Study of the development of a 3D printed bag

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Abstract. The project aimed to study the design and development process of a 3D printed bag. The research adopted a qualitative and applied approach, focusing on the detailed description of the creation process of 3D printed bags. The literature review revealed the growing relevance of 3D printing in the fashion industry, highlighting its applications and benefits. The discussions encompassed the initial three phases of product development, namely Planning, Concept Development, and System-level Design. The project's results provided a comprehensive insight into the development process of 3D printed bags, identifying challenges related to the accuracy and detailing of the foam board maquette and the realistic representation of materials used in actual 3D printed bags. Creating sketches and prototypes proved to be a useful approach for visualising and communicating bag designs before full-scale production, although the consideration of alternative materials or prototyping techniques could enhance the accuracy of the maquettes.

Keywords. 3D printing; Design product; Bag; Prototype, Product development.

1. Introduction

The Product Development Process (PDP) is a key process for the competitiveness of any company. Understanding what the customer perceives as value and directing all efforts towards achieving that objective is essential, along with utilizing methods and tools to enhance the performance of strategic and operational development [1].

Based on this, a study was conducted to assess the potential of the fashion market in the context of 3D printing, with particular attention to the lack of interaction between accessories and this innovative technology.

The overall objective of this research is to study the design and development process of a 3D printed bag. To achieve this, the specific objectives are:

• Conceptualize and develop models of 3D printed bags.

• Conduct testing and prototyping.

• Propose improvements to the development process.

2. Literature review

2.1 Product development

Product development, according to [1], involves a series of activities aimed at meeting market needs, overcoming technological challenges, and seeking the ideal product feasible for manufacturing. He emphasizes that the development process is the most critical as it must align with the demands of a competitive and increasingly diverse market.

Additionally, as mentioned by [2], the Product Development Process (PDP) is complex but plays a significant role for companies by formalizing activities into stages, ensuring product quality and cost reduction. To meet real consumer needs, product development must be driven by technological innovations capable of differentiating them from other similar products in the market.

In addition to this context, the bag is an accessory that has always been relevant and plays a prominent role in the world of fashion, as pointed out by [3]. The bag is an accessory that has always been present with a certain degree of importance and holds great prominence in the world of fashion [3].

2.2 Prototypes

As per [4], prototypes are usually constructed using the same materials and mechanisms as the final product, enabling testing under real operational conditions to evaluate technical performance and market acceptance (consumer response).

This approach facilitates the identification and resolution of potential issues prior to full-scale production. In certain cases, the creation of pilot factories may be required, particularly when examining the product-process interaction [5].

3. Methodology

In the following, the research methods used for the design of the study with a focus on the nature and approach will be identified.

Given this, this work adopts a qualitative approach. As for its nature, it is applied, as it aims to apply knowledge in practice. Furthermore, the research aims to be a descriptive study.

According to [6] The generic development process consists of six phases, and the first three will be studied in this work: Planning, concept development and Design at the system level.

4. Results and Discussion

The results and discussions were divided into three sections, which will be described below.

4.1 Planning

This initial phase precedes project approval and involves identifying opportunities based on the corporate strategy. The project's mission statement, specifying the target market, business goals and constraints, is the output [6].

In the Opportunity Identification phase, the product planning process begins by identifying development opportunities. The focus is on sustainability and innovation, aiming to find unique and environmentally friendly solutions. The use of 3D printing and PLA as the primary material is considered to create a low-cost, high-quality, and durable bag.

To Evaluate and Prioritize Projects, after collecting various opportunities, the team evaluates and prioritizes the most promising ones. Four perspectives are taken into account: competitive strategy, market segmentation, technological trajectories, and product platforms. The team selects the opportunity to create a 3D-printed bag with customization and innovative design.

When Allocating Resources and Planning Time, it is crucial to understand that resources are limited. The team allocates resources and plans the time for the most promising projects. Some opportunities may be postponed or discarded, and the portfolio of projects is reviewed to ensure a balanced approach. Furthermore, the last planning step involves creating a comprehensive Pre-Project Plan.

Tab. 1 - Pre-Project Plan.

Mission Statement: 3D printed bag	
Product Description	3D printed bag
Benefit Proposition	Lower Cost, Higher Quality and reduced environmental impact
Primary Market	Eco-conscious consumers and fashion enthusiasts.
Assumptions and Constraints	Availability of 3D printing technology and expertise.
	Stable supply chain for PLA material.
Stakeholders	Product Development Team
	Supply Chain Partners.
	Customers and End-users.

According to Tab 1, the luxury 3D-printed bag using PLA is designed to provide a sustainable and innovative option in the market. Through customization and bold design, it aims to meet the demands of conscious consumers, offering a unique and environmentally responsible experience. Leveraging 3D printing technology and PLA usage allows for on-demand production, minimizing waste, and reducing environmental impact.

The development process of the new product, a 3D printed bag, is based on data collected from customers through a qualitative and quantitative questionnaire. The objective was to identify customer needs and specify the new product. The questionnaire served as a filter to analyze the viability of the proposed product, considering the market demand.

The customers' statements and interviews with women from the production engineering course of UFTM provided essential insights. These insights were incorporated into the metrics and specifications of the 3D printed bag to meet specific customer requirements. The process involved co-creation with customers, emphasizing continuous improvement and strengthening the relationship with them.

4.2 Concept development

Target market needs are identified, alternative product concepts are generated, evaluated, and one or more concepts are selected for further development and testing [6].

Tab. 2 - Table of needs and specifications.

Need	Specifications
be small	Length 16.5cm, height 11cm and width 5cm
be easy to load	With removable strap
be durable	PLA type filament
Fit a cell phone, document and gloss	Length 16.5cm, height 11cm and width 5cm
be attractive	Differentiated design
Have an affordable price	Maximum value of R$100

The needs and metrics tables are tools used in the specification stage of product development, such as the 3D bag. The objective of these tables is to associate each consumer need with specific metrics, which represent the parameters to be achieved by the development team.

In the case of the 3D bag, several needs of the target audience have been identified and listed in Needs Tab 2. These needs include bag size, weight, wear resistance, storage space, compatibility with fashion trends, and affordability. Each of these needs reflects the desires and preferences of consumers regarding the bag.

By linking each need to specific metrics, the development team can set clear objectives for each aspect of the bag and measure their success in meeting these goals.

Thus, the needs and metrics tables provide a comprehensive framework for the product development process, guiding the team in designing a 3D bag that fulfills consumer demands and satisfies the desired parameters.

Tab. 3 - Table of needs and criteria.

Need	Criteria
be small	Functionality
be easy to load	Functionality
be durable	Durability, Innovation
Fit a cell phone, document and gloss	Functionality
be attractive	Design, Innovation, Sustainability
Have an affordable price	Price

The tab 3 identifies the key needs of the target audience for the 3D bag and associates each need with specific criteria that must be met during the development process. The criteria listed correspond to the aspects that the development team will focus on to ensure that the final product satisfies the consumer's requirements. These criteria cover aspects such as functionality, durability, design, innovation, sustainability, and price, all of which play a significant role in creating a successful and desirable 3D bag.

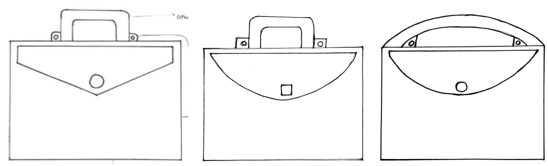

Fig. 1 - sketches 1 ,2 and 3 respectively.

Concept screening is based on a method developed by the late Stuart Pugh in the 1980s and is often called Pugh concept selection (Pugh, 1990). The purposes of this stage are to narrow the number of concepts quickly and to improve the concepts. For better visualization, there is the following caption for tab 3: Weight=W, Rating=R , Weight Score=WS and Total Score Rank=TSR

Tab. 4 - The concept-scoring matrix.

		Reference		Concept 02	
Criteria	W	R	W S	R	WS
Design	20%	4	0,8	4	0,8
Functionality	15%	3	0,45	3	0,45
Durability	25%	2	0,5	5	1,25
Innovation	10%	5	0,5	5	0,5
Sustainability	10%	2	0,2	5	0,5
Price	20%	2	0,4	4	0,8
	TSR	2,85		4,30	
	Continue	No		Yes	

Based on the pugh matrix from tab 4, it was determined that the prototype bag produced will be sketch 02 in figure 1. This decision was taken based on the criteria.

This choice was made taking into account the relative importance of each criterion, as defined by the assigned weights. And these criteria were evaluated based on the characteristics and requirements of the 3D bag project, aiming to meet the needs and preferences of the target audience.

4.3 System-level design

This phase includes the definition of the product architecture, subsystems and preliminary design of the main components. It also involves planning for production and final assembly [6].

Creating a 3D printed bag involves detailing the function of each component, including printed parts, handle, hinge, and magnet. Challenges in crafting a foam board maquette to represent the geometric arrangement of components include precision, fragility, limitations in material representation, and volume-proportion considerations.

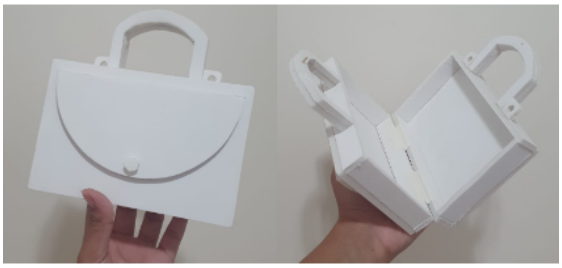

Fig. 2 - Foam board prototype.

A 3D maquette prototype from fig 2, was developed for visualization, highlighting essential interactions such as magnet and hinge adhesion, crucial for functionality and usability of the bag.

Prototype 01 was supposed to be printed using cherry red PLA filament. However, when loading the filament into the printer, it was noticed that it had been improperly stored and had an unsatisfactory finish for printing. As a solution, it was decided to print the prototype using white snow PLA filament.

The first print was carried out on the Ender plus 5s printer and had a total duration of 14 hours. White snow PLA filament was used, with the nozzle temperature set to 235 degrees Celsius, and the bed temperature set to 60 degrees Celsius.

These details are relevant to understand the printing process and may be useful in future similar projects.

Fig. 3 - Prototype 01.

Fig. 4 - Hinge of prototype 01.

Prototype 01 shown in Fig 3 presented some design flaws, including the following issues: the hinge did not adequately perform its function of opening and closing the bag at the intended position, show in fig 4; part of the bottom of the bag was not sufficiently sturdy; and the areas intended to receive the magnets were designed with a too thin thickness.

The solutions for the bottom of the bag and the magnets were easily addressed by simply redesigning them in the software and making the necessary adjustments. However, solving the hinge issue required a brainstorming session with the project team to generate new ideas and potential solutions.

As a conclusion, it was decided to test an additional 3D-printed hinge that could be glued onto the product. For this purpose, a scaled-down version of the hinge was printed using filament that would otherwise be wasted, in order to assess the feasibility of using this new hinge in the project.

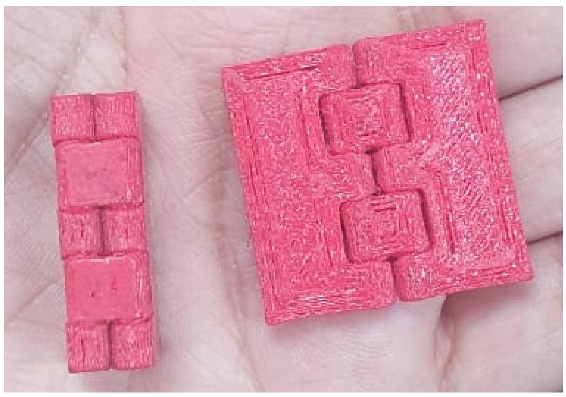

Fig. 5 - Hinge.

Upon conducting the necessary analyses, it was realized that the new reversible hinge shown in Fig 5 would indeed be ideal for the project. Consequently, the engineering drawings were adapted to print the new prototype. Some of the adaptations included removing the bottom of the bag and increasing the side contact walls for future gluing. Additionally, the hinge was developed in a size matching that of the bag's bottom.

By implementing these modifications, the team aimed to ensure a more effective and functional design for the prototype, addressing the issues identified in the previous version.

Fig. 6 -Prototype 02.

Prototype 02 was made on the same printer and had a printing duration of 20 hours, using the same filament and temperatures as the first prototype.

Overall, Prototype 02 from fig 6 represents an improved version of the 3D-printed bag, addressing the issues identified in the previous iteration and moving closer to the final design that would meet the needs and preferences of the target audience. The iterative design process allowed the team to refine the product and make necessary adjustments for a successful end product.

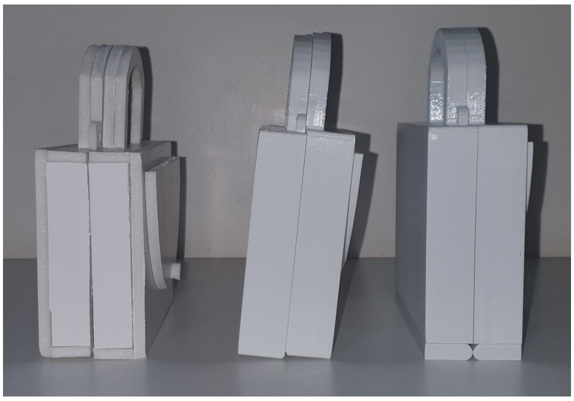

Fig. 7 - Comparison between prototypes.

Therefore, Figure 7 illustrates a comparison between the sides of the foam board mockup and prototypes 01 and 02, respectively. Through this comparison, it becomes evident that the first prototype exhibits flaws, particularly in its inability to maintain stability when placed on a surface. This instability negatively impacts the functionality criterion discussed earlier.

However, significant progress was made in prototype 02, as the team successfully addressed and corrected this issue. As a result, the second prototype demonstrated improved stability and functionality, moving closer to meeting the desired design objectives and better fulfilling the needs and preferences of the target audience. The iterative design process played a vital role in identifying and rectifying these flaws, allowing the team to refine the product and ensure its success in the end.

5. Conclusion

Based on the results and discussions presented in the three sections of the project, it is evident that the development of the 3D-printed bag using PLA has undergone a systematic and thoughtful process.

The project started with an opportunity identification phase, where the team focused on sustainability and innovation, aiming to create a low-cost, high-quality, and environmentally friendly bag. The mission statement was clear, targeting eco-conscious consumers and fashion enthusiasts.

In conclusion, the project demonstrated a well-structured approach to product development, involving careful planning, concept development, and system-level design. By leveraging 3D printing technology and PLA material, the team aimed to provide a sustainable and innovative option to meet the demands of conscious consumers.

The iterative process of prototyping and problem-solving led to improvements and ensured the final product's viability and customer satisfaction. The project's success is a testament to the importance of considering customer needs, design criteria, and continuous improvement in the development of new products.

6. References

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