CATÓLICA LISBON
SCHOOL OF BUSINESS & ECONOMICS

UNIVERSIDADE CATÓLICA PORTUGUESA

IMPACT OF 3D DESIGN ON NEW PRODUCT DEVELOPMENT PROCESS IN THE CLOTHING INDUSTRY

THE CASE OF CORDEIRO CAMPOS

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DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE DEGREE OF MSC IN BUSINESS ADMINISTRATION, AT THE UNIVERSIDADE CATÓLICA PORTUGUESA, 2014

ABSTRACT

Title | Impact of 3D Design on new product development process in the clothing industry
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The global fashion industry is facing demanding needs submitted to fast evolving trends, where innovative and upgraded solutions are essential to increase capacity of response. In order to satisfy this challenging industry, firms ought to look at their current new product development processes and analyze the prospect of implementing new solutions to keep up the pace of the industry. These solutions go from reducing design times, having fast times to market, improving quality to reducing the development cost. This work embraces the case of 3D design, a recent technology here applied in the clothing industry, which helps companies to meet the challenges posed by the market in terms of new development processes. The study takes the case of Cordeiro Campos, a SME which works as a subcontractor manufacturer for large luxury companies and represents one of the few companies in the world that has integrated 3D design in its structure. In that sense, this firm suits perfectly well the aim of this study, since its purpose is to understand the payoff of using 3D design in the new product development process in terms of the most relevant attributes in the development of products in clothing industry. After an in-depth review of the literature related to both NPD and 3D design, an analysis supported by interviews was conducted to two different perspectives: (1) Cordeiro Campos, the company which employs 3D design and (2) Lectra, the firm that provides this design solution.

ACKNOWLEDGEMENTS

It was for me a privilege and an honor to embrace this opportunity and to have the chance to contact extraordinary professionals who are an example of innovation and leaders on their careers.

The first and most profound acknowledgement is owing to Professor Céline Abecassis-Moedas. More than the overwhelming patience and comprehension that she has shown throughout the writing process, I am grateful for her constant confidence in me that goes beyond my own and I will preserve her contribution to my development as one of the things I most want to keep dearly cherishing every time I achieve the benefit of success.

The second, to Lectra and in particular to Maximilien Abadie, the Strategic Planning Analyst of Lectra, for not only helping me in opening wide doors in Cordeiro Campos, but also to all the invaluable support and prompt feedback that he has given me during this tremendous experience. In addition, to Susana Costa, the Marketing Manager of Lectra Portugal, and Paulo Ribeiro, the Service Manager of Lectra Portugal, who have offered me the privilege of their time and contribution, as well as my introduction to Cordeiro Campos.

Third, to all the managers of Cordeiro Campos, who accepted my project with great promptness, receiving me with a great sympathy and providing me with constructive and important data.

Fourth, to my colleague Mariana with whom I had the occasion to work and discuss strategies and ideas, and I whom I thank for having made the work process much richer and more pleasant.

Fifth, I leave my deepest gratitude to my amazing family for giving me a vital assistance with my academic and individual development. No words or acknowledgements would be sufficient to express how to express how tremendously important they have been to me.

Last, but not least, to Francisco and my friends that have stood by me throughout this work, always patient in times of trouble and present in times of joy.

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GLOSSARY

CAD | COMPUTER-AIDED DESIGN

CAM | COMPUTER-AIDED MANUFACTURING

ITERATION | SUBSTANTIVE CHANGES TO AN EXISTING DESIGN, INCLUDING NEW DESIGNS AND CONCEPTS

NPD | NEW PRODUCT DEVELOPMENT

PROTOTYPE | PHYSICAL PROTOTYPES FOR EXPLORATION AND TESTING PURPOSES

1. INTRODUCTION

Despite the importance of designing and successfully commercializing innovative new products, new product development (NPD) performance in many companies remains unsatisfactory. The fraction of products that fail after launch in the market place is around 40 percent (Crawford and Benedetto, 2003), remaining astonishingly high and consequently many new product development projects do not meet performance target.

Given that, the new product development process touches upon a broad range of activities and decisions; an equally broad range of success factors for R&D has been explored, ranging from factors related to technology, people, products and processes (Fixson and Marion, 2012). We focus this dissertation on the intersection between digital design tools, more specifically Computer-Aided Design (CAD), and new product development processes. In particular, we explore the effects of the increasing use of 3D design (a CAD technology) on NPD performance by shifting physical critical simulation to a virtual reality.

Over the last twenty years most industries have seen a transition from traditional product development that was local, face-to-face, and sequential to one that is more global, more virtual, and more concurrent (Eppinger & Chitkara, 2006). Broadly speaking, the digital tools supporting these changes include fast prototyping technologies and new communication tools. The assumption is based on the revolution done through new product development in terms of efficiency, allowing designs to be iterated and transmitted extremely quickly– saving time and cost before product launch (Fixson and Marion, 2012). However, in the reality of modern day in NPD this relationship between time and cost is not always clear-cut.

To investigate how increasing use of 3D design impacts new product development performance, we explore in detail a NPD process that is a very special case of usage of this design tool. Our primary source is qualitative data from Cordeiro Campos, a Portuguese company that represents an international case since it is an early adopter of 3D design and consequently one of the few worldwide firms who uses 3D design in its development process.

This thesis proceeds as follows: in the next section we develop a literature review where all the theoretical background approached in the study will be presented. Secondly, the methodology used to gather the crucial information for the thesis credibility will be described. Subsequently, all the collected data will be analyzed in light of our theme. Fourthly, a discussion will be held between the main findings from the survey and the data from the Literature Review. Finally, the main conclusions will be described to summarize the most important points of the study.

2. LITERATURE REVIEW

Today's marketplace ever-increasing demand challenges companies to supply their products in shorter lead times and in higher quality. Though, researchers such as Cooper (1993) agree that New Product Development is a *phase in which the new product is designed and developed*. In this research, we view problem-solving on NPD as an iterative process, driven by trial-and-error experiments that are guided by knowledge of underlying relationships (Thomke and Fujimoto, 2000). The same authors also describe NPD as a *sequence of problem-solving cycles*. This sequence starts with a problem recognition and goal definition cycle and continues with an iterative process of experimental search through alternatives that are designed, built, tested, and analyzed. The principle of this iterative process is to discover and solve issues in design and manufacturing procedure. Thus, this activity is one of the riskiest ones, essentially for its high cost and low rates of success; according to Crawford and Benedetto (2003) around 40 percent of new products fail.

In contrast, Swink (2000) claims that identifying factors contributing to new product success remains a vital managerial concern, not only because successful new products are a motor of sustainability in any competitive industry and can drive to an exceptional market and financial performance, but also because they may point out to previously undiscovered business opportunities.

2.1 NPD PERFORMANCE

Kumar and Wellbrock (2009) examined several studies with a special focus on recent product development theories. They confirmed that the main challenge for companies was to *develop cost-conscious product quickly and still meet performance and quality criteria*. Moreover, the challenge of meeting this criteria increase essentially because activities in the development phase account for approximately 80% of the total manufacturing cost (Ullman, 1992).

Researchers such as Clark and Fujimoto (1991), Henard and Szymanski (2001), Kumar and Wellbrock (2009), McNally, Akdeniz and Calantone (2011) and Fixson and Marion (2012) agree

that NPD performance can be evaluated in terms of three dimensions that together underlie the NPD process:

1. Product **Quality** – successful new product developments depend upon how good the product is, whether it satisfies the customer or is reliable. This input fluctuates according to the strategy of the firm, but reflects the price that customers are willing to pay (Henard and Szymanski, 2001). Product quality consists of two dimensions impacting customer perceptions: design quality, which is the extent to which the product design matches customer expectations, and conformance quality, which is the ability to produce the product per design specifications (Clark and Fujimoto, 1991). Moreover, Henard and Szymanski (2001) sub-classified quality into the following parameters:

    a. Superiority and/or differentiation over competitive offerings
    b. Extent to which product is perceived as satisfying desire/needs of the customer
    c. Perceived price-performance congruency
    d. Perceived technological sophistication (i.e. high-tech, low-tech) of the product
    e. Perceived newness/ originality/ uniqueness of the product

2. Development **Time** – how responsive the firm can be to external and internal factors. It is also referred as lead time and it is the time between the idea generation and the new product launch (Griffin, 1997). A particular concern regarding speed to market is that extreme speed may jeopardize product quality (Clark and Fujimoto, 1991). According to Malhotra, Heine and Grover (2001) time performance on design development can be measured on:

    a. Design speed
    b. Speed of introducing new products into production
    c. Ability to produce more variety in designs
    d. Ability to customize products per design specifications
    e. Ability to make designs change easily

3. Development **Cost** – how resources are allocated in the NPD process. Personnel expenses, in addition to expenditure of materials, equipment, and tools, typically dominate the total product development cost (Fixson and Marion, 2012). The cost profile can be the combination of labor cost (engineering hours), managerial attention, and materials and equipment for prototyping (Fixson and Marion, 2012). However, in this analysis only prototyping will be considered.

These three performance dimensions are closely related—any attempts to change one variable can have consequences for the other two in ways that sometimes are difficult to predict (Thomke and Fujimoto, 2000). Empirical research not only demonstrates that managers make speed to market–product quality trade-offs, but they also do different trade-off arrangements, emphasizing speed, quality and expense (Swink, 2000).

Empirical research finds both positive relationships between speed to market and development cost (Clark and Fujimoto, 1991), where speed to market–development expense relationships assumes some unspecified level of constant product quality (McNally et al, 2011). Clark and Fujimoto (1991) refer to the need for both speed to market and product quality as "balanced excellence," proposing that managers must make trade-offs between both requirements to be successful. In addition, Clark and Fujimoto (1991) also find no correlation between development cost and product quality. In contrast, Swink (2000) finds that higher development expenses are associated with higher manufacturability and lower defects, as well as higher product performance and better meeting specific customer needs (i.e. design quality).

Henard and Szymanski (2001) suggested through meta-analysis that the most important factor is product quality, followed by time considerations and then development expenses. However, the research conducted by McNally et al (2011) claims that speed to market and product quality both enhance product profitability, being the impact of speed to market larger than the one from product quality. That is essentially because the sooner a firm can launch a new product, the more certainty in forecasting customer preferences and in developing an attractive product concept there will be (Clark and Fujimoto, 1991).

In addition, those dimensions connected to NPD performance are also influenced by other performance drivers, covered by a broad set of factors such as *Product, Process, People* and *Tools* (Fixson and Marion, 2012) , that will be developed in the next section.

2.1.1 PRODUCT DEVELOPMENT

Cooper (2011) states that a new product is defined as new if it has been on the market for three years or less, and includes extensions and major improvements. According to several researchers such as Crawford and Benedetto (2003) and Cooper (2012), a new product can be classified into several different categories, being the following the most commonly accepted:

- **New-to-the-world** – these products disrupt the established product categories and they may include an innovative technology. Cooper (2012) explains that these types of products are the first of their kind and therefore they create a completely new market. This category only represents 10% of all new products.
- **New product lines** – new products that supplement the company are established into product lines.
- **Addition to product lines** – products new to the firm, but adjusted with an existing product line (already produced).
- **Product Improvements & modifications –** products with the goal of enhancing performance or perceived value.

In the development portfolios of companies, the percentage of new-to-the world product is down by almost half and, in contrast, addition to product lines and product improvements & modifications increased their importance (Cooper, 2012).

FIGURE 1 - DISTRIBUTION OF PROJECTS IN DEVELOPMENT PORTFOLIOS

Type of Projects	1990s	2000s	% change
New-to-the-world	20.4%	11.5%	**-43.7%**
New product lines	38.8%	27.1%	**-30.1%**
Addition to product lines	20.4%	24.7%	**+30.8%**
Product Improvements & modifications	20.4%	36.7%	**+80.1%**

Source: Cooper (2012)

In addition, according to Cooper (2012) line extensions or modifications will maintain market share, rather than growth. Furthermore, development or growth depends strongly on the ability to introduce new products to markets in the right time.

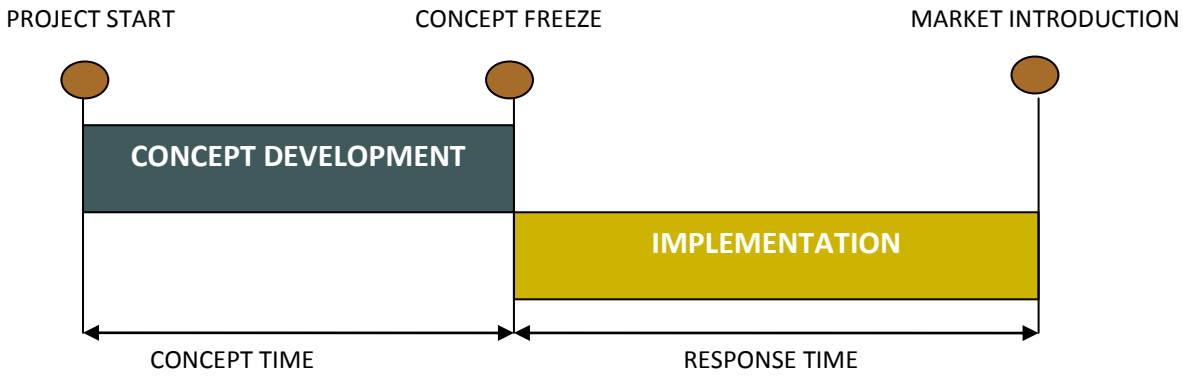
The product architecture is *the way in which the product function is allocated to its components* (Fixson and Marion, 2012). So, more connected product architectures can generate cascading and iterating activities that prolong the NPD process and, as a result, the entire process becomes more costly (Fixson, 2006). Fixson and Marion (2012) go further and explain that there are two main reasons for why solving problems early is better than late. First, in the new product development process is implicit a sequence of problem-solving activities of often interconnected activities, and therefore the degree of independency for each problem solving decreases with the rising of decisions made. In other words, problems addressed earlier face fewer constraints, since later solutions will be more independent from others problems in the process. Second, problems addressed later in the NPD process often involve prototypes and tests with higher degree of fidelity, since they are more expensive to solve on a per experiment basis.

2.1.2 NPD PROCESS: MOVING TOWARDS FLEXIBILITY

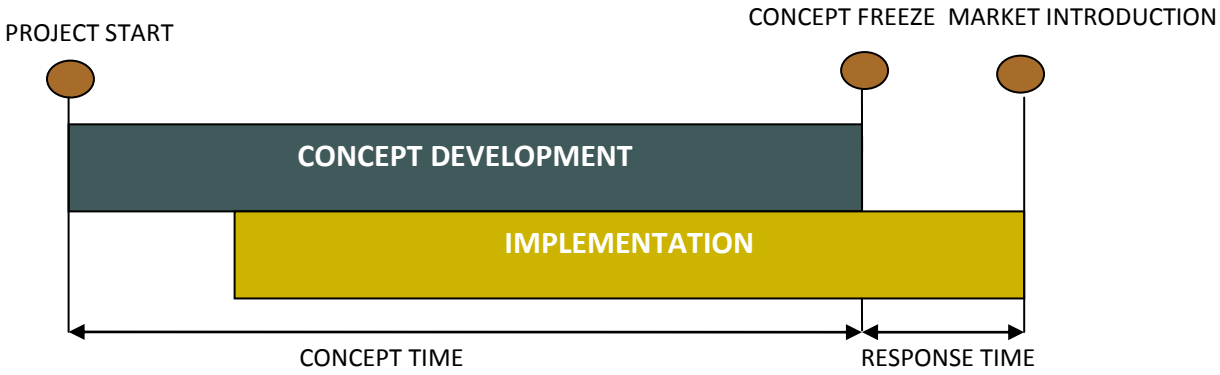
Iansiti and MacCormack (1997) explain that the way companies run their product development process changed in the recent past, essentially moving to a more flexible process (Figure 2). They claim that the approach to NPD delays until as late as possible any commitment to a final design configuration. Subsequently, by accepting the need to reduce modifications cost, companies are able to adapt easily to the market and to new information that arises during this process. This continuous flow of information enables the company to learn about customer needs and new technologies, reducing both cost and time when integrating information into the product design. The integration of this approach in turbulent environments reduces the risk of creating obsolete products, and allows for the optimization of the available resources (Iansiti and MacCormack, 1997).

FIGURE 2 – TWO APPROACHES TO NEW PRODUCT DEVELOPMENT

Traditional Approach



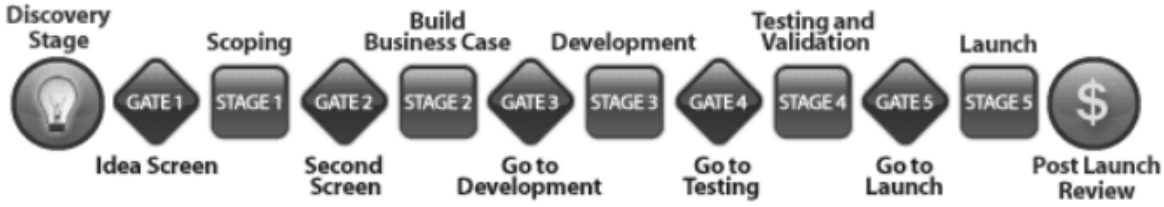
Flexible Approach



Source: Iansiti and MacCormack (1997)

One of the most popular flexible approaches was created by Cooper (2009), named Stage-Gate. This system is cross-functional and has parallel activities which must be completed and reviewed by management. These reviews are called gates and they are essential to control the process and provide checkpoints to know whether or not to continue with the project. Cooper believes that activities in each stage can be undertaken concurrently, not sequentially, making the process more efficient by gaining valuable time in the development cycle (Kumar and Wellbrock, 2009) .

FIGURE 3 – THE MOST CURRENT STAGE-GATE MODEL



Source: Cooper (2012)[1]

Griffin (1997) reported that 60% of US firms use this model for new product development, while 38,5% had no formal process. In addition, it is important to refer that exist some researchers such as Reinersten (1997) who disagree with the efficiency and functionality of this model.

2.1.3 CROSS-FUNCTIONAL TEAMS AND SIMULATION TOOLS

Other studies have identified people-related factors such as team communication, team composition, and senior management support as affecting NPD performance such as lead time and cost (Brown and Eisenhardt, 1995). In fact, there is a special consideration for the way that innovation-related activities, as new product development, influence the use of cross-functional teams for a superior NPD performance (Cooper, 2011, 2012).

Finally, a fourth set of performance drivers is represented by advanced virtualization and simulations tools. In a product development context, these technologies enable testing and support manufacturing processes to project management, workflow, data management and communication (Fixson and Marion, 2012). This research will focus further on in a specific virtual tool in CAD named 3D design.

[1] Stage-Gate is a registered trademark of the Product Development Institute Inc (www.prod-dev.com), and the term was coined by Robert G. Cooper.

2.2 DESIGN IN CLOTHING INDUSTRY

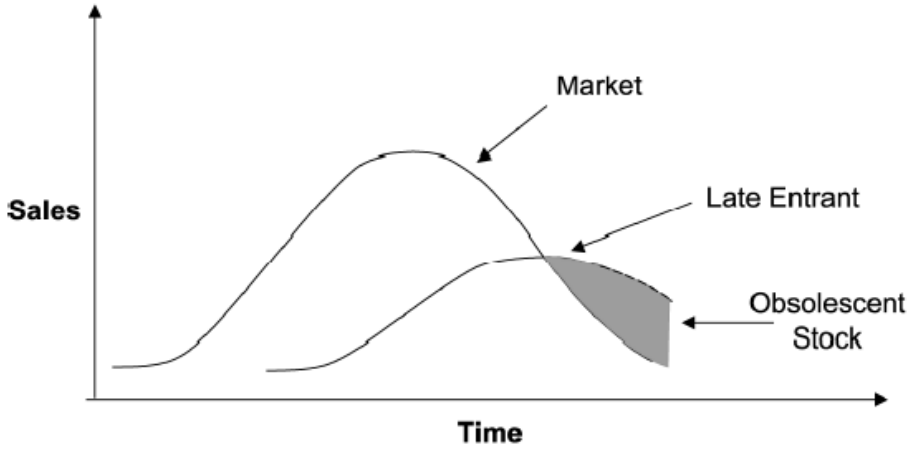
Abecassis, Caby and Jaeger (2000) agree that a significant rise of mass production and systems, and an uninterrupted introduction of technological and managerial innovations increase the levels of competition, especially in fast-paced industries. As a consequence, these new emergences are affecting the clothing industry, creating diverse opportunities and challenges. In clothing, a new product results of either a new design or changes to an existing pattern (Abecassis et al, 2000), meaning that the starting point begins with patterns. Before reaching the final pattern, samples are worked on and developed until the desirable result is achieved.

As a result of high competition, the number of collections offered each year has increased from two collections per year to more than a dozen in the most fashion-conscious companies (Abecassis-Moedas, 2006). Each of those collections has a number of lines of clothing clearly differentiated by styling, fabric and/or other factor (Senanayake and Little, 2001) pushing then for a more demanding market with higher capacity and more flexibility. Therefore, lead times have also shortened in order to have enough flexibility to attend consumer expectations. According to Stylio, Han and Wan (1994), this cycle is achievable between one to three months for fashion garments and three to four weeks for basic garments.

In these short life-cycle markets, being able to spot trends quickly and to translate them into products in the shop in the shortest possible time has become a pre-requisite for success (Christopher, Lowson and Peck, 2004). Companies that are slow to market can suffer in two ways. First, they miss a significant sales opportunity that probably will not be repeated. Second, the supplier is likely to find out that when the product finally arrives in the market place, demand is starting to fall away leading to the likelihood of mark-downs (Christopher et al, 2004).

Figure 4 illustrates the double jeopardy confronting those organizations that are slow to market. New thinking in manufacturing strategy which has focused on flexibility and batch size reduction has clearly helped organizations reduce time-to-market (Christopher et al, 2004). New approaches and new technologies have significantly increased productivity and effectiveness (Senanayake and Little, 2001) revolutionizing the ability to make product changes as the season or the life cycle progress.

FIGURE 4 – SHORTER LIFE-CYCLES MAKING TIMING CRUCIAL



Source: Christopher et al (2004)

COMPUTER AIDED DESIGN

Substantial improvements in affordability and usability of modern Computer-Aided Design (CAD) tools have led to their widespread use in new product development for the last 20 years (Fixson and Marion, 2012). This predominant change revolutionized new product development in terms of efficiency and the promise is saving time and cost before any product launch (Fixson and Marion, 2012). According to Abecassis-Moedas (2006), CAD allows:

1. *a stylist to create a design directly on-screen; to store, retrieve and modify images, patterns, color, fabrics and shapes at will: to consult databases; and to display the completed design.*

2. *design models to be taken from past collections and updated to bring them into line with current tastes.*

CAD tools have internalized a large part of the technical skill needed, being one of the most popular tools in the process of designing new products. The use of this tool contributes to the flexibility needed to attend the latest fashion trends and sales feedback (Abecassis-Moedas, 2006).

2.3 INTRODUCING 3D DESIGN

Previous researchers had already shown the benefit of Computer Aided Design on the NPD process measured in terms of product quality, speed to market and development cost (Clark and Fujimoto, 1991; Kessler and Chakrabarti, 1996; Henard and Szymanski, 2000; McNally et al, 2011). So, in a more detailed perspective, this research aims to understand how 3D design impacts new product development regarding those previous terms inserted in the clothing industry.

Pressure in the clothing industry to produce more collections under shorter lead times has led to the emergence of 3D technology, a *computer technology to assist the design of a garment product* (Liu, Zhang and Yuen, 2010). One of the major challenges in the industry is to ensure that the fit of a garment is as close as possible to its target customer. And, in most cases, *this implies providing a sample, which means patterns need to be made, fabric cut, pieces sewn together and products then shipped to the client for a fit session* (Clarke and Wilhelm, 2011).

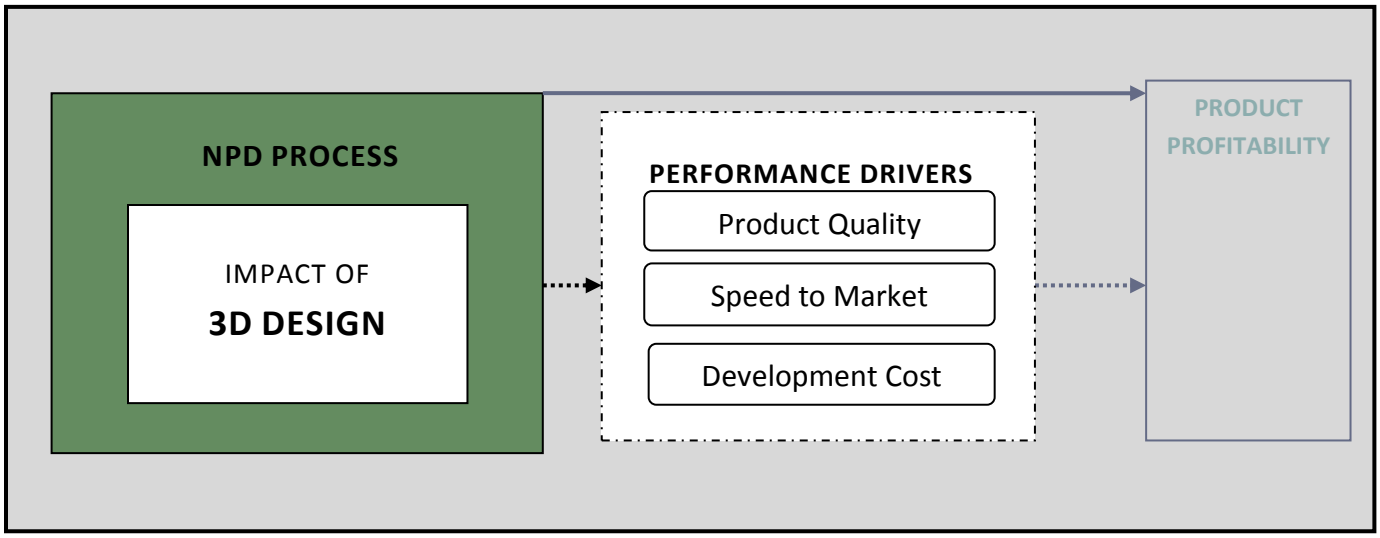
The promise of this design tool is the speeding up of development activities by shifting physical prototypes test to a virtual reality and by increasing the rate (and lowering the unit cost) of individual iteration (Thomke and Fujimoto, 2000). Thus, new product development effectiveness is translated in *faster and less costly problem-solving via simulation that can open new possibilities for learning and design innovation* (Thomke & Fujimoto, 2000). Becker and Zirpoli (2005) explain that virtual technologies carry the potential for the exploration of broader solution spaces, and as a result for producing more, newer and better solutions. Extending this line of argument, some studies go further and suggest that the virtual development not only results in NPD solutions but also enables new forms of knowledge creation (Fixson and Marion, 2012).

Furthermore, by definition, product development is a very accurate process and 3D design assumes a level of precision that in the early-stages is not available. This CAD tool met this accuracy by exploring processes that can create a better initial framing of the problem, which afterward require fewer prototypes and as a consequence remove a number of options from the solution space (Fixson and Marion, 2012).

Thus, companies can do their production using 3D design without a physical prototype, or fewer prototypes and therefore the cost of rejecting a style (in terms of material, labor, and time) is

significantly lowered and consequently the risk of the development process is also lowered (Clarke and Wilhelm, 2011).

FIGURE 5 – MODEL OF THE RESEARCH



Source: Author (adapted from the Conceptual Mediation Model - Mc Nally, Akdeniz and Calantone (2010)).

The general model to be tested here is schematically represented in Figure 5. It is the intention of this research to empirically examine the effectiveness of 3D design in the NPD process. This is to be interpreted as the technology itself in the clothing industry and how it influences NPD through performance drivers to reach successful product profitability. This research will be only specialized on NPD process and performance drivers, not reaching then, the last stage of the model which is product profitability.

This model also proposes that the implementation of the 3D design tool boost NPD performance, otherwise there would be no justification for its adoption. Therefore, the strong enabling effect associated with 3D design results in the following research question:

Has 3D design improved the way in which new product development perform in terms of quality of the final product, speed to market and cost development?

3. METHODOLOGY

The current work aims to study the impact of 3D design on the new product development process of a manufacturing company. Certainly, in order to provide insights on how this technology can have impact on this process and can be an advantage for future challenges, it is imperative that the steps that need to be taken to guarantee that the terms affecting new product development are also analyzed.

With the purpose of understanding the impact of this virtual technology on NPD performance, this dissertation is thought in line with the improvement on NPD process according to final product quality, speed to market and development cost in an international context.

Although the clothing industry is very important for the worldwide economy, there are not even a dozen of companies worldwide that integrate 3D technology in their structure. However, there is a Portuguese company that is part of this strict group and is a worldwide best practice example, namely Cordeiro Campos. The analysis of this company was carried out through the usage of exploratory case study as the data source for information.

3.1 EXPLORATORY CASE STUDY

New Product Development has been a heavily studied topic, and the majority of the research written highlights the importance of *product quality*, *development cost* and *development time* in the evaluation of the performance. Moreover, internal factors, such *as product, process, people* and *tools* are also connected with the NPD process and have an impact on the process. Consequently, it is crucial to first understand and structure all those variables that in the first phase were gathered from several academic journals, internet articles and Lectra's annual report. In contrast, we also find out that 3D design, the technology in cause, was not deeply studied, as there are not many companies implementing virtual fitting in their processes. Therefore, it is also fundamental to understand in detail all the drivers from 3D design that improved NPD performance by analyzing a real case.

Consequently, a number of interviews were conducted with people who occupy key positions at Lectra, the 3D solution provider, and the Cordeiro Campos Company, with the intention of understanding 3D technology and all the dimensions impacting NPD process in the clothing industry. In total three face-to-face interviews were conducted to six people during a one month period and had an average length of one-hour each. The first interview was conducted with two people from Lectra Portugal team, in which the main goal was to understand better this virtual fitting solution. Afterward, two interviews were done in Cordeiro Campos site. The first interview was done with three Executive Managers and the second one was done with one person from the operational team (further details on this process can be found in appendix). It is possible to label the interviews as semi-structured, since guides were developed to conduct them. However, all the answers were open, except for the evaluation of time performance rated by Célia Rodrigues, Modeler and 3D Manager (operational team).

The data collected allowed us to understand both sides of the 3D design, possible advantages and improvements and define what should the key aspects developed in this study be. In addition, the data gathered allowed us to connect the theory with the reality of a today's world company in 3D design.

3.2 CORDEIRO CAMPOS, A LUXURY CASE

Established in 1982 and based in Barcelos, Cordeiro Campos is a family owned company that has gone throughout the years through several changes due not only to the economic environment but also as a way to continuously support their client base while attracting new ones.

Since the very first beginning, the main goal of Cordeiro Campos was to follow a quality strategy. Although at the start the Portuguese firm did not have that clear direction, in 1996 a crisis turned the external outlook favorable for some small companies and led to a breakthrough for quality focuses. It took a while to establish itself on the market as a high quality reference, but in 2000 Cordeiro Campos strengthened its strategy and evolved into the production of small quantity products, working exclusively for the luxury market.

So far, Cordeiro Campos has proven to be strong when it comes to overcoming the economic crisis, enjoying all the advantages related to it and growing and becoming more solid. Nowadays, Cordeiro Campos is a strong and reliable partner of big luxury brands and wishes to reinforce its strategy by doubling its facilities with the main goal of serving its clients better.

Currently, the company works in a subcontractor regime and it is specialized in knit clothing for men, women and children. Since the firm is intended for the international market, around 99,9% of the total revenue comes from the outside of Portugal. The clothing produced is essentially exported to Europe (more than 70%) and Hong Kong, though it is also exported in an indirected way to the USA and Japan (the direct client is European).

In addition, Cordeiro Campos is also an innovation-driven company: its managers do not look at costs when it comes to innovation. The firm is always on the alert for new technologies and ready to present new options to its clients. Being a step ahead of its time is an essential need in order to follow the pace of the modern industry. Therefore, the firm is always investing in newest technologies namely in such solution as Computer-aided Manufacturing (CAM) and Computer-aided Design (CAD). The substantial investments that have been made, associated with a careful financial and management plan have been recognized with yearly consecutive certificates for PME Líder (Small and Medium-size companies) achieved from 2007 to 2010. Moreover, in 2011, the company was awarded with the PME Excellency certificate, which is a distinction within the PME for best performance and risk profile (Cordeiro Campos, 2013, *www.cordeirocampos.pt*).

4. DATA ANALYSIS

4.1 NEW PRODUCT DEVELOPMENT PERFORMANCE

PRODUCT

Since Cordeiro Campos is a subcontractor company, the firm is tailored by orders of its clients, meaning that the development is done by request. Therefore, when these orders arrive to the subcontractor, they were already designed by stylists and thought in terms of development portfolios. The integration of products architecture is determined externally which can lead to a not optimal result and consequently higher costs. However, although the company can´t change the distribution of projects in development portfolios assigned, its designers can always do some suggestions to enhance the final product.

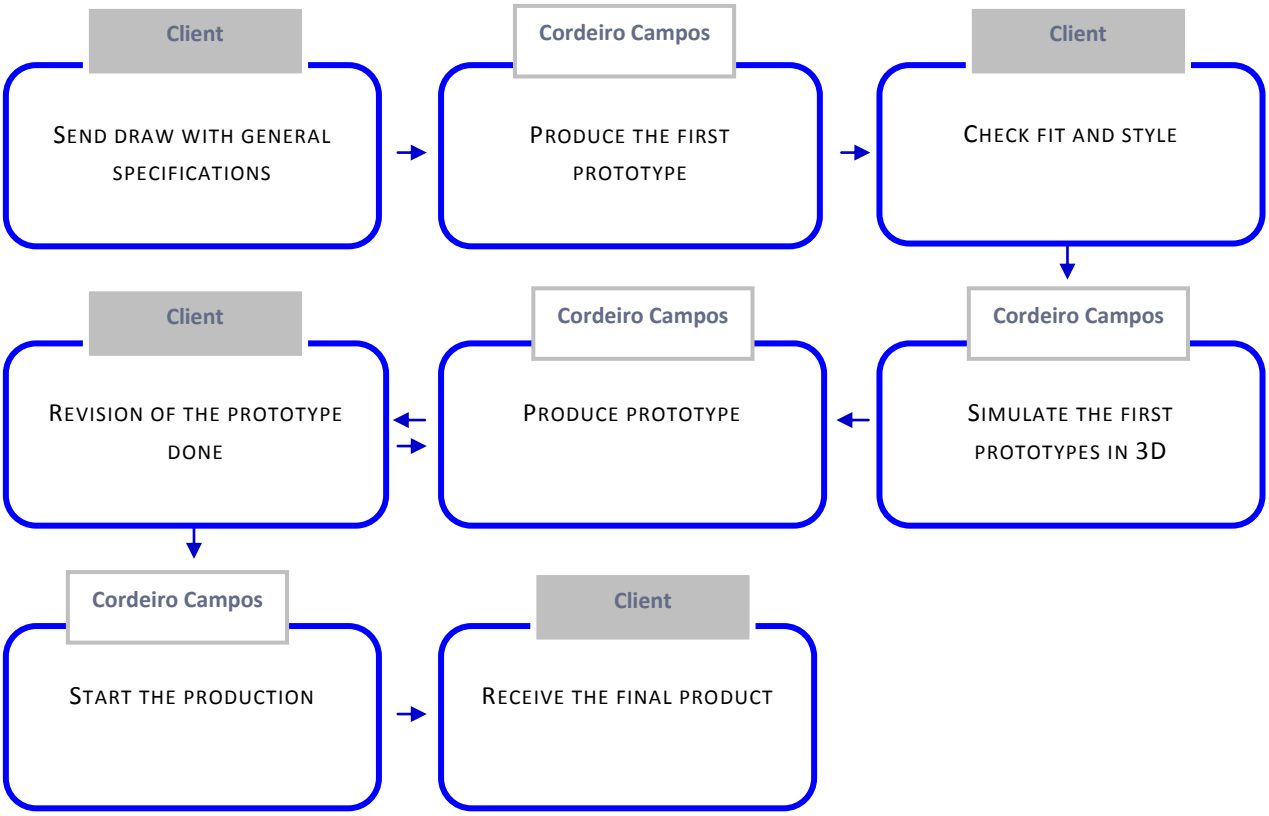
PROCESS

Cordeiro Campos does not have a clear structured new product development process, just some directions, which allows its managers to run it in a very flexible manner, enabling delay until as late as possible any commitment and therefore decreasing cost and time spent.

The flow of information starts with a drawing that comes with gender and measures specifications. Then, the development of the first prototype is produced, sent to the client in order to have his or her feedback on styling and fitting terms. With the help of 3D design, this feedback is taken into account and the prototype is adjusted according to it. Consequently, the piece of garment is simulated, avoiding the creation of prototypes to achieve accurately what is demanded. Since prototyping is one of the most expensive and time-consuming phases of product development, there is an improvement in terms of cost performance and time spent with the help of 3D design. After those adjustments a prototype is created and is sent to the client to get his or her approval. At this point, this process is repeated until what is intended is achieved. Afterwards, the production of the product is finally started. The duration of this process fluctuates according to the complexity of clothing/collections and can go from one week to three months (Interview with

Managers, 2013). The value chain established between Cordeiro Campos and clients can be translated into the following figure.

FIGURE 6 - VALUE CHAIN BETWEEN CORDEIRO CAMPOS AND ITS CLIENTS



Source: Author

Furthermore, Cordeiro Campos subcontracts other specialist firms to help them with activities out of their focus, as for instance stamping. As it is required to Cordeiro Campos, the company asks its partners flexibility and availability to work under short timing.

For Mr. José Augusto Santos, the Shareholder and the Manager at Cordeiro Campos, the flexibility of the company is very important and a good example of it is, for instance, the preparation of a fashion show, since working with the luxury market implies always a runway show. This runway

show usually starts with the client's request of the pieces needed for the show around one month earlier. The company knows the general specifications of the request: quantity and complexity. However, one month is already a tight timing because production also depends on external partners such as stamping firms and the company is aware that in the last week there can eventually be last minute requests. For instance, Mr. José Santos explained in the interview that it has already happened once when a courier came by plain to deliver fabric and waited for the complete production because the product was needed for a runway show on the same day in France. In that sense, the industry is extraordinary demanding and those types of clients request maximum attention and adaptability, essentially based on a trust relationship. Managers of Cordeiro Campos are successfully working for meeting those demands and Mr. José Santos knows that this effort is recognized and appreciated:

> *Until now, everything is going really well and we have received flowers as an appreciation for our effort.*
>
> (Interview with José Augusto Santos, Shareholder and Manager, 2013)

In addition, Cordeiro Campos has also created a private label, but at this moment it is stationary due to the huge investment required and the unfavorable market conditions. In fact, the company managers don't see any benefit of changing their current situation at the moment:

> *I don't see any interest in changing this situation; we do not want to fight the big wolves.*
>
> (Interview with José Augusto Santos, Shareholder and Manager, 2013)

PEOPLE

Cordeiro Campos is a SME, being each person an important asset to the firm. Managing 3D design involves capacity to make late changes, to postpone design decisions and needs capacity to be very focused, accurate and detail-driven. As a consequence, effectiveness of this virtual tool for problem-solving processes is very dependent on individual capabilities of its Managers.

TOOLS - UNDERSTANDING CORDEIRO CAMPOS'S PERFORMANCE

To explore potential effects increased by 3D design usage on new product development performance, we do our research by looking at set of mechanisms, focusing our analysis on performance measures such as product quality, speed to market and development time in Cordeiro Campos' context.

A. QUALITY OF THE PRODUCT. Being a quality focused company and already working for the luxury market demands very strict standards in order to ensure not just a good quality but a sublime one. Consequently, all the resources used should obey to high standards required by the clients and can differ from market to market and from client to client. Moreover, all the entities involved are obligated to respect those standards. In order to fulfill those requirements Cordeiro Campos has to run in parallel internal and external tests. During the whole development process, from the reception of the fabric to the final product, the products are inspected by internal quality controllers. Complementing it, in the final phase, the final product is also monitored by an external agent. Therefore, the final product outcomes as a fine and superior product, being it difficult to replicate due to the implicit high cost and complexity of the process. This high regulation allows the firm to show the client its high commitment, value and get the desirable reliability vital in the luxury market.

B. SPEED TO MARKET. The main challenge of the industry is to fulfill the required deadlines. Previously, the clothing industry had two main timings for production, winter and summer, but nowadays brands changed their strategy and have for instance six different periods of production. Therefore, Laurinda Campos explained that the company has to be flexible and responsive:

> *We must be responsive. If before we had 3-4 months to do the production, now we have just 1 month.*
>
> (Laurinda Campos, Quality Manager, 2013)

C. DEVELOPMENT COST. As it was previously defined, development cost in this study will only be referred to as a prototyping cost. As seen, since the organizational structure is intended for the luxury market, a very demanding industry, the products have very high development costs.

4.2 LEADING 3D DESIGN TO A SUCCESSFUL NEW PRODUCT DEVELOPMENT

LECTRA, A CHANGE MAKER IN FASHION

3D technology is a solution for Lectra, *the world leader in integrated technology solutions—software, CAD/CAM equipment, and associated services—specifically designed for industries using fabrics, leather, technical textiles, and composite materials to manufacture their products* (Lectra, 2013, *Annual Report 2012,* p3). As a pioneer of 3D design applied to the clothing industry, Lectra has developed innovative technology with the latest version of Modaris, its flagship pattern-making, grading and prototyping software solution. It enables the following (Lectra, 2013, *Annual Report 2012,* p22):

1. *pattern makers to draft a flat pattern of a garment;*
2. *visualize the style directly on a 3D model;*
3. *work interactively between the 2D and 3D formats.*

As a result of over ten years' investment in R&D, Lectra believes that 3D design solution enhances the value of pattern makers' expertise and cuts style development time in **half**, while simultaneously optimizing costs and respecting designers' vision (Lectra, 2013, *Annual Report 2012,* p22). In addition, by providing a common visual language for everyone involved – from design pattern-making to marketing to suppliers – this solution builds bridges between departments and offers a new way of working that is faster, reducing time to market (*Lectra brings the 3D revolution to the Fashion Industry*, Lectra Brochures, www.lectra.com). Paulo Ribeiro, the Service Manager at Lectra Portugal, additionally explains that 3D design is in fact a powerful weapon that enhances communication that could involve everyone in the value chain. If this technology could be shared between a supplier and a client, they both could collaborate in real

time to determine the final product, postponing the creation of prototypes and then saving more time and avoiding additional costs. Clearly, this would be an ideal situation, but at this moment this will only happen if the external agents of the value chain also own a license for the tool.

CORDEIRO CAMPOS, AN INNOVATION-DRIVEN COMPANY

When Cordeiro Campos's managers first heard about 3D design technology, they were incredulous about its potential. The benefits of this tool eventually seduced Cordeiro Campos and since they were already Lectra's client, they decided to try it and see by themselves what in fact 3D design could do.

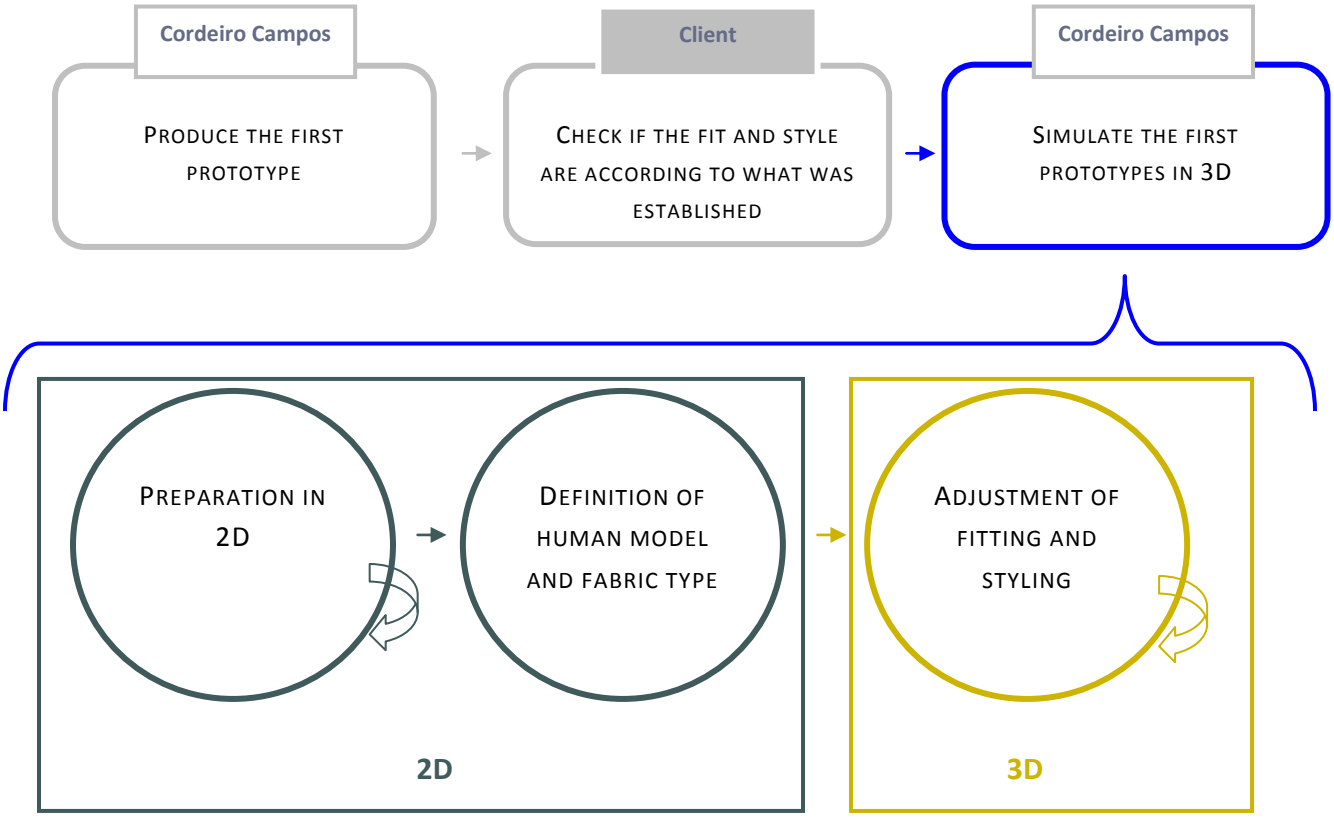
So, in 2010, the Portuguese Company integrated 3D technology in its process. Ms. Laurinda Campos explains how well those virtual simulations integrate into the company. In fact, the company has just trained a person to manage 3D due to its complexity and until now the feedback has been very positive.

> *3D fitted really well the structure of the enterprise; we didn't have to change our way of working. We are managing to explore all the potentialities.*
>
> (Interview with Laurinda Campos, Quality Manager, 2013)

In general, the production process is very complex and meticulous, as shown in Figure 7. Ms. Célia Rodrigues, the Modeler and the 3D Manager, described the main phases. The initial phase of the production process is based on 2D, where all the simulations regarding connection points are determinate as they should be on a real garment. So, the seam is simulated, as also the positioning of the connections points with the body. This phase is very meticulous and any error can lead to the repetition of the process. Then, there are already several human models defined in the database and the desired one is chosen. Afterwards, the type of fabric is selected according to its composition and weight. Finally, the next step is simulating this model in the virtual fitting room. This phase can take time and the more complex the garment is, the more time the software takes to do this transformation. At last, the model is adjusted in order to have a better fitting to reach a

simulation as close as possible to the desired one (Interview with Célia Rodrigues, Modeler and 3D Manager, 2013).

FIGURE 7 – NEW PRODUCT DEVELOPMENT PROCESS ON 3D DESIGN



Source: Author

The modern 3D technology allows design iterations, and consequently encourages a more fluid NPD process. This tool influences an increasing on flexibility essentially through two features. First, this new virtual tool can easily prioritize design decisions, allowing postponing some of them. Second, it is possible to run several designs in parallel during the development process and therefore more iterations are created during tooling and production ramp-up. The preparation in 2D and the adjustment of fitting and styling already in 3D are the phases that account for more iterations, as the process can be repeated several times until a winning solution is achieved.

4.3 3D DESIGN, A SIMULATION OF A NEW PARADIGM

3D technology shifts simulations from the physical world to the virtual one by assisting clothing design. Then, the main challenge is to move the new product development process to an efficient and profitable process. How important is the contribution of 3D in this process? Does it enhance performance?

The key for finding the effects lying in the NPD performance are linked to how is affected by 3D design, as discussed previously.

A. QUALITY OF THE PRODUCT. Working for the luxury market already demands a huge focus on having top products, as it is the Cordeiro Campos case. Therefore, when the standards are already extraordinary, improving them is extremely difficult. As a result, in this particular case, the technology alone has been shown to not influence performance in terms of the final product quality. However these findings are strong results for the luxury market, we did not have the chance to interview customers of Cordeiro Campos, which could have helped to support this conclusion. Furthermore, this finding is focused on a very specific segment and on a top-performer one. Eventually, in another type of segment, as for instance in the mass market, the result could be different and would need further analysis.

B. SPEED TO MARKET. Virtual design technology was several times referred to as an acceleration tool of new product development activities. This premise results positively on one of the main challenges of the industry: time. As a result, speed to market is reduced to two different forms:

i. LESS PROTOTYPES REQUIRED

If the number of prototypes required is reduced, naturally the new product development process will be shorter and therefore, the lead time is going to decrease. We can conclude that in the phase where 3D is managed, there is a speed-up of 2

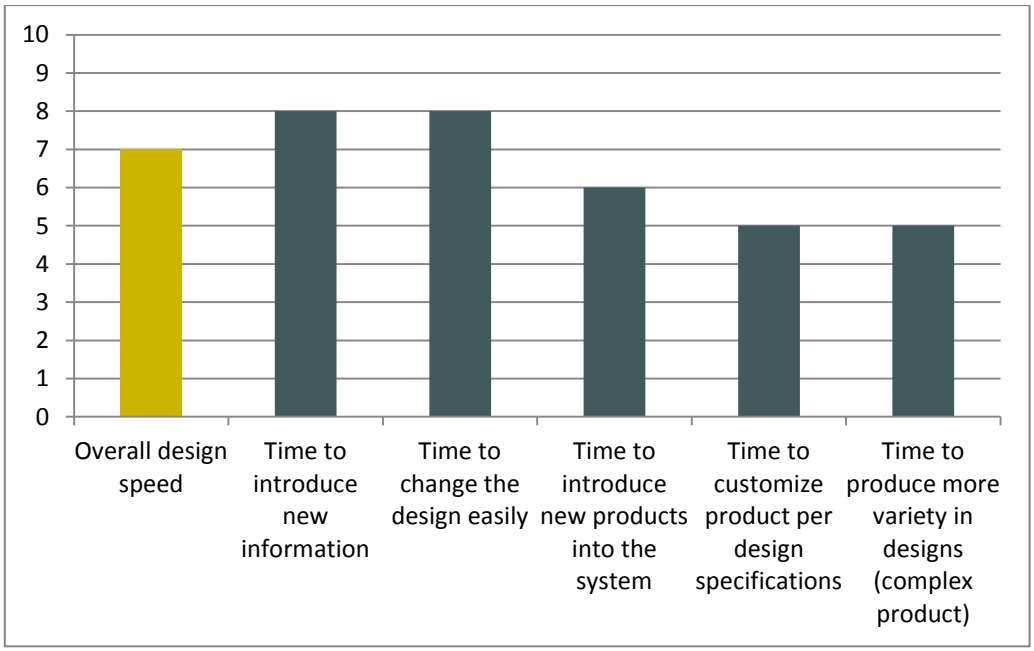
prototypes, because as Ms. Laurinda Campos explains there is an evolution from 3 prototypes to just 1.

> *It is difficult to quantify the number of prototypes, but we can say that if previously we needed to create 3 initial prototypes, now we just need to produce 1*.
>
> (Interview with Laurinda Campos, Quality Manager, 2013)

ii. BETTER PERFORMANCE ON FITTING AND STYLING

For the measurement of the virtual design tool performance in time terms, Ms. Célia Rodrigues, the Modeler and the 3D Manager, rated the following outcome discussed on a daily basis (further details on this process can be found in appendix). The results on Figure 8 were measured by using a scale from 1 = very poor to 10 = excellent.

FIGURE 8 – RESULTS OF SURVEY TO CORDEIRO CAMPOS ON IMPACT OF 3D DESIGN ON TIME PRODUCT DEVELOPMENT



Source: Author

Results show that there is a positive relation between the technology attributes and time performance. Yet, we can conclude from Figure 8 that a more complex product needs more time to be developed than a simpler one (time to customize products and to produce more variety in designs are evaluated with only 5 out of 10). In fact, a basic product has a fast development and sometimes can happen that the process is so simple and so integrated in the structure of the firm that there is no need to work the design in 3D (Interview with Célia Rodrigues, Modeler and 3D Manager, 2013). For complex products, details demand a more meticulous process and consequently this process is slower when comparing to basic products. The principal reasons for those premises are: (1) more details are needed in the system and consequently more variety is introduced into the system and needs to be customized (2) as a consequence, the software gets heavier and therefore the system becomes slower. In contrast, this software has a high learning curve and as time goes, the better can be the performance of the tool, being extremely useful for complex products where the time spent for their development is very high.

On other hand, when small adjustments and information are added into the system, the technology clearly enhances performance, having extraordinary time saving results (time to introduce new information and time to change the design easily are rated with 8 out of 10). The ability to quickly review and change virtually NPD enables a less rigid process structure. In fact, it becomes immediately clear that during the development phase the number of design iterations is larger with the use of the virtual technology.

C. DEVELOPMENT COST. As determined before, for the computation of the development cost we only considered prototyping. As expected, the primary cost saving of 3D design comes from shifting the physical work in a virtual work via 3D design, leading to fewer resources consumption. Therefore, it is clear that the prototypes number has substantially reduced:

> *We can say that our development cost reduction can be 3 for 1 in an initial development phase.*
>
> (Interview with Laurinda Campos, Quality Manager, 2013)

Nonetheless, according to the Cordeiro Campos's managers, the reduction of estimated prototypes with the use of 3D design is around **15%** (Interview with Managers, 2013). This design tool clearly allows considerable savings in prototyping costs not only through the replacement of physical prototypes, but also by an early problem solving in the NPD process which can reduce or even eliminate expensive problems.

Overall, Ms. Laurinda Campos claims that the most important advantage of 3D design is reducing time to market (Interview with Laurinda Campos, Quality Manager, 2013). This virtual technology enables time saving by moving test and experiments upstream to the digital design where the tests and experiments can be conducted at a faster pace. The second most important attribute for this firm is the reduction of resources and prototypes created, meaning less cost development. At last, in this particular case, improvements on product quality are not that relevant because, as seen, since products developed do not benefit from 3D design.

5. DISCUSSION

This research aims to understand the performance of the new product development process when employing 3D design. This performance is evaluated in terms predefined by the Literature Review and those are translated in product quality, speed to market and development cost.

The shifting of of digital tools such as 3D design to earlier in the new product development process has been prevalent. This migration has followed the conceptual lead of Thomke and Fujimoto (2000), who proposed that a NPD process with more and faster iteration activities is likely to improve its process on efficient terms. Our data show that 3D design tool has radically revolutionized the conceptual process of NPD. While we observe the increase in the number of virtually created prototypes and the lowering of associated physical prototype costs as anticipated by Thomke and Fujimoto (2000), in our study we also find that this shifting also influences other features on the NPD performance.

However, the review of the data extracted from the interviews also reveals that the effects of classical elements on NPD performance have not the same effect as predicted by the Literature Review. Each of these finding is discusses in more detail next in order to finally answer to how 3D design impacts on the product development process.

This specific case is far too small to produce representative results in any statistical sense, but we argue that the observed effects and linkages between 3D design use and NPD performance allow a discussion of potentially broader implications.

A. 3D DESIGN DOES NOT HAVE AN IMPACT ON THE QUALITY OF THE FINAL PRODUCT.

Thomke and Fujimoto (2000) explain that the output of a process is a product, and its complexity and the extent to which it conforms to customer expectations drive product quality. Despite the role of product quality (Clark and Fujimoto, 1991; Henard and Symanski, 2001), the results indicate that product quality is not impacting on NPD when 3D design is employed. While this result can be surprising for us, managers of Cordeiro Campos were already expecting this outcome since they understand the implications of working in the luxury segment. In other words, since product

quality can be a reflection of the price that customers are willing to pay and the price in the luxury market is already established as a top-performer one, it is extremely difficult to have an impact on the final quality of luxury brands products. Following the qualifications defined by Henard and Szymanski (2001), we can measure a product in a luxury market case in the next terms:

a. High superiority and differentiation over competition
b. Product satisfies desires and needs of customers
c. Top price-performance perception
d. High technological perception
e. Unique products

The types of products in this industry are established as superior in all the attributes and therefore we argue that 3D design does not have an impact on the NPD performance. Although this research has reached the previously stated conclusion, others analysis in others industries and segments can generate different conclusions. Ultimately, our study is inconclusive regarding the relation of quality with time and expense for the global industry.

B. THE USE OF 3D DESIGN IMPACTS NPD PERFORMANCE IN TERMS OF SPEED TO MARKET AND DEVELOPMENT COST.

The role that 3D design plays in lead time and expense in NPD process is according to what is suggested in the Literature Review. In other words, as studied by Thomke and Fujimoto (2000) 3D design helps to reduce time to market and met less development expenses. However, for each of those dimensions, the impact occurs in different ways.

The effect of the impact of time development is very large and it is mediated by reducing the number of prototypes, as predicted by Fixson and Marion (2012). Although in this particular case 3D design only acts in the early phases of development (there is the potential to broaden the use of 3D in more phases in NPD process if communication is increased within the supply chain), there is a speed up of 2 prototypes. Moreover, as claimed by Thomke and Fujimoto (2000) there is a better performance on the overall NPD process. While, the virtual technology enhances

development time in NPD process, this improvement varies according to the complexity of the product, as seen in Figure 7.

Regarding development costs, the employment of 3D design implies a reduction of this expense as studied by Thomke and Fujimoto (2000) and Fixson and Marion (2012). However, the saving on prototypes is only around 15%, a value that is lower than initially expected by Clarke and Wilhelm (2011). This difference can be an evidence of the partial use of 3D design in the NPD process, essentially because contractors do not have access in real time to the work developed during the 3D process and consequently more resources are spent.

C.3D DESIGN IMPACTS MORE SPEED TO MARKET THAN DEVELOPMENT COST

Clearly, speed to market and development cost are highly correlated, having a positive relationship, as conclude by Clark and Fujimoto (1991). More specifically, if a firm increases speed to market by reducing the creation of physical prototypes, in parallel, it also reduces its expense, since more resources are spared.

Thus, the literature suggests that a firm should focus on increasing speed to market prior to the investment in other dimensions (McNally et al, 2011). In fact, our research outcomes that 3D technology enhances time development prior to development expenses (as seen for product quality results are inconclusive). Although time considerations have a larger impact than development cost, there is always a positive correlation between those two dimensions resulting in a winning equation**: reducing speed to market is reducing development cost**.

6. CONCLUSION

As most of the executive leading successful firms would agree, new product development is much more than a phase during which the design and development of a product is determined. In fact, NPD can be compared to planting a fruit tree. First, it is important to select the time of year and a suitable tree for the region and climate, which means that meeting the perfect timing is crucial, otherwise the product can be obsolete. The next step is digging a hole and preparing the tree for planting which in other words means framing the right tools such as CAD and CAM in the right place in order to develop cost-conscious and efficient products. The third step is to use some compost or composted manure and at the same time resist the temptation to use a commercial fertilizer, which can be translated in always assuring quality criteria, regardless any temptation that may occur. The fourth step is to water the newly planted tree to eliminate air pockets which is the result of never stopping investment in R&D in order to keep the pace of the market. Finally, after a period when the tree is already grown, we can enjoy all the fruit from the tree grows. In fact, an effective NPD is not only a reward for higher work standards, but also for a whole tracery of strategies, tactics, resources, capabilities and cultures that were carefully put together into a formalized process which allows a better exploitation of the market. This description might not be obvious, but it is meant to illustrate how complex a NPD plan should be in order to achieve its objectives.

Cordeiro Campos has its mission studied which is to study how the 3D design solution should be used to improve the NPD process. As seen, 3D design applied to the clothing industry is a powerful enabler of answering to the main challenges in the industry. This roadmap was then understood by Cordeiro Campos and so the firm is exploiting the first beneficial element: meeting time pressure and increasing speed to market by diminishing the number of created prototypes and by improving its performance on the NPD process. The second benefit comes in a form of reducing the development of operational expenses at around 15% through the reduction of prototypes. Lastly, product quality does not benefit from the technology alone because it has already a huge influence from the luxury market structure.

Our study results are subject to limitations similar to all studies built on a small number of cases. That said, we can see three directions to extend this research. First, it will be useful to test our findings with a larger number of cases, perhaps including projects with various levels of complexity. Second, to extend the present study to the complete model of the research, that is study the product profitability, as McNally et al (2011) proposed. Lastly, it would be interesting to conduct interviews with clients of Cordeiro Campos (or to a similar company) and, in parallel, to extend the research on subcontractors in other types of markets in order to have a stronger support on the product quality finding.

To conclude, the application of 3D is appearing in several industries beyond clothing, such as medicine, construction and automobile and emerging in different forms as 3D design and 3D printing, among others. However, the promises of all the types of 3D converge for rapid prototyping capabilities with the high-volume throughput of conventional manufacturing. Proponents believe that these processes may soon lead to the tooless production of finished goods and the mass production of individually customized parts (Back, 2003).

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8. APPENDIX

8. 1 MANAGERS INTERVIEWED

1. José Augusto Santos
Shareholder and Manager
Cordeiro Campos

2. Mário Campos
Shareholder and Sales Manager
Cordeiro Campos

3. Laurinda Campos
Quality Manager
Cordeiro Campos

4. Célia Rodrigues
Modeler and 3D Manager
Cordeiro Campos

5. Susana Costa
Marketing Manager
Lectra Portugal

6. Paulo Ribeiro
Service Manager
Lectra Portugal

The interviews were conducted on November of 2013. They were performed face-to-face.

8.2 INTERVIEW GUIDE

INTERVIEW GUIDE
CORDEIRO CAMPOS

This guide will be the primary source of the dissertation about 3D design impacting NPD in Cordeiro Campos, being the interviews done at the company site. The main goal is to understand the influence of 3D design on the new product development process in terms of quality, development time and cost. It will be divided in 3 different sections, each one directed to different departments:
(1) Manager (2) Sales & Marketing (3) Operations

1. Managers

1. Could you please describe the background of the company?
2. Who are your clients?
3. On average, how many clients do you have and in which countries they are?
4. What is/are the main challenge in the industry?
5. What type of strategy are you following? Differentiation, low cost or focus?
6. How is the distribution of projects in your development portfolios? (new-to-the-world; new product lines; addition to product lines; product improvements & modifications)
7. Do you have any mechanism to respond to new information?
8. What are the main concerns before launching a product?
9. Are there different procedures in NPD according clients and markets?
10. What are the stages of the NPD in your company? How long is each stage?
11. How much time each stage of NPD takes? What is the average cycle of development?
12. What are the main issues when developing a product?
13. Do you feel pressure to innovate?
14. When and why did you decided to implement 3D?
15. What are the main differences between 2D and 3D process?
16. How 3D changed the internal process?
17. The communication between departments had increased?
18. How the employees accepted this tool? Did you need to hire new people to manage it?
19. Do you work combining flat patterns and 3D simulations?
20. What are the main advantages of this tool?
21. What are the main disadvantages of this tool?
22. How this tool influence the sustainability of the company?
23. Do you think this tool provides you an advantage regarding competitors?
24. Did it achieve your expectations?
25. What factors account the most for the garment's total cost (fabric, labor, production,…)?
26. How did 3D design impact NPD in terms of cost, quality and time?
27. Do you think that pressure for a short lead-time and less cost jeopardize quality?

2. Sales and Marketing

1. What are your main responsibilities?
2. How do you approach customers?
3. What do your clients think about the company?
4. In which way do you work on your brand equity?
5. Do you have information about clients' satisfaction?
6. What are the main issues that you find when you contact a client?
7. Did you have any client's feedback regarding your products after the implementation of 3D design?
8. Did 3D impact the relationship with clients/ influence supply chain?
9. Do your clients are aware of your technology usage?
10. Do you feel that your clients consider Cordeiro Campos as an innovative company?
11. How 3D changed the internal process?
12. Do you feel communication between departments have increased with the use of this tool?
13. How did 3D design impact NPD in terms of cost, quality and time?

3. Operations

1. Could you please describe me the phases of 3D Design in your company.
2. What are the main differences between 2D and 3D process?
3. How many prototypes (physical prototypes for exploration and testing purposes) were done on average before the use of this tool? and after?
4. Do you feel that this tool allow you to do new design iterations (substantive changes, including new design and new concepts)?
5. There is more design iterations usage (including late design changes)?
6. Does this tool reduce defectuous products? If yes, in what quantities?
7. What are the main advantages of this tool?
8. What are the main disadvantages of this tool?
9. How did 3D design impact NPD in terms of cost, quality and time?
10. Do you think that pressure for a short lead-time and less cost jeopardize quality?
11. Quantify in terms of development time (1 to 10; 1 - very poor and 10 - excellent)

- time to customize product per design specifications
- time to produce more variety in designs
- time to change the design easily
- overall design speed
- time to introduce new products into production
- speed introduce new information

(Attributes defined according to Malhotra, Heine and Grover (2001))

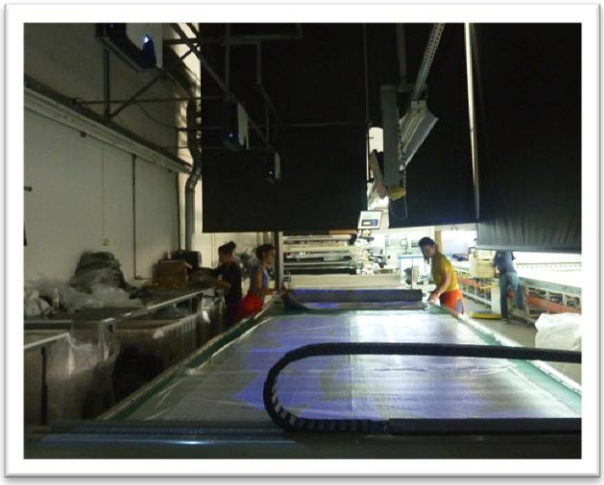
INTERVIEW GUIDE
LECTRA PORTUGAL

The main goal of this interview guide is to understand the perspective of the 3D provider on the influence of 3D design in the new product development process in terms of quality, development time and cost.

1. When did Lectra launch 3D design?
2. What is the feedback of your clients until now?
3. What are the main differences between 2D and 3D process?
4. What are exactly main phases of the tool (human modeling, garment design, draping, 3D to 2D, geometric detail modeling and parallel computation)? Can you please describe each one?
5. What clients value the most?
6. Do you feel it could be improved?
7. How did 3D design impact NPD in terms of cost, quality and time?

8.3 TOUR IN CORDEIRO CAMPOS

MANUFACTURING ROOM



DESIGN ROOM (WITH EMPLOYMENT OF 3D DESIGN)