KOOJ LAB – NATIONAL DIGITAL DESIGN AND TESTING SYSTEM FOR THE INTERNATIONAL PRODUCTION OF FOOTWEAR

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ABSTRACT:

The main objective of this research is to be able to improve and streamline the generation of prototypes, a process that is currently one of the biggest obstacles in the clothing, footwear, and accessories design industry; take advantage of a resource such as 3D design and rapid prototyping technologies, avoid interpretation problems due to language or cultural references of manufacturers or suppliers, reduce costs when sending samples abroad and the carbon footprint in the process, and development time of a new product from 60 to 15 days.

Keywords: Rapid Prototyping; Digital Prototyping; Footwear, 3D Design; Methodology.

INTRODUCTION

Currently, the use of computer-aided design (CAD) and computer-aided manufacturing (CAM) software has been relegated to the primary manufacturing industry in our country; on the contrary, in our footwear industry (secondary), its use is scarce, since obtaining and implementing this software is highly expensive. Although manufacturing is an important activity for this field, it is not carried out by each company, relying on third parties, and the use of 3D technology and rapid prototyping options are almost non-existent activities in this field.

PROBLEMS

Why is Chile's industry not competitive? Basically, the high costs of the country versus those of other latitudes, mainly in Asia, and particularly those of China. Since January 2010, footwear from China enters the country without any barriers and with no import taxes.

But this is not the only competition. According to data from the Chamber of Leather, Footwear, and Allied Industries (Fedeccal) at the last Meetings of Latin American Footwear Chambers, **labor costs per hour of footwear workers in Brazil are US$ 3.1; in China, US$ 3; in Mexico, US$ 3.2 and in Vietnam, US$ 1.8**. **A comparison is made with those of Chile, at US$ 7.**5 (Economía y Negocios, El Mercurio, March 2019)**.** These values include labor costs with social security, vacations, and insurance.

Janne Kyttanen, a pioneer in the 3-D printing industry for 2 decades and one of the first designers to commercialize 3-D printed products, has focused on building new businesses and empowering others to leverage 3-D printing in creative and innovative ways to grow manufacturing industries. The author points out the following:

“The key learning from all of this is that to move the needle with your 3D business initiative, you must start looking at how you can generate new ideas and create products that benefit your own value network. When the collective approach creates more value for both the product and the end user, everybody wins” (Kyttanen, 2019).

Rapid prototyping techniques in the world of product design are growing exponentially along with the development of new tools or the improvement of the existing ones. According to Grand View Research, the global 3D printing market, one of the leading rapid prototyping technologies, was valued at USD 13.78 billion in 2020 and is expected to grow at a compound annual growth rate (CAGR) of 21.0% from 2021 to 2028. Furthermore, Statista projects that this market will reach approximately USD 37.2 billion by 2026. This robust growth reflects the increasing adoption of rapid prototyping technologies in various industries, including automotive, aerospace, healthcare, and fashion, openly questioning us. **How do we incorporate these new technologies in the footwear industry?** Based on our experience. **Could rapid prototyping solve the interpretation problems between designer and producer, avoiding the time lost in the constant shipment of samples and counter-samples between Chile and China.**

Currently a 3D model can be sent anywhere in the world, so that it can be quickly materialized into a real object. This allows reducing up to 75% of the time and the project can be finished in just hours or days, depending on the magnitude of the project. It allows us to create prototypes, molds, or small mechanisms without the need for stock, and it can be done in a minimum of time and with low development costs.

RELEVANCE

The process of designing shoes and manufacturing them in other countries has been the production standard for some time now in Chile. Given this manufacturing outsourcing process, it has been possible to use machines, tools, and production systems that were previously unattainable for Chilean companies, thus allowing them to focus their investments on improving their services, marketing, and user experiences.

This new production system model results in the systematic closure of factories providing raw materials for the production line of a shoe in the national market, for example: lasts or manufacturing materials, thus making it increasingly complex to build the prototypes that are sent through "traders" to China, Brazil, or India to be produced.

In November 2018, after 43 years of life, the brand native of Concepción, Albano, closed; and at the end of that same month, after 62 years of operation, Hormas Hormital lowered the curtain. A similar situation occurred in February 2019, when Calzados Beba announced its forced liquidation process, after 47 years of existence. More than 3,000 people have been left without work due to the closure of factories and retail. The few remaining companies have decreased their production by 70% due to the lower number of employees remaining. (La Horma, 2021).

Currently, this new production standard has become one of the major obstacles, since errors of interpretation between the ideas of designers and the product manufactured by the factory, delay and increase the cost of production with the constant shipment of samples and counter-samples to reach the desired product.

A study released in 2019 points out that "3D printing is changing the way companies are approaching manufacturing, with this announcement New Balance is pioneering localized manufacturing," according to Dávid Lakatos, Product Manager at Formlabs, a Massachusetts-based 3D printing company. “By eliminating the dependence on molds and direct printing for both prototyping and production, their team shifts from months to hours in the development and production cycles. We are moving towards a world where design cycles are closing in on the whim of the consumer and it is exciting to be on the frontlines of this with New Balance” (New Balance, 2019).

In this sense, this fact has an impact on the ambition of new model developments in the national industry, discouraged by the direct relationship between cost and complexity. Likewise, tooling is a highly expensive component in the production process, not allowing innovation in shoe and sport shoes outsoles in our country or hindering the design and development of them to be produced abroad. Therefore, forcing the reuse of outsoles that were already designed for another larger production company.

Through a combination of rapid prototyping and traditional model building methods, high quality prototypes can be created with lower costs and faster response times. The market offers different solutions to different problems in 3D technology. There is a wide variety of software and hardware that allow us to perform more efficiently processes previously done by hand, seeking perfection in them.

Large international footwear industries such as Adidas have invested in innovation and are already implementing 3D printer manufacturing in some of their product lines, managing to print complete outsoles and even the footwear itself. As printing has become increasingly popular, it is now possible to print with materials with some degree of flexibility, which is very helpful for printing outsole prototypes.

Outwear companies in Chile are trying to survive in the business and has led them to become familiar in the machinery that will allow them to save on national production. Meanwhile, other companies have decided to close and continue their business with imports as the basis of their economic system, thus buying ready-made products in large international fairs where they only change the logo of the brand to the product they deliver to the local consumer. This discouragement of the sector caused entrepreneurs to stop looking at the progress made in other areas to make a technological crossover and solve their problems.

The creation of the KOOJ LAB footwear laboratory, aims to improve and streamline the generation of prototypes in the clothing, footwear, and accessories design industry, incorporating 3D design methodologies (observation, ideation, testing, representation, and digital manufacturing.) We will work experimenting with software and rapid prototyping systems, to find the best way to adapt the processes and procedures for optimizing the problems posed, thus achieving 3D printed footwear samples and renders of these products.

OBJECTIVES

How do we take advantage of new technologies for the footwear industry? Can rapid prototyping solve the interpretation problems between designer and producer, avoiding the time lost in the constant shipment of samples and counter-samples between Chile and China? How much time and costs will be decreased by using rapid prototyping tools? What is the accuracy of product testing by using digital prototypes?

The main objective of this research is to develop and test a rapid prototyping system based on digital manufacturing for the national footwear industry, allowing the local development of prototypes and their testing and validation, thus considerably reducing production costs. A process that is currently one of the major obstacles in the clothing, footwear, and accessories design industry, since there are constant interpretation problems due to language and cultural references.

1. Develop a design methodology with technological modeling tools to reduce the design and production time of footwear.

2. Reduce design times using technological tools.

3. Analyze the difference of product testing using the proposed methodology versus the existing manufacturing methodology.

METHODOLOGY

The use of technologies associated with the development of digital prototypes in the footwear industry, should demonstrate advantages and optimize manufacturing processes, where industrial technology can provide relevant contributions to the sector. For this purpose, the process will be based on the incorporation of digital manufacturing in the design and modeling stages to draw, scale, and cut the pieces, manufacture molds, lasts, and soles, which will speed up the testing and evaluation process, reduce costs and develop new products (lasts and soles) that do not exist due to the technical complexity for the national market.

STATE OF THE ART

The book “Footwear Design” by Aki Choklat, tells the story and the design processes behind each shoe. In six chapters, the author shows the past and present of the first and most recent footwear models, as well as case studies with interviews to brands and designers, basic notions of concepts and shapes, analysis and prediction of trends, and an explanation of the research, development, and presentation process to create your own line of footwear, specifically “Footwear production needs to be reinvented in such a way as to provide a more accessible platform for creating new styles and types of footwear. One area of footwear design that requires a new way of thinking is the “eco” footwear market. Global demands on footwear companies’ ethical stance have presented challenges in design and production” (Choklat, 2012)

The trend is to explore and innovate around shoe manufacturing, for example: avoiding the use of glue (only using stitching), manufacturing shoes from recycled materials, a challenge that often focuses on making more ethical and sustainable footwear. There are many areas that can be environmentally considered in footwear manufacturing, but it is very difficult to achieve a 100% "green" shoe.

To achieve this objective, it is necessary to design and develop a digital manufacturing method together with a manufacturing and protocol manual, including the development of molds, pieces, and tools necessary to adopt the new production process and develop prototypes of new lasts and soles.

According to Marco Annunziata (2019), former Economist and Director of Business Innovation Strategies, General Electric, the additive manufacturing plays a major role in the industry 4.0 revolution; it will help upend traditional economies of scale, making micro factories economically efficient; and it is already contributing to reshape global supply chains, strengthening local networks.

Currently, 3D printing could be used in any industrial field, decreasing production times, and generating the components or products in a customized way: according to Dávid Lakatos (2019), Product Manager of Formlabs, 3D printing company, "it will be obvious", the additive manufacturing through 3D printing allows to quickly create prototypes, an important challenge for any company, and even that is proving difficult to master. "Any way you look at it," Lakatos says, "there's a difference between those using 3D printers for rapid prototyping and those that could."

PROCESS

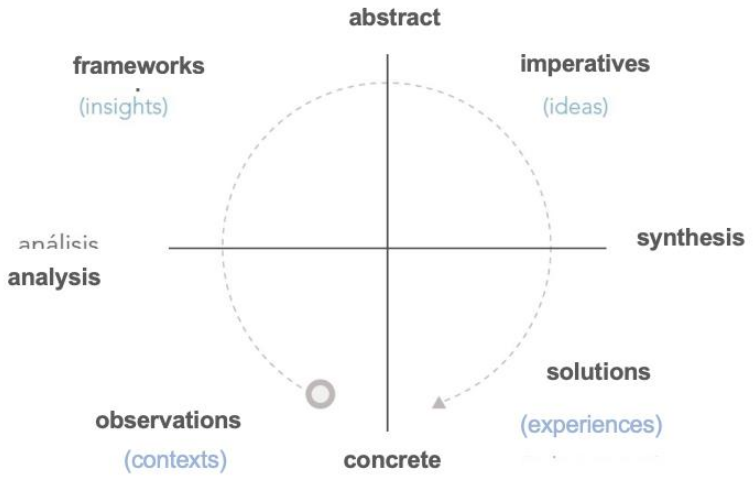

Figure 1 Design and Innovation through Storytelling. Beckman, S. L., & Barry, M. (2007).

Through the schemes presented by Beckman, S. L., & Barry, M. (2007). The members of the research team must be careful not to remain separated in either the concrete or the abstract field; on the contrary, they must move fluidly in the iterative process of innovation proposed by the authors.

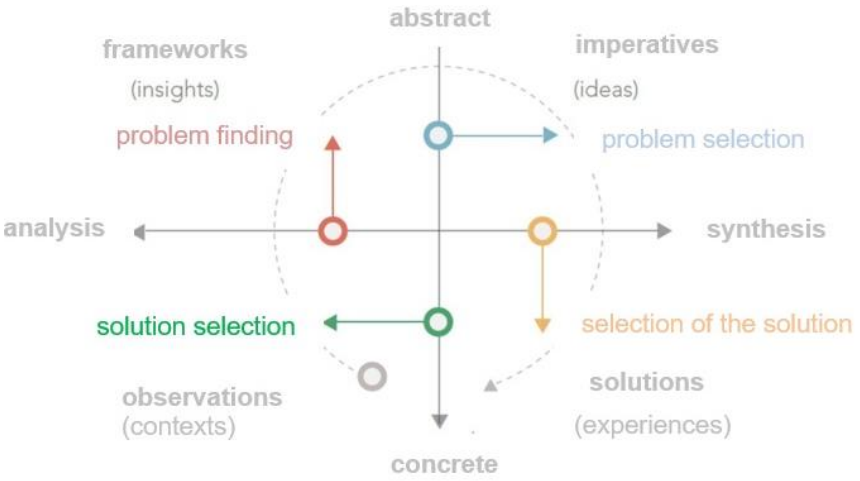

Figure 2 Innovation as a learning process. Beckman, S. L., & Barry, M. (2007).

The tasks related to the development of this research allow us to enable a production line through the digital design of molds, patterns, and soles by means of specific software and their materialization by means of additive manufacturing (3D printing and other tools.)

The digital production line development process consists of three stages:

1. Survey and confirmation of gaps, opportunities for optimization, and the use of specific software.

2. Design of an agile prototyping line, and creation of a manual and protocol for the experimentation environment.

3. Evaluation and implementation of the new process in the final production environment. Additionally, the feasibility of developing integrated and changeable sole bases will be studied.

The research of the design and digitization processes of objects in four dimensions will be carried out. This consists of:

1. Design and modeling of shoe and sport shoe outsoles with Rhinoceros software.
2. Prototyping shoe and sport shoe outsoles with 3D printers.
3. Prototyping the entire shoe with 3D printers.
4. Development of photorealistic digital prototypes of footwear.

The above is carried out for developing and prototyping footwear and outsoles in Chile through 3D printing. Currently, testing is a problem for the industry and incorporating digital tools will reduce the cost of shipping samples abroad, thereby reducing the carbon footprint in the process and reducing the development time of a new product from 60 to 15 days.

The goals to be met, test, and measure are the optimization of the use of materials by simulating the surfaces and 3D shapes of the footwear selected as a solution, additive manufacturing using techniques that allow printing 3D models, obtaining the last (even articulated) to copy and scale.

In this way, the methodology used contrasts with the current development models focused on problem solving, with emphasis during this research on the search for the problem, the identification and iterative progress towards the solution. Activities that are equally important for this process are solving problems and developing an appropriate solution.

The process will be based on the incorporation of digital manufacturing in the design and modeling stages, to draw, scale, and cut the pieces, manufacture molds, lasts, and soles, which will speed up the testing and evaluation process, reduce costs and develop new products (lasts and soles) that do not exist due to the technical complexity for the national market.

RESULTS AND DISCUSSION

The research focused on developing and testing a rapid prototyping system based on digital manufacturing for the national footwear industry.

The local development of prototypes, their testing and validation, allowed us to establish the following results from the application of the methodology used (**Figure 3)**

1. Develop a design methodology with technological modeling tools, to decrease the design and production time of footwear - **75% decrease in development time.**

2. Decrease design times by using technological tools - **70% decrease in prototype development.**

3. Analyze the difference in product testing using the proposed methodology versus the existing manufacturing methodology - **Estimated decrease of at least 50% in testing times, to be evaluated once the client company delivers the prototype product.**

The decrease of the previously established times results in a constant decrease of production costs. Currently, this process is one of the major obstacles in the clothing, footwear, and accessories design industry since there are constant interpretation problems due to language and cultural references.

Main Findings:

1. The use of digital prototyping tools will decrease new product development times.

2. The use of a design methodology with technological modeling tools will lead to the growth of the footwear industry at the national level.

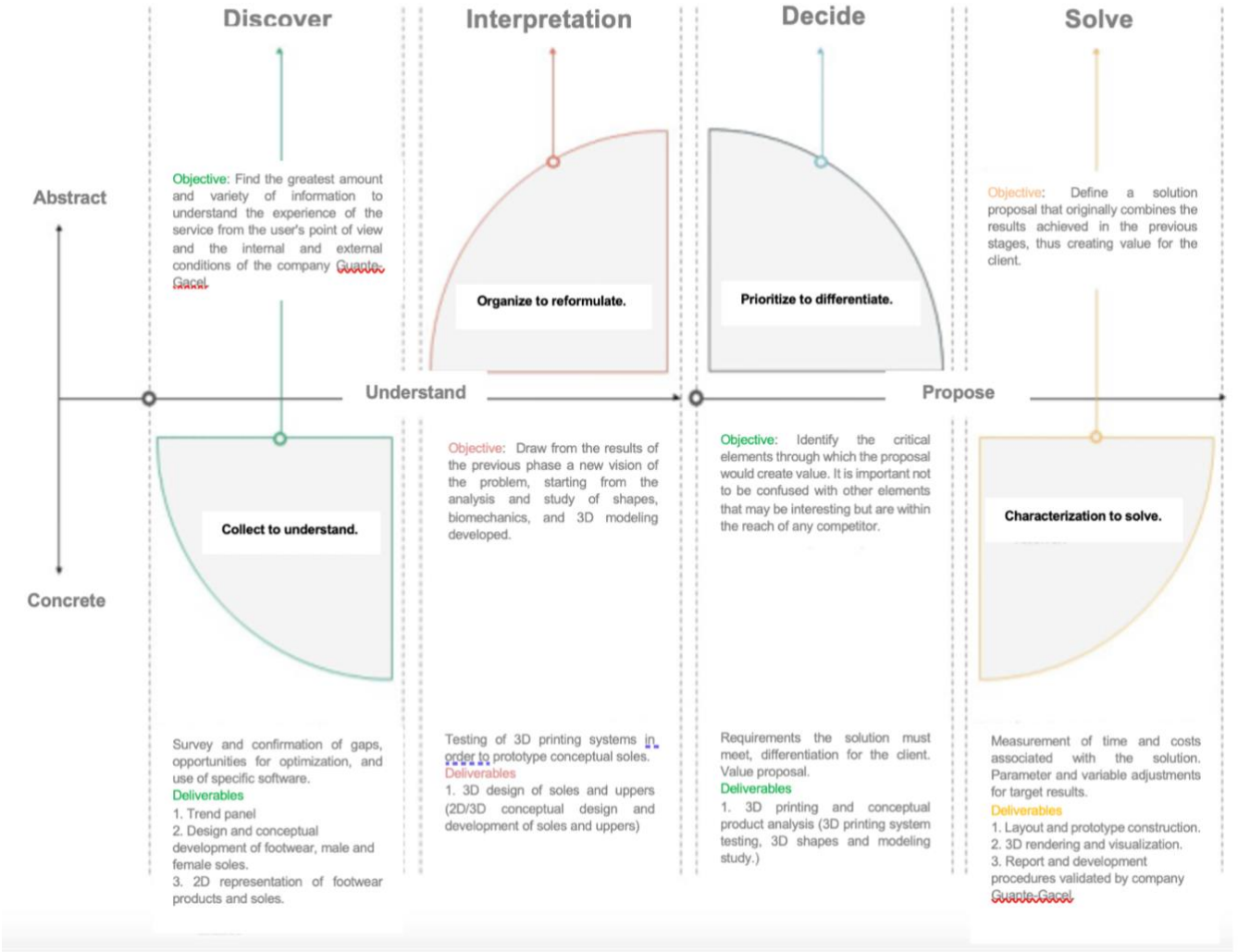

Figure 3 KoojLAB methodology based on publication Beckman, S.L., & Barry, M. (2007). Innovation as a Learning Process: Embedding Design Thinking. California Management Review, 50(1), 25-56. Retrieved from https://doi.org/10.2307/41166415)

EXPECTED IMPACT AND ENGAGEMENT

Strategically KoojLAB aims to develop and expand the competencies that teachers and students can contribute to the footwear industry. Initially, the project is developed in collaboration with national client companies, who have vast years of experience, tradition, design, and comfort in each of their footwear. One of its board of directors has pointed out that the future is "to continue evolving as a brand that has its employees and customers at its heart. Innovation, design, and agility to stay ahead of trends are our core values, with the purpose to continue leading the market."

It is expected that other players will allow us to continue with the applied research carried out and achieve the objectives set, generate new findings, and contrast the results initially obtained with these companies.

In the future, we intend to strengthen the design of soles and lasts together with additional client companies, dedicated to continuing the tradition of designing and manufacturing all leather footwear in our country, a tradition and profession that has been in force for more than 40 years.

On the other hand, it will be ideal in the future to promote the analysis and 3D modeling of soles (study of shapes, biomechanics, and testing of developed prototypes) in direct collaboration with producers and distributors, dedicated to meet the demand for personal protective equipment (PPE) with 100% coverage nationwide, where we can participate and improve.

CONCLUSIONS

The proposed development process allowed us to successfully complete three stages, concluding the following:

By collecting data from observation, the gaps in the national footwear industry are confirmed, there are opportunities for optimization and for the use of specific design software in the industry.

The experience of the members of Kooj LAB in this field allowed us to learn the procedures used by other sectors in prototyping, and to implement them in the footwear industry.

Design of a rapid prototyping line, creation of a manual and protocol for the experimental environment.

The use of a proprietary methodology allowed us to integrate CAD/CAM/CAE solutions for the design of shoe components, design variations to the specific production methods for companies that promote new product releases, thus reducing the cost of pre-series and prototype production, and offering a good solution in the production of footwear components in terms of cost and development time.

Evaluation and implementation of the new process in the final production environment.

We evaluated and analyzed the feasibility of developing integrated and changeable sole and outsole bases, allowing the local development of prototypes, their testing and validation. In the future, the difference will be analyzed from the testing of products using the proposed methodology versus the existing methodology.

The prototypes were built in a matter of hours and were ready for functional testing within two days.

After the first year of the project, the results are highly encouraging for a profitable and novel application in the footwear sector, incorporating rapid prototyping technologies, and short series production in its product development engineering processes.

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