New materials and products from synthetic textile waste: a model and framework for the management of the development & research team

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Abstract

This paper presents the continuity of the studies previously described by the authors in another two papers, which presented a model based on the abductive reasoning as an alternative to approach the problem of synthetic textile waste, and its application in new materials development, as well as preliminary process model for the Research & Development (R&D) activities. In this paper is presented and discussed the management of the R&D team here considered as a "creative group". The main questions that guided this dimension of the investigation included: "how to select the right members for the team?", "how to manage their work?", "what is the most suitable structure for organizing their work?", "what is the best process for this team?", "what is the best leadership style for this team?", "how they must interact?", and "how to stimulate them to think about the project in a more entrepreneur way, considering eventually building their own businesses models based on the findings of the research?" The active-research was the main research method, conducted with a team of 16 researchers, being two professors of design and one of chemistry, ten bachelor students of fashion design, one specialist in fashion design, two of graphic design, one bachelor student of chemistry, and one master student on chemistry. This team conducted a set of activities related to the design process and empirical experiments in laboratories, as well as exploratory workshops for product and business models development. As a result, the authors present a conceptual model and framework for the team management and leadership, based on the literature and the R&D process model initially proposed. The next activities include the refinement of the proposed model, and its validation with two different research teams: a sample and a control one.

Keywords
Textile waste, New material, Design-oriented method, Team management, Creative groups.

Background

The context and problem of synthetic textile waste and a Brazilian research project

The production of synthetic fabrics has shown significant growth in recent years worldwide, spurred by increased consumption, with significant environmental impacts. Most of the global production is presently located in China (49 %), followed by India (7%), Pakistan (3.8%) and Brazil (2.9%) (Abravest, 2010). In Brazil the average waste generation is estimated by the 26.000 Brazilian industries to be about 1400 kg/year per company (Sebrae, 2004). The donation of waste is a common practice in the Brazilian garment industry, and there was in the last years an excess of waste offered in the market (Sampaio *et al.*, 2014). Although the garment sector does not generate solid remainder of great striking power, these remainders are generated in large volume. The toxicity of the remainder is not significant, but the high volume affects other environmental variables, such as CO^2 emissions and non-renewable natural resource exhaustion, and that is why the textile waste causes a critical environmental impact (Martins *et al.*, 2011).

The most common destinations for clothing discarded during production or post- consumption is the reuse, recycling, incineration and sending to landfill. According to Allwood *et al.* (2006, in WRAP, 2010) in the UK, for example, annually 1.12 million tons of clothes (30

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kg/capita) are discarded, representing about 8% of the total weight of household waste (WRAP, 2012). Of this amount, 350,000 tonnes (31%) go to landfills, 47% are reused in other countries (34%) or in the UK itself (12%), 14% is recycled and 7% is incinerated, as pointed out by Oakdene Hollins Ltd et al (2006, in WRAP, 2010).

Regarding the recycling of textile waste, Life Cycle Analysis (LCA) studies done by ERM (cit. in WRAP, 2012) showed significant reductions in energy use and in emission of greenhouse gas (Korhonen, Dahlbo cit. in WRAP, 2012). The benefits of recycling compared to incineration were also identified. In general, recycling can occur in two ways (Bastian, 2009): in or out of the process. In this sense, the creation of new materials from recycled textile waste involves recycling out of the process as the materials to be developed are not necessarily incorporated back into the clothing production. Instead, they can integrate other processes, such as products for construction industry, architecture, decoration, accessories, footwear, gardening and so on.

In the case of synthetic textile materials, one difficulty for recycling is the variety of materials available, being polyester and polyamide the most significant. A study done by Nike pointed polyamide 66 as the worse environmental performance material among the 25 most commonly used materials for the company. Nevertheless, there are already initiatives for recycling polyamide 66 (Bodero and Cansell, 1999; Booij *et al.*, 1997; Frentzen *et al.*, 1997; Kasserra, 1998).

Polyamide 66 (trade name *nylon 66*) is used in the manufacture of various compound fabrics such as *Lycra, Cordura, Coolmax, Thermolite* and *Supplex* that use different materials in its composition, which further complicates recycling. They are widely used by Brazilian manufacturers of clothing; however, there is not an adequate knowledge on how to properly dispose this material waste.

A recent study done by Brazilian researchers in a company of Londrina, Paraná (developed at the State University of Londrina – UEL, in partnership with Mulher Elástica, a brazilian garment company), indicated the waste of raw materials, lack of proper disposal and lack of appreciation of the waste as major problems concerning the use of *Supplex*. The waste were usually donated to artisans, or collected by a collection company, which was responsible for the destination (Martins *et al.*, 2013). So, a partnership with the UEL Chemistry Department was established with the aim of developing new forms of synthetic textile waste recycling, including the creation of new materials. This partnership has been particularly successful, and initial results indicated that the *Supplex* is a challenging recycling material, and that this can be done in an environmentally appropriate manner.

The design thinking approach, innovation, and the abductive reasoning as startpoint for framing the problem

This R&D project emphasized the role of design to solve the environmental problems of textile waste (environmental values) and, at the same time, generating and delivering values for users (both emotional and functional), organizations (profitability, brand value, public recognition, and improvements in the internal processes). In the design thinking context, the generation and deliver of value is how the concept of innovation is well understood. So, innovation can be seen in

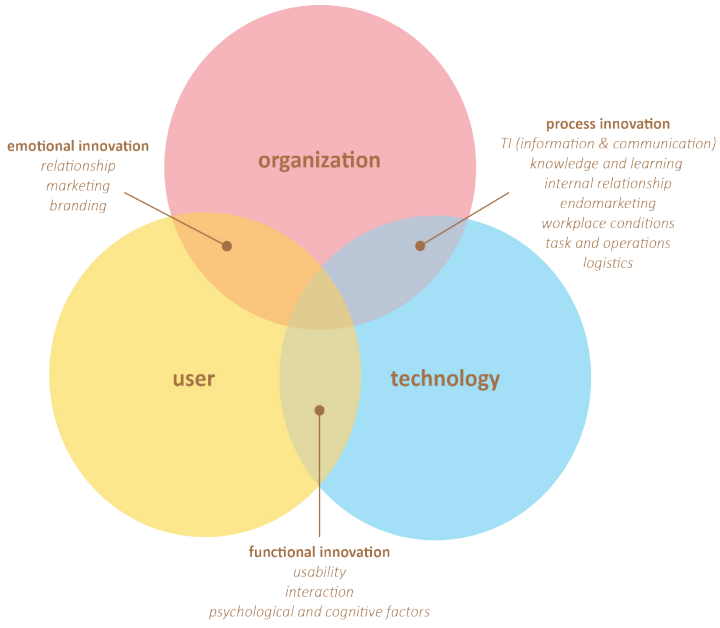

Figure 1 – The three dimensions of design thinking, and its "innovation spaces": functional, emotional and of process
Source: Adapted from Brown, 2008

terms of the interactions ("innovation spaces") that occur in these three main dimensions (Figure 1) (Brown, 2010).
Starting from the Brown`s model and the "innovation spaces", the contribution of a new R&D process and team management model can be seen in terms of the following aspects, as is the Figure 2. Beyond the values previously described, an effective R&D process and team management can also promotes gains from other three specific interactions:

• Enriching and strengthening the way the R&D team and organizations (frequently as businesses) interact to produce innovations;

• Enriching and strengthening the way the R&D team and users (frequently as consumers) interact to produce a deeper understand of behaviours, attitudes, habits, needs and desires;
• Improving the internal processes and activities related to R&D by the inclusion of other knowledge areas (as design and sciences), and thus promoting an effective group learning.

It can be noted that all these three forms of benefits are strictly related to the work process the R&D team, whether in the form as it relates to the organizations or users, or even in the form of develop its activities to produce and manage new knowledge and innovations.

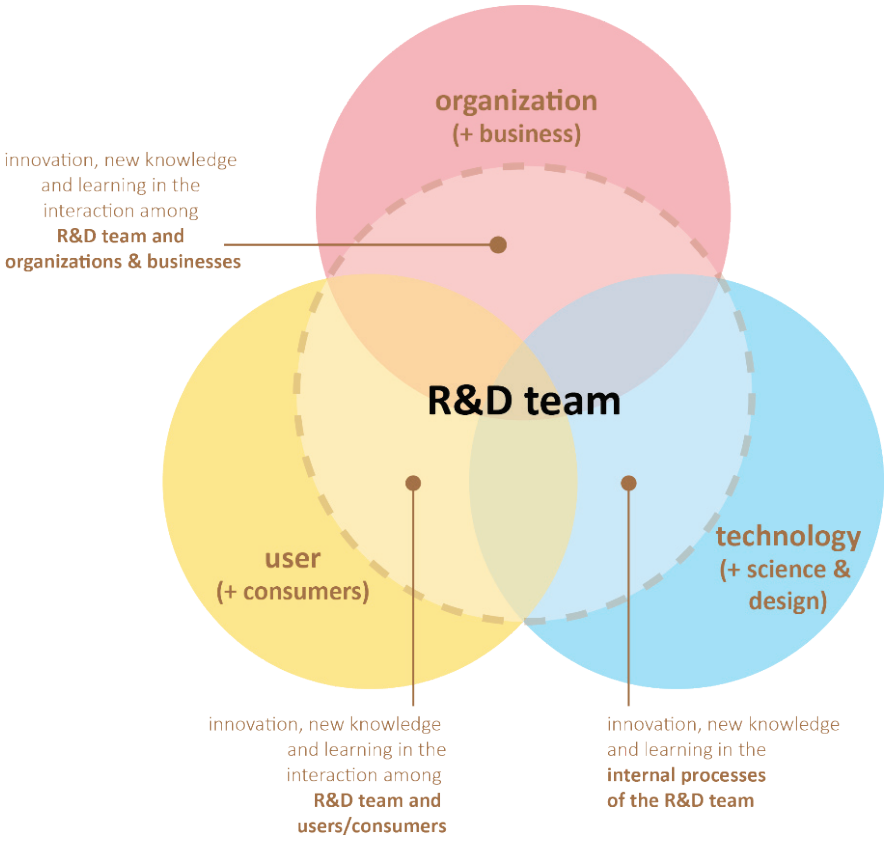

Figure 2 – Innovation and design thinking in the perspective of R&D process and team management
Source: authors' material

The abductive resoning of design thinking

Considering the relevance of the creative thinking when facing complex problems (including sustainability and innovation), and the fact of this kind of reasoning, also known as abductive reasoning, is very common in the design area (Dorst, 2011), the authors proposed, in a previous paper, a model to frame problems related to waste and its conversion in new materials (Figure 3).

According to this model, the desired benefits (value) includes environmental values (reduction of the environmental impact), user values (both emotional and functional ones) and economic values (e.g. differentiation, competitiveness, cost reduction and image gains). Following the Dorst proposal, the objects ("what") include both the development of a new material from the recycling of textile waste, new products to be developed with this material and new businesses to deliver value for economy for companies, people and government.

Then, the principle of operation ("how") is reflected in the objective of designing and testing a methodology that enables the development of new materials from synthetic textile waste. This methodology include issues as innovation (value generation), collect and analysis of environmental, technological economical and legal data (as intellectual property and legislation) and too about the R&D process and team management, including the role of the leadership.

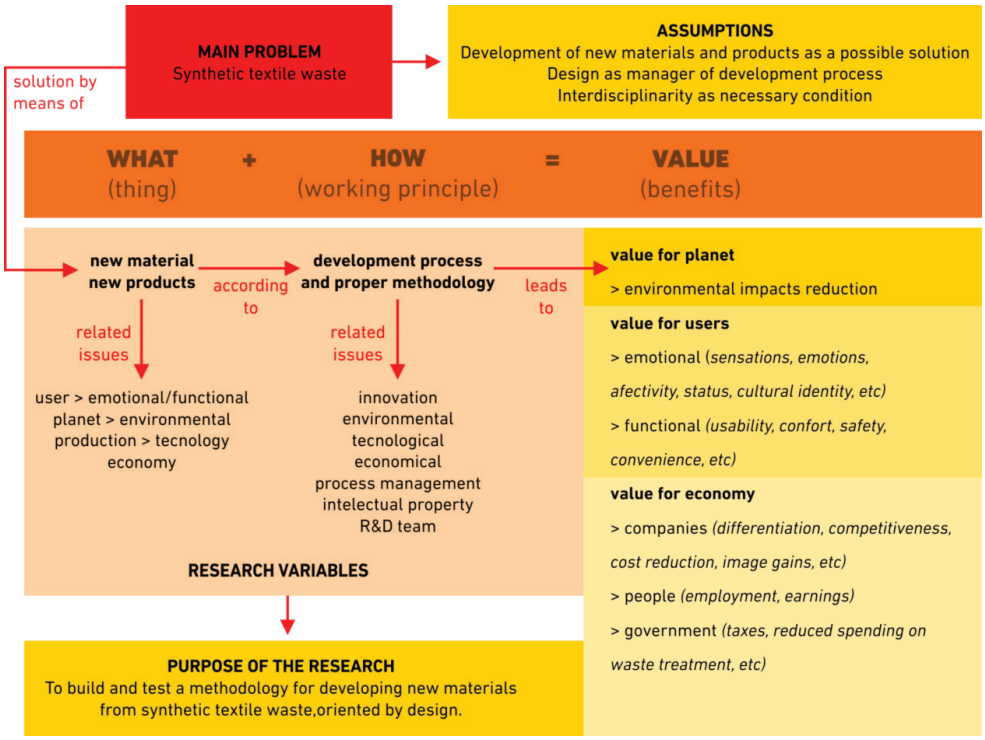

Figure 3 – Abductive-2 reasoning model (Dorst, 2011) applied to the research proposal (Sampaio et al, 2014)
Adapted from Dorst, 2011 and Sampaio et al, 2014

A brief explanation on model, framework and methodology

Since this paper presents a proposal of a model and framework for the management of the R&D team, this section aims to present and discuss some definitions about three terms which are frequently cause of confusion. This section becomes more significant because the model and framework presented in this paper will serve as a basis to construct a methodology for the management of R&D process and team, as a result of the doctoral studies being conducted by one of the authors. The following taxonomy (Tomhave, 2005) were identified from the most abstract to the most concrete:

• **Model:** Tomhave (idem) proposed that model is a high level construct representing processes, variables and relationships, abstract in nature and generally detailed on how to be implemented, and ideally technology-independent.

• **Framework:** Less conceptual and more detailed than model, framework is a type of structure which set assumptions, concepts, values and practices designed to directly impact implementation.

• *Methodology:* It is the lower-level among these three constructs, and consists in a set of practices, procedures and rules to implement the proposals. In science, methodology is usually defined as a set of techniques and processes to produce scientific knowledge, as well as the study of these methods. In the study presented in this paper, the aim is to build up a methodology according to the first definition.

Research methodology

The preliminary model for the R&D process already developed, as well as a preliminary model for team management and leadership presented in this paper, were built by the authors as a result of a research in which it was used a lot of methods and tools, including: literature critical review - it included data collect and analysis (in papers, congresses, reports, books and other relevant sources) about the main problem of the research (synthetic textile waste), the proposed approach (design and materials development), the expected values, the objects (materials, products and business design), and the issues related to the methodology expected as a result of this study (R&D process, team man-

agement, innovation and others); semistructured interviews: this tool was used to complete the lack of information on some of the themes of the literature review, by talking directly with R&D coordinators that have the mission of manage R&D projects and teams in areas related to this study. It was taken one interview until this moment, and others will be performed in the next months.; active research: this method has origined in the social sciences, and have been increasingly used in organizations to enlarge the understanding of the problems by the teams, and to solve them in a collaborative and participatory process (Thiollent, 2005). It was applied with a group of Design and Chemistry teachers and students, in order to build a deeper comprehension about the problem of textile synthetic waste, and develop innovations in new materials, products and businesses. This group was organized in seven teams, each one with a leader: one for chemical experiments, one for physical experiments, one for data collection on environmental aspects, three for product and business development and one for graphic design activities. The product and business teams were responsible, each one, for a specific group of users-consumers, for whom they must develop a proposal from the concept to the prototype.

The R&D process

The three "what" (new material, new product, new business) of the model were included in a preliminary model for the R&D process (Figure 4), in which these three elements are organized in three distinct levels of action: material design, product design and business design. Additionally, a fourth level is added, specifically for the environmental aspects, the life cycle design. This level could be integrated to the product design level, as it is done in some design methodologies but, due to the importance of the environmental dimension for a research about waste, it was put in a specific level.

This R&D process model is presented and explained in another paper (Sampaio *et al.*, 2015), and is the first of the three stages of the methodology that the authors aim to build and assess. The second stage refeers to the team management, and the third is dedicated exclusively to the leadership aspects. Once provides an overview of the stages and its relationships, this model can be seen also as a kind of pre-framework, if more details be added to the structure in order to enable the implementation.

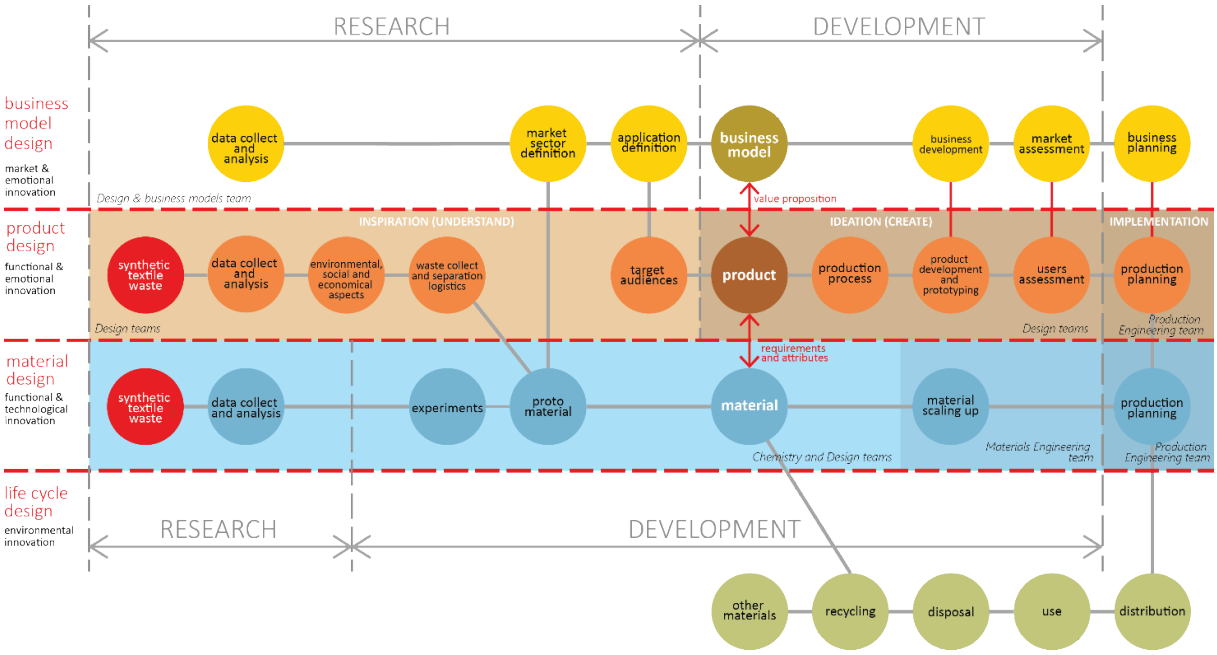

Figure 4 – Preliminary model for the R&D process in new materials from synthetic textile waste

Source: authors' material

The R&D team

Innovation, R&D activities and Brazilian R&D peculiarities

The Brazilian Federal Law 10.973, 2004, defines innovation as "introduction of novelty or improvement in the production or social environment that result in new products, processes and services". Similarly, the Oslo Manual (OCDE, 2013) consider innovation as "introduction of a new good or service or significantly improved in terms of its characteristics or provided uses". According to the Oslo Manual (idem), innovation process can be divided in three main activities: R&D, innovation in product and process, and innovation in marketing and organizational. This study is concentrated is the first, but aims to develop innovations in the two others, an in a disruptive level, even if incremental innovations may also be achieved.

In this study, the context in which the R&D is carried out is also relevant; the authors conducted the research in a brazilian research group established in a public university, and this implies in some specific characteristics. In these type of university, the research is strongly funded by the government, both local and federal.

Etzkowitz and Leydesdorff (2000) explain this model as a "Triple Helix I", in opposite to the laissez faire model ("Triple Helix II) practiced in highly liberal countries as USA and Sweden. Despite this, it have increased the participation of other actors (companies, laboratories and other organizations) in the brazilian innovation system, as an attempt to change the model for something near to the "Triple Helix III", in which the knowledge flows no more only from the university to the companies, but in reverse.

Moreover, the tripod teaching-research-extension practiced in public brazilian universities implies in a frequent participation of graduate students, in the majority very young and unexperienced, but frequently very intelligent and creative. As experienced by two of the authors in their teaching and research activities along the last years, this is particularly noticeable in the design courses, due to the very arduous and demanding entry process in the public universities in Brazil. Otherwise, one frequent difficult found by the R&D project coordinators in Brazil is the inconstance in the liberation of funds by the government, what frequently cause disorders like lack of resources, interruption in scholarships payment, among other problems.

Knowledge society and the role of teams and creativity in innovation

The meaning of knowledge has changed during the history of humanking; in antiquity, and until the beginning of the industrial revolution, it was seen as something generic, focused in the individuals and their self-knowledgment, self-development and self-identity, by using grammar, logic and rethoric. With the advent of french enlightenment in the 17th century, the emergence of "scientific knowledgement" has changed this meaning, and emphasized the practical character of the knowledegement (Drucker, 1999).

Since then, the search for practical results has been guided the scientific research, and this fact was reinforced in the 20th century, with the growth of globalization and the new technologies, that affected communication, production, transportation, health, food and many other human activities. In this new reality, innovations are developed not by lonely individuals, but by teams compound of people with very distinct and frequent complementary knowledge and competences (Drucker, 1999). So, interdisciplinarity emerges as a necessary condition for these teams.

Considering that the most important resource to produce innovations in the "knowledgement society" (Drucker, 1999) is people and their brains (specially in R&D teams), and their capacity of producing always new and more creative answers for the R&D problems and deliver value for users, companies, government and environment, creativity can be seen as another essential resource for innovation. Emphasizing the role of knowledgement and creativity, this kind of group is called by Drucker (1999) as "knowledgement team", but also as "creative team" in a sociological approach by DeMasi (2003) and as "great groups" by Bennis (1999) from a north-american corporative point of view. All these approaches are convergent to the idea of teams organized to produce innovation in an interdisciplinary way, and using knowledge and creativity as a main resource.

The R&D team as a creative group

Bilton (cit. in Dolan, 2010) comments that the idea of creative groups goes back to the renaissance time in Europe, during the period between the 14th and 17th century, when groups of artisans, painters, sculptors, architects and other professionals were formed to carry out projects commissioned by the church or by the nobles (Dolan, 2010).

Advancing to the 18th century, DeMasi (2003) identified a lot of groups formed in different areas of knowledgement which he called "creative groups", and which had many common characteristics as: strong, but charismatic and non-authoritary leadership, high sense of mission and responsibility, high level of involvement and motivation, respect for the diversity, mutual confidence, flexibility, privileged spaces and moments to dialogue and discussion, high level of informality in the relationships, high level of creativity and stimulating environment for that, among many other aspects. strong, but charismatic and non-authoritary leadership, high sense of mission and responsibility, high level of involvement and motivation, respect for the diversity, mutual confidence, flexibility, privileged spaces and moments to dialogue and discussion, high level of informality in the relationships, high level of creativity and stimulating environment for that, among many other aspects.

Creativity, in particular, it was one of the central factors of these groups, and have been studied from several approaches since the end of the 18th century. DeMasi (2003) identified that the scientific researches on this theme started with a very biological and hereditary approach in the end of the 18th century, and strongly focused in the individuals, not the teams. Since then, the interest in creativity increased, and gradually included psychological, anthropological, socio-environmental, systemic, epistemologic and sociologic aspects. The scientific investigation on creativity gained importance specially after the 2nd war, with the emergence of the big north-american companies, and the exodus of some of the best scientists from Europe to USA, due to the war.

The previous emphasys on individual creativity in the first decades of the 20th century has changed to an increasing focus on the creativity of groups, because of the growing need for innovation in the organizations. So, the large knowledgement about creativity accumulated along the previous years, specially in the psychology, anthropology and sociology were largely used by the American companies to form, enable, empower and manage the teams, what was significant in the success of the USA companies in the post-war years (DeMasi, 2003).

All in all, on the other side of the planet another type of creative team also emerged, in a very different context: the Japanese companies, mostly destroyed by the 2nd war. Inspired by the need, but also by an old social tradition of collectivity, dialogue and search for consensus in the decisions, emerged the J-form teams; in fact, this model of organization was one of the foundations of the very revolutionary Toyota Production System (Dolan, 2010).

Specifically in terms of the R&D teams, Drucker (1987) pointed out that the first research laboratory inside an industry it was created in 1872 by Hefner-Alteneck, a Siemens engineer, with the aim to create new products and processes, and also to identify new applications and markets for them; for that time, this can be seen as a very innovative proposal, and also inspired the study presented in this paper.

R&D team as an adhocratic form of organization

Drucker (1999) considers that innovation requires systematic effort and high level of organization, as well as descentralization and diversity, in opposition to the centralized planning. This implies that a bureaucratic structure can not be the best form of organization for creative groups; in fact, the literature pointed out that the most successful innovation groups in history have been structured in a very flexible and non-hierarchical way. The most common models of organization with these characteristics have an organization structure called "adhocracy".

Adhocracy is a term firstly used by Bennis and Slater (1964), referring to the military "task-forces" in that time, and popularized by Tofler (1970) who considered this as the organizational model of the future. Waterman (1990) defined adhocracy as any organization that breaks with the bureaucratic processes, simplify the process and adapts to the situations as they shown.

Some of the main characteristics of adhocracy are:

- Organic organizational structure, based on cooperative groups and teams
- Temporary positions and tasks;
- Non-hierarchical and descentralized organization
- Modular design, formed by specialists;
- Structure is undone when the goals are achieved;
- Minimum formalization of procedures and behaviours;
- Minimum standardization of processes;
- Specialization of the work based on the members formation and competence;
- Coordination and control by the own group;
- Ill defined roles, subject to readequations;
- Communications sometimes incomplete.

Adhocratic organizations, in two main forms: "new adhocracy" and "J-form". "New adhocracy" is a model strongly based in the renaissance cooperatives described before, and influenced many organizations in the creative arts, like cinema, music record companies, scenic arts and others, and recently, journalism and professional sports (Dolan, 2010). The R&D groups in the universities, mostly, also have worked according to this model, emphasizing the focus in the goals and targets, low level of formality and bureocracy and most friendly work environments.

Similarly, the "J-form" teams are also characterized by the aspects described above, but with an own characteristic: the search for consensus in the decisions, that are taken only after an exhaustive dialogue and discussion, with respect for all the opinions and ideas, in a non-conflicting process; this is a significant difference from the western groups, and the success of Japanese companies like Toyota and Sony seems to confirm the value of this approach.

Another interesting way to see the creative groups and teams is using the Mintzberg (cit. in Dolan, 2010) analogy with the sports teams, as he says:

> *"I must, however, complain about baseball. That strikes me as the professional bureaucracy, football as machine bureaucracy, rugby as adhocracy, and our beloved hockey as (sometimes) a political arena"* (Dolan, 2010, p. 40).

This analogy were also used by Drucker (1999), which argues that there are at least three types of teams, according to the type and level of leadership, interaction and flexibility of roles, among other aspects: baseball teams, football teams and tennis doubles. The first is a very static organization, strictly controled by the coach, and wherein each player occupies a specific position; the second demands a more dynamic movement of team members, but is also dependent of the orientations of the coach, who defines the strategy; the last is a more flexible and non-hierarchical structure, what demands high level of articulation and autorregulation among the two members. Each one of these forms can be used by the creative teams, depending on the context, as found in the literature, but the last two were identified most frequently by the authors.

R&D team as a learning organization

According to Argyris and Schön (1978) organizational learning is a permanent reflexive and questioning process, that the organization members use to develop shared knowledge, based on the learning from each other. The final goal is to develop the team ability of "learn to learn", also called deutero-learning, overcoming the steps of single loop learning (individual learning based only on explicit knowledge) and double-loop learning (changing the mental models of the organization and its members from the cultural and objective knowledge).

Senge (1990) proposes that, to build a learning organization, the group and their members must be proficient in five disciplines:

• **Systemic thinking:** The ability of understand that, as in the nature, the human events are interconnected, and it is important to pay attention not only in the parts of the system we are in, but also in the whole.

• **Personal mastery:** It starts by clarifying what is really important for the individual, its aspirations, because this is the basis of any human entepreneurship.

• **Mental models:** The set of predefined ideas, opinions, generalizations an images which we have about the ourselves, the others and the world, and that influences our behaviours and attitudes.

• **A common goal definition:** It is essential to create and communicate a clear vision about the future to inspire people, and this one of the first obligations of any leader.

• **The group learning:** It depends on the individuals learning, but goes beyond them, due to the synergy of intelligences. It starts with dialogue and recognition of interaction patterns that hinder it.

Since these disciplines are being dominated, the innovation process can be started. Following the idea of learning organization, Beckman and Berry (2007) proposed that innovation process can be seen as a learning process. If Owen (idem) proposed that the innovation process include both identification and selection actions of problems and solutions, Beckman and Berry pointed out that, to perform these actions, are needed at least four learning styles: Divergent,

Assimilative, Convergent and Accommodating. The process proposed by them is based on two polarities axes, that put the activities in terms of abstract-concrete and analysis-syntesis, resulting in four quadrants of actions: reflexive observations about the context (concrete informations) and conceptual framing of insights (in abstract level) which are basically analytic steps, and ideas imperative (still abstract) and solutions creation (active and concrete experimentation), that demands ability of synthesis (Figure 5) (Beckman, Barry, 2007).

These learning styles are relevant for the definition and management of the team roles for the innovation process and, specifically in this study, for the R&D team. This is an important activity that can be considered in the first step of the R&D management process: the project planning.

The team management

Project planning

There is a lot of models for the project planning for R&D, but usually they contain more or less the same elements, which include: problem description, goals, targets, motivation, opportunities, risks, expected benefits, theoretical foundation, key partnerships and resources, funding sources, teams, competences and roles, tasks, framework, methodology, methods, tools, communication strategy and channels, schedule and a preliminary list of references. This is a structure commonly used by government agencies in Brazil, in official notices for funding new research projects.

In terms of the team management, is specially relevant the item related to team definition, which can include: the necessary competences and intelligence types for the project, and the roles related to these elements, team size, available budget and remuneration policy, availability of scholarships, contract time, days and working hours, among other elements.

The set of tools that can be used in project planning includes: mindmaps (manually or using softwares like XMind or Freemind), SMARTER targets (McGrath and Bates, 2014), SWOT analysis (idem), system maps (Halen *et al.*, 2005), project planning and schedule (using softwares like GanttProject or Microsoft Project), Balanced Scorecard (Assen, 2010).

Since the project planning be submitted and approved, it is time to form the R&D team, which includes two distinct phases: recruitment and selection.

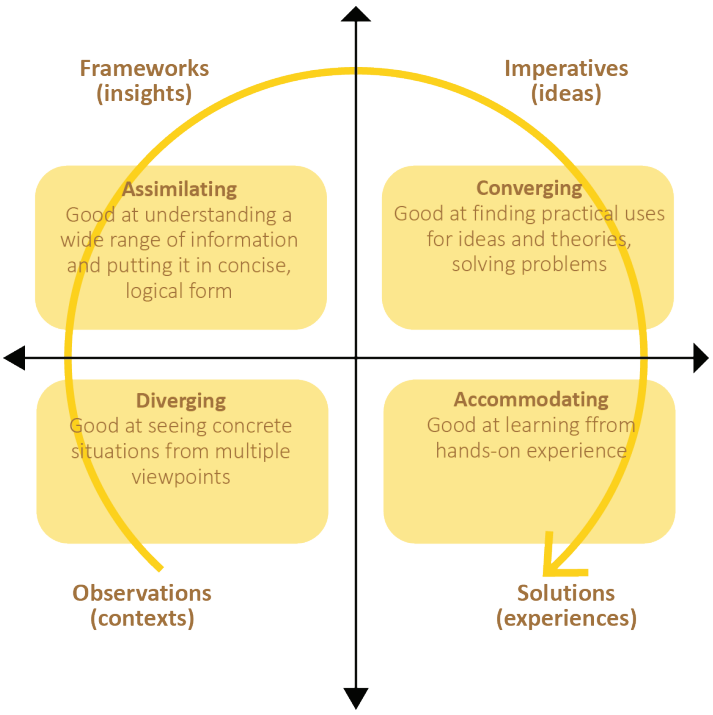

Figure 5 – The four learning styles (Beckman and Berry, 2007), based on the innovation process of Owen (1997)
Adapted from Beckman and Berry, 2007; Owen, 1997

Recruitment and selection

The team formation starts with the dissemination of the vacancies available for the R&D project in the channels chosen by the project managers. The requirements for these vacancies, already defined in the project planning, must be explicitated for the candidates in this stage. So, the selection phase begins, and a variety of techniques and tools can be used. Terra (2000) argues that the selection of creative members is one of the most important decisions for knowledge-based organizations. According him, the cognitive, creative and motivational abilities, can be improved and facilitated, but not changed in their essence, because they are built along the life of the person (Pitcher, 1995; Quinn *et al.*, 1996).

Badawy (1988) emphasizes the importance of evaluate the adequacy of the candidate to the culture of the organization, as well as its interpersonal ability to work in teams, because the innovation process demands dfferent roles, skills and creativity levels.

According to Terra (2000), and citing contributions of other authors, Psychology can con-

tribute to the formation of creative groups in four distinct categories:

• **Measuring the ability to think creatively:** This includes cognitive aspects connected to creativity, like fluency, flexibility, originality and elaboration, all related to divergent thinking. Tools like the Torrance Tests can be useful to measure these characteristics.

• **Assessing the personal characteristics associated to creativity:** The most common are tolerance to uncertainity and ambiguity, self-confidence, unconventionality, originality, intrinsic motivation, intelligence above average, determination to success, humour and nonconformity. Not all these characteristics are found in all the creative individuals, and they vary as the age, gender and professional occupation, according to King e Anderson (1995). Among the most known related tools, are the KAI, 16PF e OPQ tests;

• **Assessing the biographical characteristics and of past products associated to creativity:** This implies in a historical assessment of the past creative work of the candidate since his childhood, based on factual data, and serves to preview future creative achievement. Hocevar e Bachelor (1989), Shapiro (1985) and Badawy (1988) consider this tool more reliable than the previous, mainly in áreas like scientific research, engineering and design, but less effective to evaluate recente college graduates (Terra, 2000).

• **Measuring the motivation to work:** Parmeter and Garber (1971) identified the high level of intrinsic motivation as the main feature of creative people, based on a study carried out with 110 scientists. In addition, Kabanoff and Rossiter (1994, apud King and Anderson, 1995) suggested the importance to measure the motivational historical when selecting creative professionals (Terra, 2000).

For Keller (1978) the assessment of creative features is always approximate and subject to revisions, and the psychological approaches must be applied carefully. Hamel and Prahalad (1994) emphasize the importance of hiring persistent and resilient individuals, and the company ability of develop their own creative capacity; in this perspective, training programs can assume a relevant role. Shapiro (1985) see with restrictions this way, although recognize the importance of training people; for him, each individual should have its own approach to develop its creativity, from ideal working conditions given by organizations (Terra, 2000).

In order to better understand the people who will be assessed for the vacancies, is useful for the project managers to know about the diferente forms of intelligence, as proposed by Gardner (1995) in terms of seven: logical-mathematical, linguistics, musical, spatial, intrapersonal, interpersonal and naturalist. Goleman (1999) in turn, focused him attention to the emotional dimension of intelligence, also called “emotional intelligence”, as the way people face with their emotions and the people around. Some individual aspects affected by emotional intelligence include self-conscience, motivation, persistance, empathy, social features and leadership (Goleman, 1999).

In relation to the intrinsic temperament of the individuals, some authors like Robbins and Finley (1997) and Robbins (2008) consider that, although be important, they are not decisive for the success of the team. For them, what really matters is the behaviour, and indicates the importance of investigate the candidate´s behaviours in past projects as an indicator.

Despite this, the temperament tests are very used by many team managers around the world, as one of the tools to better know the candidates. One of most known are the Myers & Briggs Type Indicator (MBTI) (Wicklein, Rojewski, 1995), a tool based on the Jung psychological types, that frames the personalities in terms of the people preferences of think and act, based on four dichotomies: extroversion-introversion (E-I), sensitive-intuitive (S-N), thinking-felling (T-F) and judging-perceiving (J-P). The combination of these dichotomies result in 16 different personality profiles in which people can be framed.

Other tests are also used, as the Eysenck Personality Questionnaire (EPQ), a tool that frames the temperaments in terms of two polarities: introversion-extroversion and emotional stability-neuroticism.

The variety of personal profiles is pointed by Belbin (1993) as a relevant fator to success when forming teams. For him, the team must be formed considering the complementarity of roles, what allows a better balance between strong and weak points of the team. Belbin proposed that the ideal team demands three groups of roles, as follows:

• **Roles oriented to action:** Former, Implementer and Finisher;

• **Roles oriented to people:** Coordinator, Team worker and Resources-investigator;

• **Brain roles:** Evaluator-monitor and Specialist.

Belbin also defended the importance both of self-evaluation and evaluation by others as a way to improve the team as a whole.

In a later work, Kelley (2005) proposed a similar approach based on roles, but centered in the innovation process. This demands a confluence of competences to be carried out. According to Kelley (2005), these competences can be seen in terms of tem specific roles (personas) organized in three distinct categories , and who participate in the diferente moments of the process:

• **Learning roles:** Antropologist, Experimenter and Cross-pollinator;

• **Organization roles:** Hurdler, Collaborator and Director;

• **Construction roles:** Experience Architect, Set Designer, Caregiver and Storyteller.

These roles seems to be useful to build up tools for the selection and training stages of R&D creative teams.

Motivation

The seminal study carried out by Mayo (1933) in a GE factory in the thirties pointed out the relevance of interaction, recognizing, approval and participation in the workplace, instead of the work conditions and economical rewards (DeMasi, 2003; Chiavenato, 1983). Ten years after, Maslow proposed that the human needs could be hierarchical, although nor universal neither rigid, in the following order: physiological, safety, belonging and love (low level needs); esteem, self-realization, knowledge search and aesthetical needs (high level needs). For Maslow, motivation is a both internal and external phenomena, and it is up to the organization to create conditions to attend the human needs (Maslow, 1943). McClelland *et al.* (1955), for instance, proposed the human needs in organizations in terms of three types: realization, affiliation and power.

Based on the studies of Mayo and Maslow, Argyris (1957) and McGregor (1966; 1960) argued that there is in the organizations a constant tension between two systems, the individual and the organization; in this situation, the individual aims to meet his needs and enlarge his self-determination, whereas the organization must contain these needs by means of rules. In this context, Argyris (idem) puts the possibility of self-realization as a strong fator of motivation, and points out that no work is more motivating than the creative team. McGregor (1966) for instance, proposed two forms of relationship between the organization and the person, called X Theory and Y Theory. In the first, there is no self-motivation, and work is seen with aversion by people, who consider it just a way to make money. In the second, people see the work as natural in the life, and they are creative, competent, responsible and naturally self-motivated for the work.

Herzberg (1959) identified two groups of influencing factors for motivation and satisfaction in the work: the "hygienic factors", including payment, stability, prestige, environment and a capable leader, and the "motivating factors", like correlation between vocation and well done job, recognizing, appreciation, compatible responsibility, possibility of professional and human growing. "Hygienic factors" does not motivate to work, but can diminish the motivation, whereas "motivating factors" can leverage it. Specifically about the creative groups, DeMasi (2003) iddentified that they tend to have higher levels of motivation than other groups, like executives.

Shapero (1985) and Badawy (1988) proposed the following list of principles for R&D teams motivation:

• Encouraged behavior tend to be repeated;
• Positive reinforcement is more effective to motivate researchers than punishment;
• Motivation based on fear tends to generate ambiguity and uncertainty;
• There should be distinction between training need and motivation need;
• There should be clear and concrete explicitation of the desired performance;
• The researchers chacracteristics are distinct, and must be considered, including: time horizon is longer, the goal is the invention, not the sell; they are oriented to products, not to market, they tend to identify with peers more than the company;
• The main motivation systems for R&D professionals are related to task, including challenge aspects, creativity, imagination and flexibility;
• Adequate resources to carry out the activities.

These principles can serve as the basis for reward systems, as below.

Assessment, measuring and reward

Shapero (1985) and Badawy (1988) list the following characteristics for effective reward systems:

• Performance assessment is an important incentive;
• Reward must be immediate to the behavior desired to be repeated;
• Reward must be given as the researcher moves to the desired goal;
• The assessment of creative work must be multidimensional;
• One should avoid excessive emphasys on external rewards, as safety, salary and prestige, but on internal, as personal improvement opportunities and new challenges offering. The ideal is the combination of two;
• One of the evaluation criteria for R&D professionals must include the financial performance of the company;
• The division of activities for the R&D professionals in subactivities can favours their performance evaluation.

Attitudes and emotions

According to Robbins (2008), the team management includes the daily challenge of dealing with many aspects related to behaviours and attitudes of people, including:

• **Resistance to change:** Some people can be difficulties in deal with changes, whereas others can enthusiasticly adopt them. Flexibility, freedom and autonomy for the team members to organize and develop their work can be useful to diminish the resistance of the most reactive; clear communication about the change effects, involvement of the resistants in the decision-making process and rewards are also part of the solution of this problem.

• **Different levels of expectancy and involvement in relation to the work:** This aspect is related to individual differences about the need for self-realization, because some people find it in the work, but others in the art, education, social interaction, religion and so on. This is strongly related to the level of involvement and, for instance, in the performance. To accept this fact is important for the leader, in other words, it is not mandatory to deliver stimulating challenges for all, but only for that who see the work as a place for self-realization. In the case of R&D teams, this is not a big problem, because creative groups usually have high levels of self-commitment (DeMasi, 2003). Despite the differences in the level of expectancy, it is important to establish a minimum level of involvement in order to achieve the goals defined in the beginning of the project, and this can be done by the definition of the minimum level of acceptable performance.

• **Different levels of performance:** Performance is usually strictly related to the involvement level, as well as to the excellence level of the team members. According to the Pareto´s Principle, about 80% of the results are usually obtained by only 20% of the members, also known as "high performance collaborators". One significant aspect of these type of person is the frequent immersion, in the work, in a mental state called by Csicszentmihaly (1996) as "flow", characterized by a high concentration in the object which is being studied or developed. This seems to be common in the R&D activities.

• **Competitive instead of collaborative behavior:** Not all people wants and know how to work in teams, and some of them are to much competitive to work with others, what does not means that could not be useful for the project. If the leader delas with this situation, there are at least two options: relocating the individual to another function in which he can apply his talent for the benefit of the project, or disconnecting him, if it is not useful for the project and team.

• **The habit of create and nurture rumours:** One of the most dangerous risks for the team work is when one or more members use to create difficult situations by rumours, because this can affect the integration and confidence in the team. The leader must identify and neutralize as soon as possible any source of negative and false message, by means a transparent, clear and objective communication, and thereby avoiding a lot of conflicts.

• **The risk of "herd thinking":** This is a significant risk to creativity and innovation when working in teams, and specially in creative teams, but can be minimized if the leader use to listen everybody in the team impartially. Covey (2001) also suggests to discuss the risks

before the benefits when making decisions, and to choose a member to play the "devil´s advocate role" in the meetings; the "six thinking hats" of De Bono (2008) can also be used to stimulate different points of view.

• **Conflicts:** The behaviors and attitudes of team members and the leader can result in conflicts that must be managed by the leader. They can be seen in terms of two categories: functional conflicts, if present in a moderate level, which helps the team to grow, and dysfunctional conflicts, usually derived to relationship problems. This last demands a quick action by the leader, before the problem get out of hand. In fact, one of the most important functions of the leader is to manage the emotions of the team members, whar requires him a high level of emotional intelligence.

To deal with the behaviours and attitudes above, Robbins (2008) points out that is fundamental for the leader to lead by his own example, more than by words, and suggest that leaders should not manage sitting in his chairs; instead of this, the should be in frequent contact with the team and follow their activities, using the technique of "manage by walking around (MBWA)".

Work conditions and resources

As firstly pointed by Mayo (1933) the existance of suitable workplace conditions can be less importante for the workers than social interaction, recognizing, approval and participation; Herzberg (1959) for instance, classified work conditions as "hygienic factors", that does not motivate to work, but can diminish the motivation if get below acceptable levels.

De Masi (2003) identified that creative groups commonly used to convert their work environments in places stimulating to creativity, and, independently of the knowledge area, they usually had a high level of aesthetic sense.

This aspect is presently relevant in the studies of innovation teams, and can be quite favored by disciplines like human factors, interior design, lightning design and others.

Information and communication

Information is a crucial resource in the "knowledge society", and the raw material for decision-making processes frequently present in innovation and R&D processes. Information management includes the stages of research, selection, filtering and proper use, and requires appropriate systems and channels (Covey, 2001) as well as competences of team members and the leader to use it. Also, information influences the communication process, both inside the team and with external actors.

As pointed out before, team motivation, behavior and attitudes are also related to the quality of communication, both among the members and with the leader. The team is commonly composed by different people, with differences in terms of gender, culture, age, formation, congition, interaction and communication styles, and communication must be adapted to these differences (Robbins, 2008). These differences can produce noise in the communication, resulting sometimes in poor comprehension of the messages. Based on the Neurolinguistics Filtering Principles, Grindler and Bandler point out that people use elimination, distortion and generalization resources to filter the messages received, so it is important for the team members to understand these mechanisms in order to establish a more emphatic and effective communication.

In adittion, Robbins (2008) argues that, specially for the leader, is important to provide constant feedback for the team members in the communication process, what can avoid surprises in the end of the project.

Combined with honesty and openness, empathy can allow a communication process based on listening to the other more than speaking, which also requires frequently enough time to listen (Covey, 2001). This act of listening everyone in the team should be extended to the external partners, and specially the client, as defended by Peters (1985) as a necessary condition for effective innovation.

Decision-making

Robbins and Finley (1997) consider that, despite the importance of decision-making processes in the team management, many leaders fail in this aspect. They explain that there are at least seven different decision-making styles that leaders should master:

• **Consensus:** All the team members can opine and should agree with the result. This method can lead to very innovative answers, but is time-consuming and requires high level of ability by the members.

• **Majority:** Decisions are made by voting, in

a democratic process. It requires less time than consensus, but some members can remain dissatisfied, what can difficult the implementation.

• **Minority:** When just some members are abled to decide, the time is short or the decisions are not strategical, the decision is delegated to a subcommittee of a few members of the team.

• **By mediation:** Is based on negotiation, haggle and cheating, an usually the only satisfied at the end are the moderate. The most experienced opinions can be cancelled by the younger, and can lead to a weak commitment by the team.

• **By specialist:** Useful when the knowledge of a person is much more relevant to base the decision than the member teams, making the discussion irrelevant. Commitment of the team is null.

• **Authority domain without discussion:** The most authoritarian style of decision-making. Is useful when there is no time for discussion, the team hopes that the decision be made by the leader, or the tema members are not able and well informed to decide.

• **Authority domain with discussion:** Also known as "participant decision-making", is used when the final decision is responsibility of the leader, but supported by a discussion with the team. It demands both communication ability of the team and a leader willing to decide.

Robbins and Finley argues that there is no right or wrong style of deciding a question, but the important is that the team could choose, before the decision-making, what method will be used, because this can avoid many unnecessary conflicts (Robbins, Finley, 1997).

Creativity: selection vs. training

Quinn *et al.* (1996) advocate the use of training as a tool to promote creativity, as well as Parnes and Harding (1962), the precursors of this resource, but these last also state that creativity can not be teached, but only stimulated. Kelley and Caplan (1993) agree with the importance of training, based on studies carried out between 1986 and 1993, that pointed the preponderance of work strategies on psychological characteristics, including cognitive ones (measured by QI tests). In opposition to the behaviourist theories, and specially to Herbert Simon, about the possibility of changing individual characteristics and his judgement ability, decision-making process and risk assumption, Pitcher (1995) consider that people selection is more relevant than training. Despite this, most of researches about the use of creativity training seems to indicate de usefulness of this tool, so it is possible to infere that creativity training can be expanded also for innovation and R&D teams.

The team leadership

Historically, industrial revolution demanded a kind of leader with more authoritarian and centralizing features. But with the increase in the workers awareness about their own condition, organizations gradually started to search for new ways of interaction, and leadership began to have characteristics more focused on workers motivation. In this direction, Likert (1961) and Slater and Bennis (1964) proposed the "participative management" as an effective way to manage organizations using a more democratic management style, in opposition to the authoritarian style of the previous decades. Slater and Bennis (1964) already pointed in that decade a change in the leader profile, from a heroic role to another focused on the team work; he confirmed this perception in later years, based in a series of studies with north-american creative groups as Disney, Xerox, Apple and Lockheed (Bennis, 1999).

Presently, in the "knowledge society", the intelectual capital of workers became central, and the role of the leader is, mostly, to search for new ways to take care of the team and its knowledge, and to make it more motivated and productive, na idea defended by authors like Levitt (1976), Mintzberg (1973) and Katz and Kahn (1978).

Characteristics of the leader

Base on a study carried out with European creative groups of the 1850-1950 period, De Masi (1999) identified that their leaders had the following characteristics:

• Almost heroic dedication to the project and team goals;
• Efficacy in creating the work environment with an uncommon atmosphere;
• Strong orientation to the task, to the group or for your own, with equivalent tensions;

• Charismatic and competent;
• Attention to preserve and nurture the memory and history of the team;
• Frequent acceptation and respect, and even eventual veneration by the group.

Bennis (1999), for instance, pointed out four common features in the "great groups" leaders:

• They offer orientation and meaning for the team members;
• They inspire and sustain confidence, enabling disagreement without compromising the work process;
• They tend to action and curiosity, and a natural disposition to risk of failure;
• They promote the hope for the group get over the dfficulties, by using tangible and symbolic resources.

Independent of the time in which the groups were studied, the characteristics of leadership in creative groups seem to be the same, combining high levels of personal features, as empathy and charisma, with technical competences, depending on the área. It is also relevant to consider that the most suitable style of leadership for each team is strongly dependent on the cultural context in which the team is inserted, whether the organization or in the last instance, the society itself.

Roles of the leader

Levitt (1976) emphasizes, beyond the technical skills in management, the importance for the leader to domain personal and interprersonal competences, including way of acting, personality and work philosophy, which must be attuned with cultural and work standards of the organization, and also of people who he will work with. For Katz and Kahn (1978) is the performance and the way the leader deals with people and the situation what will determine oe not his success. This performance depends on the leader abilities, that can be technical, human and conceptuals.

The expectations of the organization about the leader also relevant to this performance, according to Mintzberg (1973) and manifest in the form of ten leader roles, organized in three categories: interpersonal (interaction and influence), informational (information management) and decisorial (decision-making).

One of the "empowerment" precursors, Moss Kanter (1983) highlighted the importance of leaders assume the role of "change masters", considering the need for change for organizations survival. For this, she argues that the "change masters" should: focus the attention on the tasks and results, not in the procedures; organize and empower teams, giving them total responsibility for their participation in the end result; and create an environment that evidence the value of people involved in the project.

Senge (1990) for instance, shows the importance of building a learning organization in which the leader have the fundamental role of conduct the learning process. For this the leader must develop, in yourself and in others, the five learning competences also described in the section "R&D team as a learning organization", what demands the assumption of three distinct roles: leader as designer (to design the organization guidelines, strategies and systems by integrating the learning disciplines); leader as guide (to guide the team in the cycle of thinking, doing, assessing and reflecting, always focused in a relevant goal collectively established); and leader as teacher (to help the team see the reality in a more systemic way, emphasizing the availability of creative resources and possibilities, instead of limitations).

Results

Team management

Based on a critical assessment of the literature, the first proposal for the team management model was built considering six stages (Figure 6):

• **Project planning:** This first phase is done basically by the manager(s) of the R&D project, and results in a document that contains the problem description and justification, goals and targets, motivations, risk and opportunity analysis, mission and vision statement, key partnerships and resources, team and roles characterization, tasks description, workflow, schedule, expected results, intellectual property and other legal issues, and communication and dissemination strategy. Tools like midmaps, SMARTER targets, system maps, SWOT analysis, Balanced Scorecard are commonly used in this phase.

• **Team members selection:** Include two main aspects: recruitment and selection of the team members. In the first the requirements for the candidates are established, as well as the channels in which the opportunities will be of-

fered; in the second, the recruited candidates are then selected, based on the roles, competences, intelligence types, personalities, creativity capacities and other personal characteristics defined as necessary for the team. For this, a lot of tools are used, as interviews, group dynamics, portfolio analysis and creative challenges, among others.

• **Team preparation:** Since the team members are chosen, it is necessary to prepare them for the activities, what include de definition of the team size and the distribution of functions, considering aspects as flexibility and heterogeneity, among others. Motivation is also a relevant topic in this phase, including special attention to the members needs, expectations and emotions, as well as their social integration, which affect the involvement, as pointed out in the literature. Considering the R&D process as a learning process, it is also important to provide activities and tools to improve learning competences in the team, including: common goal definition, collective learning, personal domain, mental models and systemic thinking. The tools for this phase can include workshops, group dynamics, training classes and the use of techniques to improve the dialogue and discussion, as well as others.

• **Conditions and resources:** The availability of conditions and resources for the team should include: information technologies, systems and channels that allow an effective and efficient flow of information along the team; financial resources that are enough to achieve the goals of the project; a work environment that is physically and psychologically healthy, safe and stimulating for the team; technical infrastructure, including equipment, softwares, library and other resources. Human factors, including both micro and macroergonomics provide valuable concepts, methods and tools that can be in this phase.

• **R&D process implementation:** Once the team is prepared, motivated and integrated, and the conditions and resources are made available, it is time to work. This phase is particularly demanding for the project manager, that can be able to lead the team in its communication, considering the different interaction styles and preferences of the members, and removing barriers for the clear and effective communication. The deliver of constant feedback to each member about his performance is also relevant to allow improvements during the process, and to prevent eventual surprises for him when the project is in the end. At the same time, an effective implementation demands to the leader must be always attentive to the attitudes and emotions of his team, being capable of manager the conflicts when they appear. This implies that some aspects must be carefully considered, as freedom of opinion, participation, autonomy, equity (win-win approach), empathy, synergy and respect for individualities. The reduction of bureocracy to the minimum necessary and the technique of "manage by walking around (MBWA)", can help to motivate the team and keep their focus on the project. The implementation also includes frequent decision-making moments, that must be closely monitored and, if necessary, oriented, and the team must be conscious of the most suitable type of decision-making for each moment. Beyond this, the management of creativity, both individual and collective, is crucial to redefine the project problems and to obtain creative answers for them. A lot of creative techniques are available for this, including the classical brainstorming sessions, the six thinking hats of DeBono, morphological box and many others.

• **Assessment, mensuration and reward:** Once the work is completed, the results should be evaluated and measured, for two reasons: first, to verify if the goals established in the beginning were really achieved and in what level, and second, to reward the teams and individuals according to their merit in the final results. If the aim is to appreciate and stimulate the collective efforts, more than the individuals, this phase must emphasize the use of measurement tools with this focus. The individual performance also can be evaluated, but aiming to reduce the "social inertia", as pointed out by the literature. Finally, if the learning of the team is one important competence present in the phase of the preparation, this also must be evaluated at the end of the process; this can be done by using the 360 Degree Feedback, a tool whose function is to deliver to the team member relevant data for his personal improvement.

For each stage, it was identified a set of tools that can be used to operationalize it. Even if some of them seek to organize the results in terms of a number, these tools are basically qualitative in its essence.

In this model, is possible to note that the R&D process is positioned as one of the stages, in other words, the R&D process is contained in the team management model. This was a relevant finding in this study, because the author who conducted the active research initially supposed that was the R&D process that should include the team.

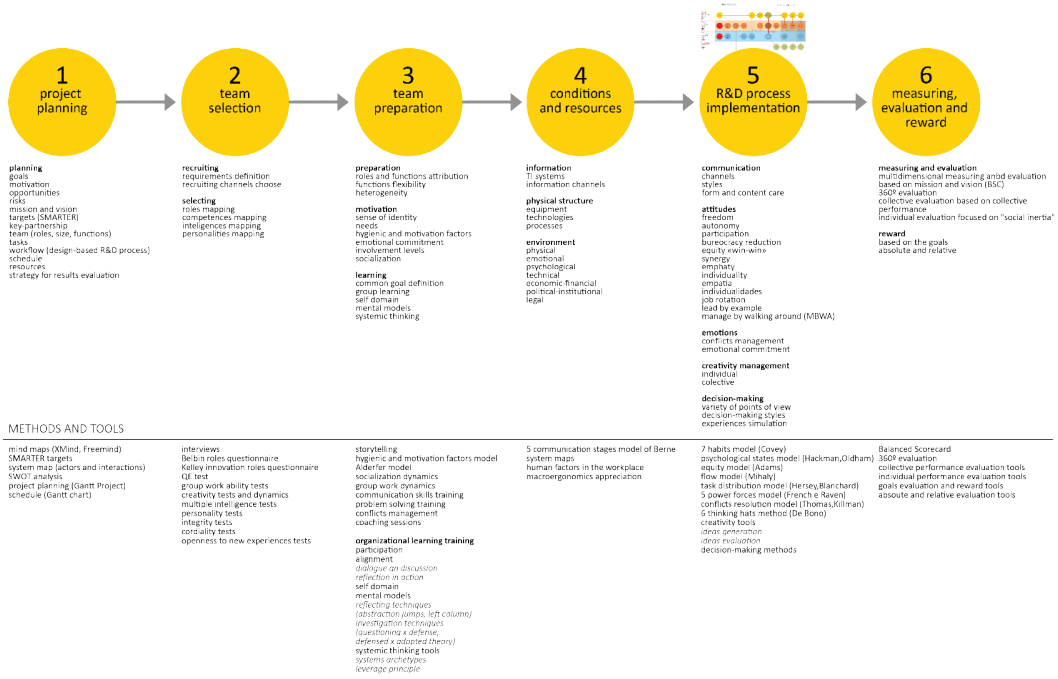

Figure 6 – Preliminary model for the team management

Source: authors' material

So, this finding seems to point to a team-based methodology or, ultimately, a methodology with a very humanistic approach, based on empathy, respect, consideration, dialogue and discussion, diversity and other human-based carachteristics. These aspects found in the theory of creative groups are, not by chance, some of the fundamental aspects of the design thinking approach.

But another essential characteristic found on creative groups it was the primacy and relevance of the leadership (DeMasi, 2003; Bennis, 1999). So, this element should be also integrated in the team management model as a necessary condition for the success of the team.

As well as the R&D process model presented before, the R&D team model also can be considered as a pre-framework, if more details be added to the structure to allow its implementation.

Leadership management

The various characteristics, competences and functions of the leader in a creative team were organized in six disctinct dimensions, that were the basis for the leadership model (Figure 7):

• **The leader as an individual:** The first dimension of the leadership is dedicated to develop and/or improve individual characteristics related to self-knowing and self-improving that are important for the later action as a manager, as pointed in the literature. It includes self-conscious, self-confidence, integrity, responsibility and search for truth. The set of tools and methods that can be used in this dimension includes a variety of temperament tests, multiple intelligences tests, emotional intelligence tests and training, and also other non-usual techniques, like meditation.

• **The leader as a manager:** The management of the R&D team and process requires a distinct set of skills of the leader, including: organization, communication, autorregulation, intrinsic motivation, broad, clear and anticipatory view, persistence, perseverance, be attuned to the organization and creative-abductive thinking. The leader can use tools and techniques like self-questionnaires, checklists and tests, which can be build based on the theories of Belbin (1993), Kelley (2005), Mintzberg (1973), Moss Kanter (1983).

• **The leader and the people:** To act as manager, is essential for the leader to develop

and/or improve interpersonal competences, as communication, empathy, motivation, aggregating capacity, assertivity, genuine interest and appreciation for the people, recognition of their value, and the ability to lead by example. For this, the leader may use the sets of tools and techniques already presented in the team management model, and included in the phases of team preparation and R&D process implementation. The ability of manage conflicts and maintain the team integrated, motivated, nourished, aligned and focused are central in this leadership dimension.

• **The leader and the information:** If information is the raw material that feed the leader decisions, is important for the leader to develop competence in how to manage it. This include the stages of search, selection, filtering and proper use of information, that can be better conducted if the leader has at its disposal the right tools and techniques; to identifiy them is one of the next tasks in our investigation.

• **The leader and the decisions:** To make decisions is one of the most frequent tasks of the leader. This is an essential competence to manage teams and processes, and implies that the leader should know the various styles and processes of decision-making, and share them with his team. So, this dimension covers a set of decision-making tools and techniques that will be identified in the next stage of this study.

• **The leader and the learning:** R&D is seen, in this study, also as a learning process. For instance, this requires the leader to develop specific competence in manage the team learning along the process. Based on the Senge (1990) proposal, the leader must assume three distinct roles of learning: designer, guide and teacher. Each of these roles can be developed and/or improved using proper tools and techniques. Some of them were already been identified in the literature, and integrated in the team management model, specifically in the stage 3 (team preparation) and 5 (R&D process implementation), others will be investigated in the next stage of this study.

Conclusions

This paper started from the identification of a relevant problem (synthetic textile waste) with environmental, economic and social implications, and findings about it, obtained in a Brazilian research project, which included the use of design thinking as both conceptual (using abductive reasoning) and operational approach to frame it. Design was applied here in an interdisciplinary way, combined with other knowledge areas, as Chemistry and business innovation. By means of active research, preliminary results (materials, products, patents, business models) obtained with the research team in that project indicated the utility of this proposal to deliver environmental, economic and user values.

These findings proved to be useful to develop a model for the R&D process, already presented by the authors in another paper, as part of a doctoral study by one of the authors, and it was the basis for the second stage of the study: the R&D team management.

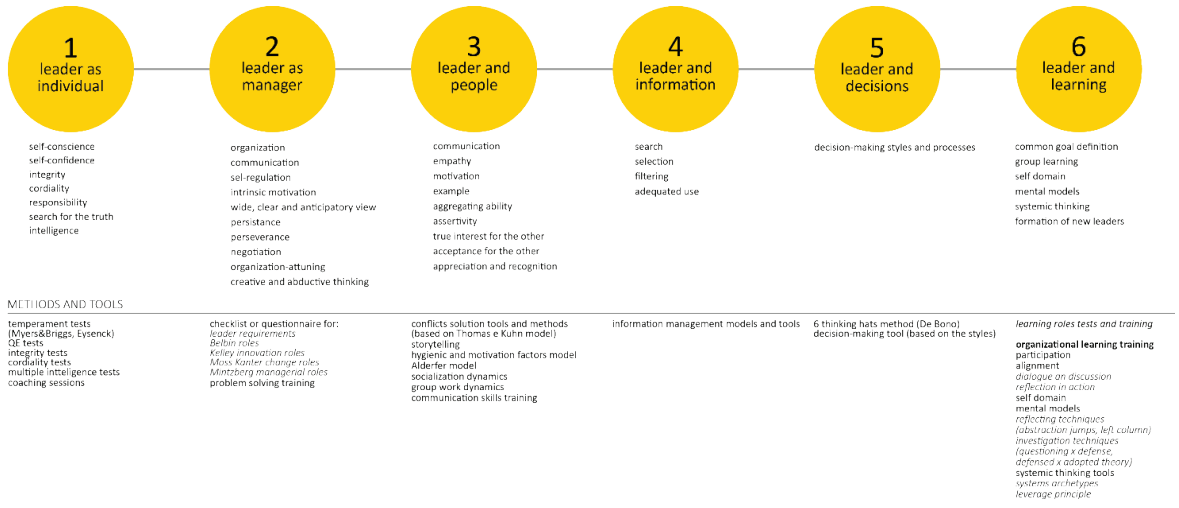

Figure 7 – Preliminary model for the R&D team leadership
Source: authors' material

About the R&D team, and based on the experience with the active research, it was possible to note that Brazilian R&D teams have their own peculiarities, due to a specific institutional and scientific context, which affects the way the research groups work. Allied to this, the literature critical review and the use of interviews allowed understanding the place and role of R&D teams in the knowledge society as a learning organization, as well as the relevance of creativity and the need of an adhocratic organizational structure. These aspects demands a high level of leadership and management, and the authors proposed here that they could be operationalized by means of an effective management model, including three elements: the process, the team and the leadership.

The results presented in this paper seems to indicate that the various aspects of team and leadership can be integrated in a model in a logical and comprehensive way. In fact, the aspects identified in the literature, active research and interviews are present both in the team and leadership management. It is possible to conclude that the integrated model is based on a humanistic approach (also present in design thinking), and strongly centered in leadership. However, in this model, the leader is not the end of the model, but the element whose function is mainly one: to make the team members innovate, improve and learn continuously. Thus, the leader in this model must assume, as main roles, to be he organizer, energizer and guide of the process.

After construction of R&D management model here presented, the next activities include the refinement of the proposed model, and its validation Once the integrated model is composed of three distinct models (process, team and leadership), the next stage of validation will be for each one of them. Thus, the first validation step will be for the R&D process model, using two different research teams: a sample and a control one. The second validation step will be for the R&D team model, using the same teams configuration.

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