https://doi.org/10.59476/ilpmt2025.v1i2.22-29

IMPLEMENTING PRODUCT DESIGN METHODOLOGY TOOLS: A DESK LAMP CASE STUDY

Maria Minaoglou[1], Lazaros Firtikiadis[1], Nikolaos Efkolidis[1], Renata Gudaitiene[2], Panagiotis Kyratsis[1]
[1]University of Western Macedonia, Greece
[2]Kauno kolegija/Higher Education Institution, Lithuania

Abstract
The product design process is used to develop new innovative products or to improve existing ones. The category of space decoration covers items that are mainly designed based on aesthetics and thus help users to enjoy an easier and more efficient lifestyle. Desk lamps are developed either for functional or aesthetic purposes. A large part of their use is in the workplace, and they aim to increase productivity. The contribution of the present work is to deal with the design of a prototype desk lamp that can combine both the functional and aesthetic characteristics required. In order to achieve this goal, a number of methodological and technological tools have been implemented in the development of the product itself i.e. mind-map, sketches, color selection process, a 3D Computer-Aided Design (CAD) modeling and 3D assembling, a high-quality rendering tool, and prototyping. A step-to-step approach was taken, starting with a search for similar works published, developing the design concept from scratch and finishing with a prototype using 3D printing technology available. The developed prototype provided a solid basis for an early evaluation of the users' perception of the designed product. A 3D CAD system has been used to achieve both the modeling and the prototyping of the product. Combining functionality and aesthetics, a design concept has been developed, a 3D printing prototype has been produced and finally an early evaluation of the outcome became available by experienced design engineers.
Keywords: *design thinking, design product, CAD, prototyping.*

Introduction

Desk lamps are divided into two main categories. The first category is the decorative desk lamps which offer a pleasant atmosphere at home. Utilizing such a decorative object in close spaces offers the opportunity to create a relaxing environment. The second category concerns desk lamps which have a more functional character and purpose (Zhang et al., 2019).

These lamps are used either at home or at the workplace. However, beyond that, desk lamps differ depending on the type. There are mainly 3 types of lamps. The first type includes the lamps whose base is placed on the desk with a clamp. The second type supports those that have enough arms and joints to have the appropriate adjustment. And at the last type belong the classic ones whose base is fixed. In addition, the intensity of the light plays a decisive role. Lighting can affect the user's performance in studying.

Lian et al., in their research published on the design of desk lamps, refers to a new system of smart lamps. These lamps differ in that they provide a camera and two servo motors that help the lamp lock the position of the book that the user studies as it moves. The design of the lamps includes a vision system as well as a servo motor control system. These lamps also have two tilt adjustment capabilities at 30 degrees and 60 degrees. Finally, the FPGA technology (Field-Programmable Gate Array) is used (Lian et al., 2021).

Su et al. in their article, refer to the correlation between the products of the modern era and the impacts they create on the environment. In addition, the research focuses on the tools and methods for properly creating a new innovative lighting product from scratch. It is worth noting that ecological design played a dominant role. Then, after the new product was completed, LED lamps were compared with the traditional lamps available on the market. The results showed that LED luminaire is superior in terms of product life cycle and lighting efficiency but mainly in terms of affecting the environment (Su et al., 2021).

Wang et al. state that, the product life cycle should not consist of just one phase but of two different ones. The first phase includes product development, which usually includes the initial designs and prototyping or otherwise manufacturing the product. The second phase concerns services, which usually involve sales, distribution, purchasing, maintenance and others. Both phases combined can lead to a successful product design and fabrication. According to a study conducted, LED luminaire was 46% less harmful to the environment and the resources saved were over 14% annually (Wang et al., 2020).

In the present study, a desk lamp was designed and 3D printed, with a stable base and unusual shape. All the characteristics introduced contribute towards combining both the successful aesthetics and their functional behavior. This was the main aim of this study in order to include advantages from both directions. During the design process the methodological tools provided increased inspiration and novel geometries. At the same time, the appropriate digital tools used 3D CAD (Computer Aided Design) based models that were fit for 3D assembling, rendering, prototyping and early evaluation.

Proposed methodology

The methodology followed was based on a design thinking approach that manages to utilize not only methodological tools for increased inspiration, but 3D CAD based technologies with a number of downstream applications. The mind map tool was used for documenting a number of different design directions. It was supported by words and images that could be used to spark new ideas that could be used towards the novel desk lamp design. Furthermore, they were based on demand and requirements for extra lighting features and geometrical forms.

2D sketches were the basis for exploring a series of ideas, improving the designer's perception of the product and documenting concepts that could be effectively implemented (Manavis et al., 2024a). Firstly, the customer needs and the technical specifications demands were used as the starting point for initiating the product development cycle. Then a great deal of 2D sketches were developed and assisted in exploring the design space in more detail (Manavis et al., 2024b). Finally, the selected idea was 2D sketched in detail and with the use of alternative features and geometrical characteristics.

Based on these 2D sketches provided, the 3D model was produced by using an advanced CAD system to which the product features and details were added. The proportions and dimensions of the product were included, and a detailed definition of the final product was delivered. The aesthetics and functional use of the product were tested via a 3D printing fabricated prototype (Figure 1).

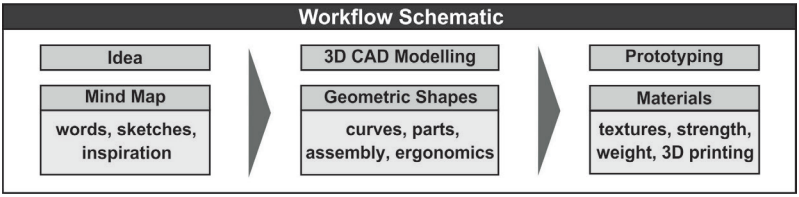

Figure 1. Workflow schematic (ideation, 3D modeling and prototyping)

Case study development

Following the different steps presented, a set of 2D sketches were prepared and developed the conceptual design steps based on the ideas revealed from the mind map. The ideation phase visualizes the designer's inspiration, and the ideas can be easily communicated within the design team and the customer/user. For this reason, it is important to follow a structured way

with an aim to use the sketching procedure effectively, which leads to a four-level approach described in the literature (Minaoglou et al., 2023).

Figure 2 depicts a simplified version of the mind map used. It contains the main directions proposed and the computer-aided based tools to be used. The figure also provides a detailed understanding of the 2D sketches four levels theory application. The first level develops basic concepts, the usage of the product and is an evolution and visual continuation of the mind map. The second level develops many different directions and inspirations for the product with the aim of creating novel geometries, characteristics and forms. In the third stage, the sketches focus on a particular design form. It can combine prior ideas or develop further an existing one, while analyzing in more detail the selected product's inspiration. Finally, in the fourth stage, the product is presented within its working environment.

The final proposal was to develop the desk lamp following the geometric combination of relatively simple shapes i.e. circle, triangle, square. As a result, the primary forms emerged, and the final proposal was to integrate geometrically a circle and a triangle. Combining sharp angles with fillets and curves provided an unusual geometry that could be produced only with the use of 3D printing technology.

The concept was 3D modeled using Autodesk™ Inventor™ advanced CAD system (Computer Aided Design). When the 3D modeling process finished, different colors and textures were incorporated in order to prepare a set of photorealistic images (Figure 3). Those images were able to facilitate the lighting effect and present the lamp very realistically. It was expected that the lamp would be basically metallic for increased durability (Myerson et al., 1990).

Regarding the preferred colors, for this concept brown, yellow and gray were selected. These colors are neutral, making them easier to be integrated into interior space decoration (Figure 4).

Although, a 3D printer was used in order to fabricate the prototype, the same technology could be used for producing the final product as well. For prototyping purposes and for assessing the desk lamp in real dimensions the PLA-EVO (Polylactic acid) by NEEMA3D™ was used, well known for its biodegradable nature (Figure 5). Furthermore, the proposed material for fabricating the final product could be the composite material Spartan Copper by NEEMA3D™. This material consists of 80% copper powder and 20% PLA. This would result in having an almost metallic desk lamp with the advantages of plastic material.

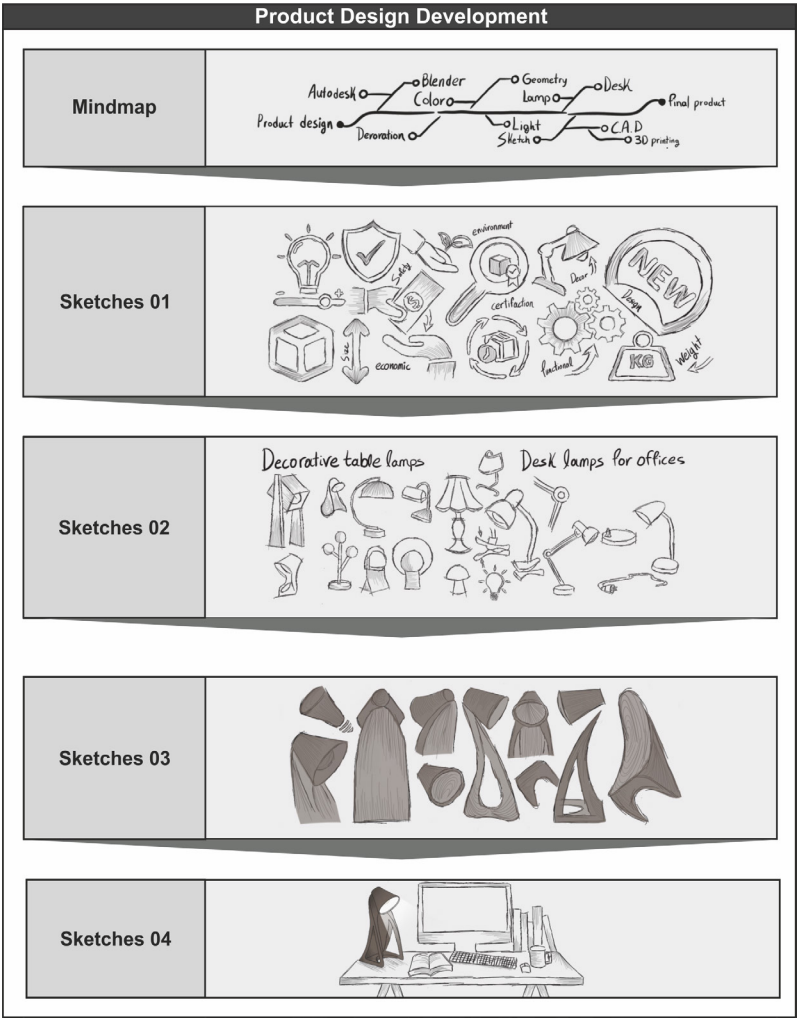

Figure 2. Product design development (mind map and sketches)

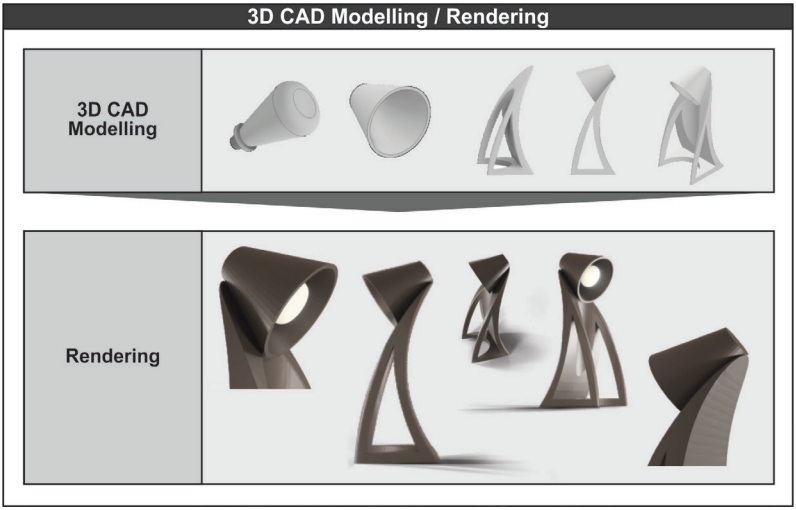

Figure 3. 3D visualization and Rendering

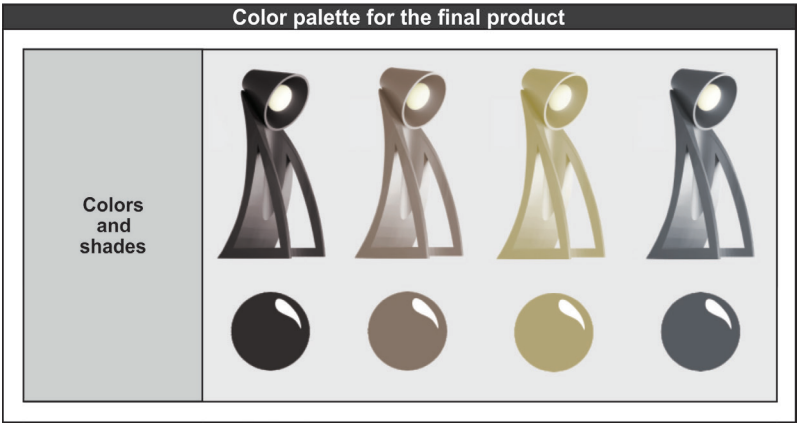

Figure 4. Application of colors to the product

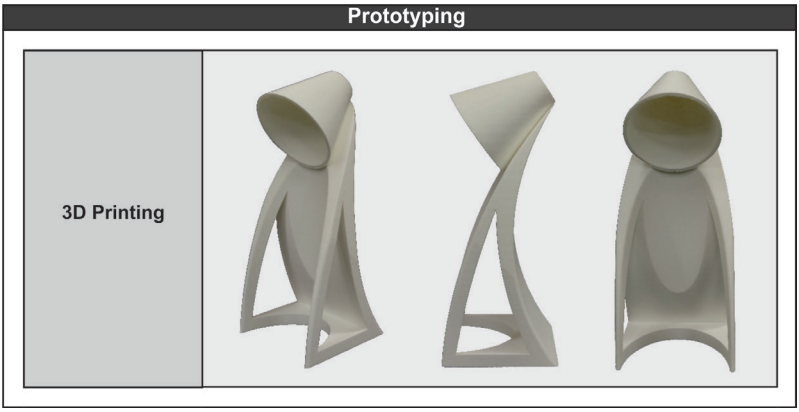

Figure 5. The prototype created by 3D printer

Results

The prototype was examined by three design engineers with more than 5 years of experience, and an early evaluation became available. Although they enjoyed having 3D printed prototypes of unusual geometry products early for evaluation, they expressed doubt if the same 3D printed fabrication could be used in a large-scale production due to time constraints. Nevertheless, based on their opinion the unusual geometry proposed for the desk lamp design is attractive. It can be a solid basis for designing customized lamps that will be fabricated by a variety of materials with 3D printing technology. Following this strategy both coloring and texturing can be implemented with most materials available with the fused filament fabrication (FFF) technology.

Conclusions

The presented work emphasizes the design and fabrication of a desk lamp, when combining methodological and digital tools for its development. Mind map and 2D sketching helped develop the geometrical characteristics of the product and 3D CAD modelling offered additional photorealistic images of the final product. Due to the unusual geometry of the desk lamp, 3D printing was proposed for both the prototyping and the final fabrication processes. For this reason, two separate materials were used and proposed. Especially the composite material Spartan Copper by NEEMA3D™, can offer increased durability of the metallic materials together with the advantage of light plastic. In addition, a series of alternative colors were proposed with the aim of offering an easy to incorporate product within the office interior design.

References

1. Zhang, J., Yin, Q., Gu, J., Xu, Y., & Luo, R. (2019). Design of intelligent desk lamp based on STC89C52 MCU. In 2019 IEEE 3rd Information Technology, Networking, Electronic and Automation Control Conference (ITNEC) (pp. 1845-1848).
2. Lian, Y., Wu, D., & Ji, Z. (2021). STM32-Based Intelligent Desk Lamp Design and Implementation. Open Access Library Journal, 8(8), 1-11.
3. Su, D., Casamayor, J. L., & Xu, X. (2021). An Integrated Approach for Eco-Design and Its Application in LED Lighting Product Development. Sustainability 2021, 13, 488.
4. Wang, S., Su, D., & Wu, Y. (2020). Application of life-cycle assessment to the eco-design of LED lighting products. Euro-Mediterr J. Environ Integr. 5(2), 41.
5. Manavis, A., Liokos, T., Efkolidis, N., & Kyratsis, P. (2024). Holistic Product Design for The Fur Fabric Industry: A Floor Lamp Design Approach According To Brand Principles. Acta Technica Napocensis-Series: Applied Mathematics, Mechanics, And Engineering, 67(2s).
6. Manavis, A., Minaoglou, P., Efkolidis, N., Kyratsis, P. (2024). Digital customization for product design and manufacturing: a case study within the furniture industry, Electronics, 13(13), 2483.
7. Minaoglou, P., Kakoulis, K., Manavis, A., Kyratsis, P. (2023). Computational wearable design: shoe sole modelling and prototyping, International Journal of Modern Manufacturing Technologies, 15(2), 143-151.
8. Myerson, J., Katz, S., Myerson, J., & Katz, S. (1990). Desk Lamps. Lamps and Lighting, 47-58.