Video Games

Note: AES - Neo Geo AES; A 2600 - Atari 2600; A 7800 - Atari 7800; DC - Sega DreamCast; FAM - Nintendo Famicom; GC - Nintendo GameCube; NES - Nintendo Entertainment System; PSOne - PlayStation One; SNES - Nintendo Super Entertainment System; SMS - Sega Master System; TG – Turbografx.

Continue on the next page

Source: own elaboration

(Cont.)

Cases		Console(s)				Modification Categories															
						Object			Process			Outcome		Interaction Set-Up						Purpose		
														New		Same					
Nr.	Description					Console	Controller	Data Support	Substitution	Addition	Removal	Within Original Hardware	New Piece of Hardware	Link to Other Technologies	Function Independently	Same console	Older console	Newer console	New Use	Same Use	Description
37	TurboGrafx Portable	TG	PSOne			x			x	x	x		x		x					x	Portable Video Games
38	Atari 2600 Jukebox	A 2600				x			x	x	x	x				x				x	Video Games
39	NES Controller Business Card Holder w/ Sound	NES					x			x	x	x			x				x		Business Card Holder
40	Vectrex PSX Controller	PS1					x		x		x	x					x			x	Controller
41	PSOne Portable	PSOne				x			x	x	x		x		x					x	Portable Video Games
42	Dreamcast Tablet	DC				x			x	x	x		x		x					x	Portable Video Games
43	NES Controller for Nintendo DS	NES	DS				x		x		x	x						x		x	Controller
44	NES64	NES	N64			x			x		x	x				x				x	Video Games
45	NES Controller iPod Remote	NES					x			x	x	x		x					x		Remote Control
46	Wiintendo	NES	Wii			x			x		x	x				x				x	Video Games
47	NES Controller 4 Port USB Hub	NES					x			x	x	x		x					x		USB Hub
48	NES Controller MP3 Player	NES					x			x	x	x		x					x		MP3 Player
49	PS1 Massage Kit	PS1					x		x	x	x		x			x			x		Massage Kit
50	HarmoNESica	NES						x		x	x	x			x				x		Harmonica
51	SNES Controller for PSP	NES	PSP				x		x		x	x						x		x	Controller
52	Nintoaster	NES				x			x	x	x		x			x				x	Video Games
53	NES Controller 4 Port USB Hub	NES					x			x	x	x		x					x		USB Hub
54	SNES Portable V1	SNES	PSOne			x			x	x	x		x		x					x	Portable Video Games

Note: DC - Sega DreamCast; DS - Nintendo DS; NES - Nintendo Entertainment System; N64 - Nintendo 64; PSOne - PlayStation One; PS1 - PlayStation 1; PSP - PlayStation Portable; SNES - Nintendo Super Entertainment System; Wii - Nintendo Wii.

Continue on the next page

Source: own elaboration

(Cont.)

Cases		Console(s)				Modification Categories															
						Object			Process			Outcome		Interaction Set-Up					Purpose		
														New		Same					
Nr.	Description					Console	Controller	Data Support	Substitution	Addition	Removal	Within Original Hardware	New Piece of Hardware	Link to Other Technologies	Function Independently	Same console	Older console	Newer console	New Use	Same Use	Description
55	NESp3	NES					x			x	x	x		x					x		MP3 Player
56	Nestation	NES				x			x	x	x	x				x				x	Video Games
57	Super Nintoaster	NES				x			x	x	x		x			x				x	Video Games
58	Nintendo Super Nii	NES				x			x	x	x	x				x				x	Video Games
59	NES DVD Player	NES				x				x	x	x		x					x		DVD Player
60	LED Coffee Table	A 2600					x		x		x	x		x						x	Coffee Table
61	Wireless NES and SNES controllers for Wii	NES	SNES				x		x	x	x	x						x		x	Controller
62	Super Genintari	A 2600	NES	SG	SNES	x			x	x	x		x			x				x	Video Games
63	Dedicated NES Arcade Emulator	NES				x			x	x	x	x				x				x	Video Games
64	NESpV1	NES	PSOne			x			x	x	x		x		x					x	Portable Video Games
65	NESVD	NES				x				x	x	x		x					x		DVD Player
66	SNES Portable	SNES				x	x		x	x	x		x		x					x	Portable Video Games
67	NES Zelda Edition	NES				x				x	x	x				x				x	Video Games
68	Modified NES	NES				x			x	x	x	x				x				x	Video Games
69	NES Cartridge Hard Drive Enclosure	NES						x		x	x	x		x					x		External Drive Casing
70	Top-loading NES	NES				x			x	x	x		x			x				x	Video Games

Note: A 2600 - Atari 2600; NES - Nintendo Entertainment System; PSOne - PlayStation One; SG - Sega Genesis; SNES - Nintendo Super Entertainment System.

Source: own elaboration

ANNEX C – Questionnaire

Home Video Game Consoles Survey

The data collected in this survey are strictly confidential and will be used for academic purposes only, in the context of a Master thesis at Aalborg University, Denmark.

*Required Answers

1. Uses
This section characterises your past and current video game habits.

1.1. Have you ever played video games in your life? *
O Yes
O No

1.2 In which platform(s) do you currently play or have played video games? *
Please check all items.

	In the past	Currently	Never
Home Video Game Consoles	O	O	O
PC	O	O	O
Handhelds (e.g., Game Boy)	O	O	O
Arcades	O	O	O
Other	O	O	O

1.3.1 Did you play games in home video game consoles before you started modifying them? *

O Yes. Only the model(s) I modify.
O Yes. Model(s) other than the one(s) I modify.
O Yes. Both the above.
O No.
Please specify which model(s) _____

1.3.2 Do you currently play games in home video game consoles? *

O Yes. Only the model(s) I modify.
O Yes. Model(s) other than the one(s) I modify.
O Yes. Both the above.
O No.
Please specify which model(s) _____

2. Modifications
This section aims at understanding the motivations, context and uses of hardware modification.

2.1 Rate the importance of the items below as a motivation for conducting modifications in home video game hardware. *
Please check all items.

	Not important at all	Somehow important	Important	Very important
Fulfil a special need	O	O	O	O
Find other use(s) for the hardware	O	O	O	O
Be entertained for some hours	O	O	O	O
Make an additional income	O	O	O	O
The thrill of the technical challenge	O	O	O	O
Improve the performance of the hardware	O	O	O	O
Challenge the limits of the hardware	O	O	O	O
Overcome the lack of technical support from the manufacturer	O	O	O	O
Retro things are trendy and/or fashionable	O	O	O	O
Emotional attachment to video games	O	O	O	O
Be recognised by other people doing modifications	O	O	O	O
Competition with other people doing modifications	O	O	O	O

2.2. Rate the contribution of the items below to the success of the modification(s) in home video games hardware. *
Please check all items.

	Not helpful at all	Somehow helpful	Helpful	Very helpful
Education background	O	O	O	O
Influence of others (e.g., family, friends or acquaintances)	O	O	O	O
Internet resources (e.g., tutorials, forums or communities	O	O	O	O
Learning by yourself	O	O	O	O
Playing games for many years	O	O	O	O
Cooperation with other people doing modifications	O	O	O	O

2.3 Do you specify any rules prior to a modification? *
Please check at least one item. If you check "Other", please specify which.
□ No
□ Limited Timing
□ Technical constraints
□ Limited budget
□ Other:

2.4 Do you modify or have modified other types of products? *
O Yes. Old things.
O Yes. New things.
O Yes. Both old and new things.
O No.
If you answered "Yes", please specify which type(s).

3. Personal Details
This section characterises you.
Age
Sex
O Male
O Female

Location
O Europe
O North America
O South America
O Africa
O Asia
O Australia
O Other:

Thank you very much for your cooperation!!

If you have further comments or contributions regarding the issues covered in the survey, or that should have been included otherwise, please do not hesitate to contact me.

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AUTORES
Bernardete Sequeira
Jorge Graça
Marielba Zacarias
Paula Martins Ventura
Rodrigo Magalhães

UAlg
UNIVERSIDADE DO ALGARVE

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