



An Appraisal of 3D Printing Technology in Interior Architecture and Product Design

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Abstract: Printing technology evolves at a quick pace, and what was once only capable of printing two-dimensional objects is now capable of producing true three-dimensional objects. Three-dimensional printing, often known as 3D printing, allows you to create a work of art quickly, easily, and in great detail. 3D printers can create a wide range of objects, including statues, automobile components, toys, shoes, furniture, clothing, weaponry, human body parts, and more, and their printing capabilities will only improve in the future. This type of technology must be presented to students in a formal and creative manner in their creation activities in order to develop them to be creative thinkers who can use technology as a medium to fulfil their creativity. The technology of 3D printing can influence creativity, resulting in the realisation of ideas inside the design creation process without having to go through the lengthy design process. The purpose of this research paper is to see how creative products can be designed while using technology. The systematic literature review has been explored through internet and secondary data from relevant published academic literature from journals articles and research papers. The case study method is used to identify extensive information through an in-depth analysis of existing cases in Interior and product design.

Keywords: 3D printing, additive manufacturing, interior design, product design

1. Introduction

3D printing is currently one of the world's fastest growing technologies. The concept of 3D printing has advanced since the 1980s, albeit few studies have focused on specific 3D printing methods.

As a result of these developments, 3D printers are becoming increasingly popular. It has also resulted in significant change/transformation in the field of architecture. Their use in architecture has progressed from scale modelling to a finished product that is full-size (Selçuk & Sorguç, 2015). The global spread of technology has had an impact on all parts of life, including the creation of visual creations. 3D Printing technology is one of the visual work's creations. 3D Printing technology has made a number of significant developments that can aid the advancement of the realm of interior designing. 3D printing is a printing process that can now make true three-dimensional objects, including work that has never been imagined before. The needs of the learning process of interior design student creativity are met by 3D printing technology. Designers go through a lengthy creative process that includes selecting design concepts, sketching alternative designs, digital modelling, and prototyping works. Without the appropriate media, the development of visual works would take a long time and may stifle creativity. As a result, the correct technology is required in the creative learning process.

According to the M. Heleihil research about 3D printing technology as innovative tool for math and geometry teaching applications, explains that 3D printing requires higher levels of thinking, innovation and creativity. It has the power to develop human imagination and give students the opportunity to visualize numbers, two dimensional shapes, and three-dimensional objects. The combination of thinking, design, and production has immense power to increase motivation and satisfaction (Huleihil, 2017). The 3d printing technology makes it possible for interior designers to explore their creativity in creating visual works. Heidegger, a philosopher, said about 'technology perspective' that " the technology perspective is a perspective that is challenging, embracing (framing) and dissecting (revealing, exposing) (Sugiharto, 2013).

3D printing is a technique for creating actual objects by layering materials based on a digital model. All 3D printing methods necessitate the collaboration of software, hardware, and materials. Different technologies are used by different types of 3D printers to process diverse materials in different ways. SLS (selective laser sintering) is a 3D printing technique that involves using a laser to fuse powder particles together to form an object. The materials used in the SLS method are usually robust and flexible. The most frequent materials are nylon or polystyrene (Hager et al, 2016). As a result, studying the relationship between creativity and technology is particularly important since technology allows designer to experiment

with new forms and creative products. A need to embody an idea or a perspective is accommodated through form (White, 2011). In comparison to the traditional method, designers will be able to develop innovative designs with endless geometric shapes as a manifestation of their creativity using this technology.

2. Research methodology

In this paper qualitative research method has been used. The systematic literature review has been explored through internet and secondary data from relevant published academic literature from journals articles and research papers. The data collection in the qualitative research are the data that comes from a number of case studies examples that are described descriptively and are supported by illustrations and photographs to reinforce the arguments put forward. The basic concepts and backgrounds are investigated through literature and on-line media, observations to work for qualitative analysis conducted for the applications of 3D printing technology in interior design and product design. The case study method is used to identify extensive information through an in-depth analysis of existing cases in Interior and product design. It is typically used to obtain empirical evidence for investigating problems or business studies. The five relevant cases have been selected to validate the study.

3. 3D printing and additive manufacturing

Additive manufacturing (AM) is a novel way for creating three-dimensional objects by layering extraordinary materials like plastic, metal, concrete, sand, and other materials. 3D printing is a relatively new technology that can be quite useful in the design process. Initially, and in accordance with their capabilities, these technologies were viewed from the standpoint of modelling or prototyping, in which complicated one-off things could be produced more quickly and cheaply than traditional model-making techniques (Lindley et al, 2014). This technology can print all of the simple shapes we require, as well as others that aren't conceivable with existing procedures. Since the mid-1960s, additive manufacturing has been used, and there have been numerous improvements in terms of materials used in the process. PLA (Poly Lactid Acid) and ABS (Acrylonitrile Butadiene Styrene) plastics are currently the most commonly used materials, as they have melting temperatures low enough to use in melt extrusion outside of a dedicated facility while high enough for prints to retain their shape at average use temperatures (Tymrak et al, 2014).

The utilisation of a computer, 3D modelling software (Computer Aided Design or CAD), machine equipment, and layering material are all prevalent AM methods (Chang and Shawn, 2016). The CAD file may need to be converted into a format that a 3D printer can comprehend, depending on the CAD programme used (Osborn, 2014). In next step, printer begins layering the material on top of each other to construct the thing in three dimensions. All 3-D printers make use of 3-D CAD software, which measures hundreds of cross-sections of each product to calculate how each layer should be built (Berman, 2012). These objects can be made out of powder, liquid, or sheet metal. Additive Manufacturing technologies such as Rapid Prototyping (RP), Direct Digital Manufacturing (DDM), Layered Manufacturing (LM), and 3D printing may all produce identical goods quickly. (Chang and Shawn, 2016)

Additive manufacturing, often known as 3D printing, has proven to be very effective in lowering manufacturing costs and reducing waste during the manufacturing process. The fact that 3D printers are now widely used in a variety of industrial industries is due to the numerous advantages that this technology offers. In contrast to typical subtractive manufacturing procedures, 3D printing is an additive method of production (Figure 3). In this regard, 3D printers may work with a variety of different materials, each of which is provided in phases (powder, filament, pellets, granules, resin etc.). The application of this technology allows students to explore and create difficult and complex geometric shapes.

4. 3D printing technology in architecture and building construction

Architectural models can now be printed in three dimensions. Typically, architectural models are made of cardboard, wood, or other easily moulded materials. Models are required by architects in order to explore various aspects of their ideas. It is frequently updated in both architectural and interior design to get a flawless concept of their vision. Large-scale 3D printing in the construction business will have a wide range of applications in the private, commercial, industrial, and public sectors. These technologies may result in faster construction, lower labour costs, increased complexity and/or accuracy, higher function integration, and reduced waste. To date, several various approaches have been proven, including building and construction component manufacturing on-site and off-site, as well as the utilisation of industrial robots, gantry systems, and tethered autonomous vehicles (Tay et al, 2017). Construction 3D printing technologies have been used to fabricate houses, construction components (cladding and structural panels and columns), bridges and civil infrastructure, artificial reefs, follies, and sculptures. It may also enable building in difficult situations where human labour is not acceptable, for as

in locales with unique conditions (Camacho et al, 2018).

5. 3D printing technology in interior architecture and product design

Additive manufacturing, often known as 3D printing, has opened up new options in the design and manufacture of goods across a variety of industries. The worlds of architecture and interior design have begun to explore and diversify into 3D Printing, using this technology to build spatial elements, furniture, decor, and lighting (Ami). The materiality of 3D printing is unrestricted, and it has been demonstrated to be sustainable, efficient, and aesthetically pleasing in its application. Designers have envisioned and realised their ideas in 3D Printed shapes all across the world.

"A house is more than simply the walls; the visual design and feel of the interior is equally important," says Emerging Objects, a design firm that produced a 3D printed interior for a 3D printed house (National Design Academy). "These interiors are massive, beautiful walls or "vessels" within the house that look like enormous sculptures from the outside," they explain. They can quickly manufacture lightweight interior walls to partition interior space using both cement polymer and their unique substance Saltygloo (National Design Academy).

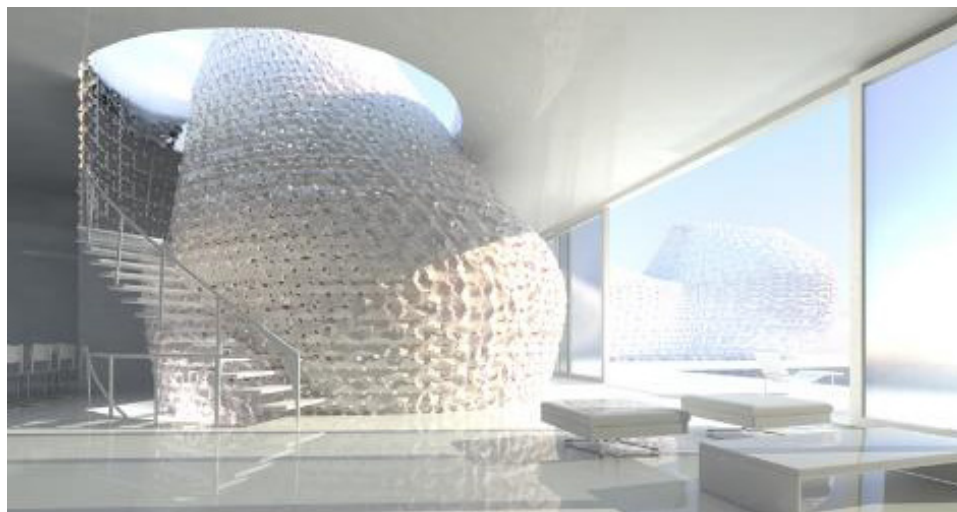


Figure 1. An Interior space made of 3D Printed mixture obtained by salt and glue constituting an efficient, translucent and inexpensive material.

Many architects and interior designers are utilising 3D printing to develop fresh and unique designs that give a property's entire environment a truly modern and global appearance. Designers are no longer restricted by technical limits for any object thanks to greater design flexibility provided by 3D printing. The interior cladding is made up of 3D printed biological vessels made of salt polymers, while the outside cladding is made up of polymer printed blocks (Figure 1). They can express their creativity to the fullest and create one-of-a-kind designs that were previously impossible to achieve using traditional production methods (Roberto and Ingrid, 2015).

In reality, 3D printing saves time because a single part may be manufactured in a matter of hours rather than the days or weeks required by traditional methods. They no longer have to rely exclusively on what is available on the market; these designers may also allow clients to choose the colour and size of the product while maintaining the design (Chen, 2015). With improved access to 3D printing, architects and interior designers are no longer required to seek for materials to complete their projects, as material selection is gradually but steadily becoming an integral part of the interior design process.

6. Case studies

The various modern trends in 3D printing technology with reference to building construction system that have been employed in contemporary architecture around the world through three case studies have been analysed. The following three case studies discuss and illustrate how various technological concepts have been realized architecturally.

6.1 Case study 1: Juice Bar at Loft Flagship Store

Loft, a Japanese department store, has reopened its flagship building in Tokyo's Ginza district (Figure 2). Exclusive DUS 3D printed furniture is featured in the interior design: A one-of-a-kind look at 3D printing, new materials, and old crafts (House of Dus).



Figure 2. Juice bar at Loft Flagship Store.

The Loft Flagship store's 3306 Sq. M total interior design was handled by Schemata architect Jo Nagasaka. He challenged DUS to create "new 3D printed furniture." Clients Loft recognised the need of constantly finding new ways to distinguish themselves and promote their items as a household name warehouse. DUS responded by creating five custom settings that showcase the best features of each product category (House of Dus). DUS merged 3D printing with new and familiar materials influenced by old techniques to create whole new functionality and tactile characteristics.

The Juice Bar Kiosk at the Loft Flagship Store uses 3D printed solutions to produce statement furniture pieces that mix aesthetics and usefulness. To produce recurrent printed patterns that translate into the Form, the company draws inspiration from Japanese folding and drawing techniques (Figure 3). The Juice Bar achieves transparency by printing semi-open screens with the ability to open and close, revealing circular internal patterns (Ami). To provide an attractive and sensual experience for clients, the idea envisions 3D printed furniture in six various typologies throughout the store.

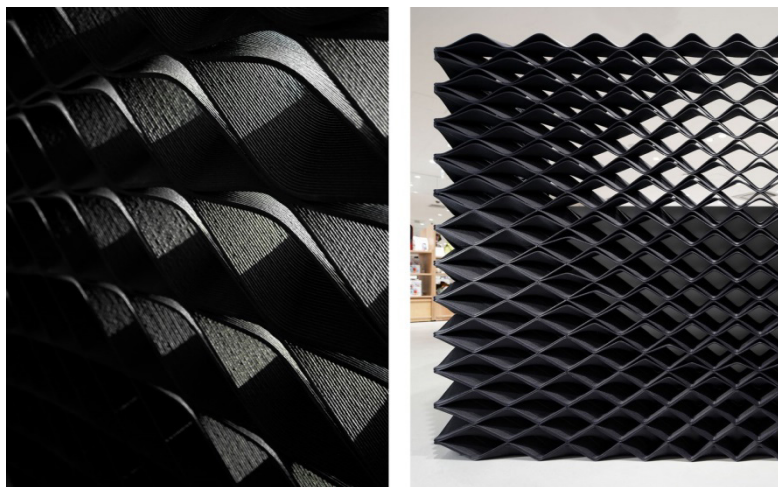


Figure 3. Recurrent 3D printed patterns closed views at Loft Flagship Store.

The Juice Bar in the 'healthy cooking' department serves as a showcase for the juicers and kitchen machines on the surrounding shelf. Japanese paper screens inspired the open design. The printed three-dimensional panels are detailed to the point where the bar appears to be a single monolithic structure. The surface appears solid at first glance, but closer inspection reveals detailed patterns that play with light, texture, and colour (House of Dus).

6.2 Case study 2: SuperMod by Simplus Design

Sebastian Misiurek and Arianna Lebed, the founders of Simplus Design, created and built Supermod, a modular wall system. The design firm's residency at Bold Machines, the Innovation Workshop at Stratasy, resulted in this extremely useful item. Bold Machines is a cutting-edge firm that uses 3D printing and the most cutting-edge technology in the industry. It is made up of enthusiastic, young people that believe in the potential of 3D printing to change the way we live in the future. Simplus Design's modular wall system is both functional and visually appealing, serving as storage and space dividers while also serving as a wonderful piece of furniture in its own right (Andreas). This unique wall is made up of various sized modules that may hold a wide range of everyday and ornamental items such as plants, books, and spirits (Figure 4). The system is incredibly adaptable, as the modules may be separated and rearranged to suit any purpose or preference. It is also designed to be versatile in space, able to function as a decorative element on its own or as a porous partition dividing and complementing

spaces (Andreas). The modules' exteriors feature a level of detail that has been created to reflect light and cast shadows in a variety of angles and forms. On the inside of the modules, the detail design pattern is scaled down and illuminated during the day and night. Light can permeate the modular wall and produce dazzling effects that enrich the ambience of the interior space, thanks to the use of 3D printed materials of varied opacities ranging from opaque to translucent (Figure 5).



Figure 4. Supermod by Simplus Design.

Supermod is another another example of 3D printing's limitless potential. However, 3D printing is not a new technology, and it should not be regarded as such, as the first 3D printed designs date back decades (Ami). It has progressed to the point that we now have the technology and technical know-how to make practically whatever we choose. A radical mode of manufacturing that alters our thinking, working, designing, and living. Today's artists, architects, designers, and innovators have more options and opportunities than ever before, but this isn't always a good thing. It's easy to become so enamoured with this superior technology and its practical method of manufacture that we forget to design and instead rely on the machine. 3D printing should be viewed as yet another form of convenience in our lives, one that is driven by our desire for design, innovation, and creative thinking (Andreas). Finally, designers should be inventive and observant. 3D printing has a bright future, in my opinion.

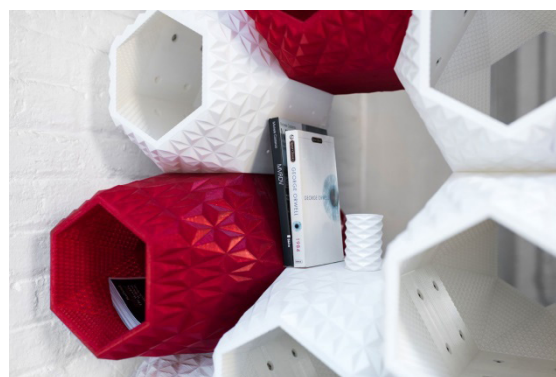


Figure 5. Modular wall system, acting as a shelf.

6.3 Case study 3: Stratasys — 3D Printed Chair

Zaha Hadid Architects (ZHA) began by designing a very lightweight chair (Figure 6) that utilised its geometry, details, and manufacturing to highlight and improve its performance (Zaha Hadid Architects, 2015). ZHA evaluated the loading situation of a person sitting down when investigating the design potentials of the structural optimisation process, and used the optimisation results to produce a structural pattern that deploys material density and depth where structurally required (Jakob, 2016).



Figure 6. Stratasys – a 3D printed chair design.

The designers were then able to include these structural features into the design using the superior capabilities of Stratasys' Objet1000 Multi-material 3D Printer. Stratasys was able to 3D print the chair with a range of colour and opacity, from transparent to opaque cyan, to indicate the structural performance of each area (Figure 7).

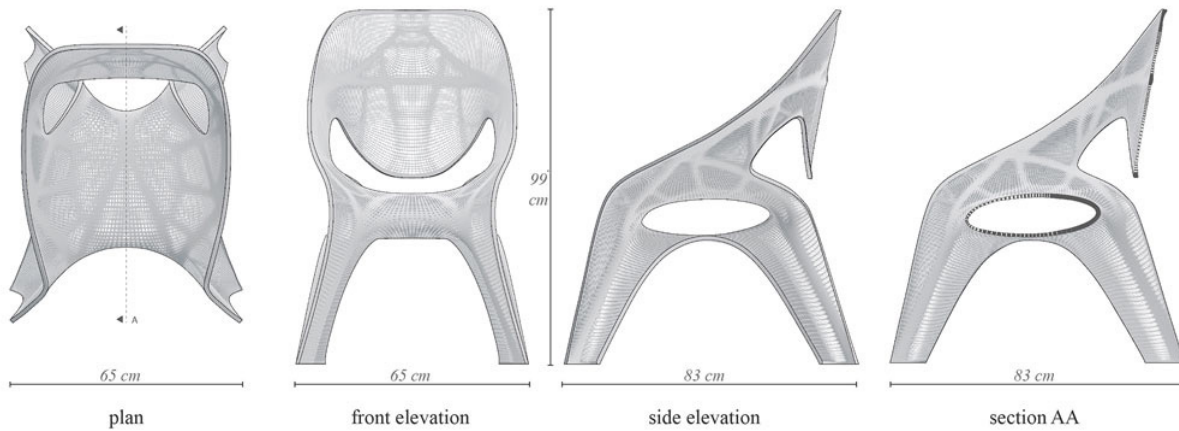


Figure 7. Plan, section and elevational details of the chair

The chair has been reproduced in a variety of colours and modifications since the development of the first 3D printed prototype in 2014. The starting point for ZHA was to develop a relatively lightweight chair that used its geometry, detailing, and construction to highlight and improve its performance (Figure 8). It was created expressly to investigate the possibilities of multi-color, multi-material 3D printing (Zaha Hadid Architects, 2015).

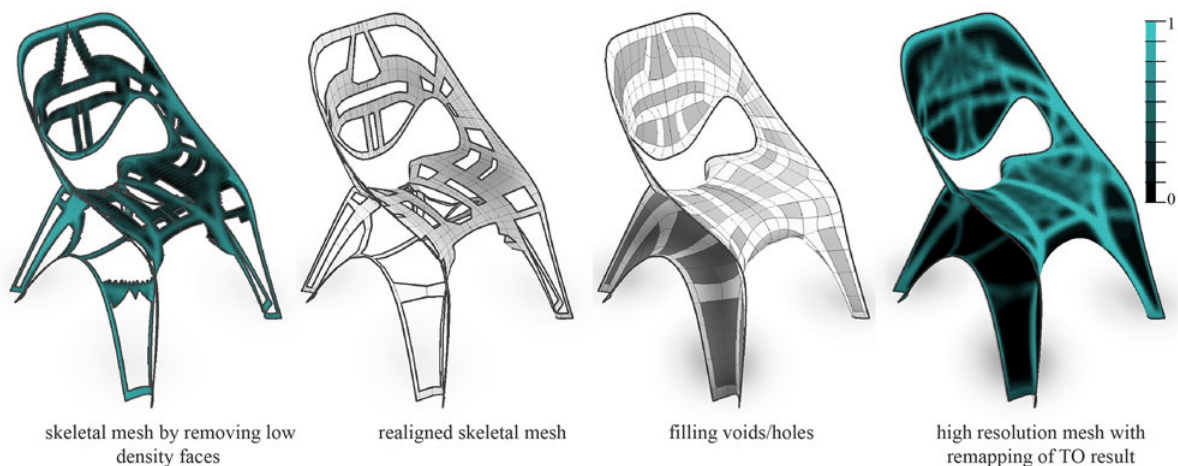


Figure 8. Structural form- finding

6.4 Case study 4: Queen, Rhea, Ombra – Lamps

At VDF's cooperation with Ventura Projects, Hola Studio will debut three 3D-printed lights that are meant to be whimsical and emotional (Lizzie, 2020). Hola Studio creates lights that are both whimsical and emotionally involved in nature using 3D printing (Figure 9). These 'emotional design principles' enable for lamp customisation and modification in response to human contact. The studio wants to start a conversation about consumerism habits and encourage emotional attachment between people and things. To reduce overproduction and waste, these lamps are printed on demand in a sustainable manner (Ami, 2022).



Figure 9. 3D printed lamps by Hola Studio.

Hola Studio is a new design studio specialising in 3D printing lighting and taking a "emotional design approach." For the VDF x Ventura Projects collaboration, the firm is showcasing three of its most recent designs, Queen, Rhea, and Ombra. Hola has created each lamp to be emotionally appealing. Ombra, for example, changes colour when touched, and Rhea may be customised. They're also printed on demand to avoid waste and overproduction. The studio's goal is to create a "emotional attachment between the user and the used object," which would push people to reconsider their consumption habits (Lizzie, 2020).

6.5 Case study 5: 3D-printed lamp

Paris-based artist duo Linlin and Pierre-Yves Jacques merged interior design and 3D printing in their latest gorgeous creation- a lace-patterned light (Figure 10). When turned on, it creates lovely floral patterns on the walls of your room (Audra, 2015). For a dazzling impact, its little elements have been enlarged on the walls and ceiling.



Figure 10. 3D printed lamp by LP Jacques

Traditional lace served as inspiration for the designers, who digitally recreated its qualities. They claim that the technology enabled them to bring their grandiose concepts to reality, as well as provide enhanced carved details that would not have been possible without 3D printing (Sara, 2014).. Between the thin white stems are microscopic shapes and textures that imply the look and feel of actual lace (Figure 11).



Figure 11. Lace patterned light looking pretty decent.

7. Benefits of 3D printing services in interior and product design

Interior design is a highly competitive field, and architects face stiff competition with every project they begin, especially when clients have a wide range of options. To stand out and stay ahead of the competition, interior design firms must strive for success and inventiveness. In the future, they should be able to win more projects.

7.1 Showcase complicated design in greater details

A 3D printer is an important tool for creating and inspecting complicated features like the façade and the finely textured roof. These intricate and precise features, which would be difficult or impossible to design accurately by hand, may be quickly accomplished using 3D printing online (Makenice, 2021).

This will help clients comprehend how the features would appear in real life and improve their visual perception. To bring the model to life, it might also show how shadows and sunlight would appear during the day.

7.2 Experiment with different materials and colors

A 3D printer is an important tool for creating and inspecting complicated features like the façade and the finely textured roof. These intricate and precise features, which would be difficult or impossible to design accurately by hand, may be quickly accomplished using 3D printing online (Makenice, 2021).

7.3 Reduce manual labour by a significant amount and save hours of overtime

Making a construction interior design by hand is a tedious and time-consuming procedure that necessitates perseverance in order to generate high-quality results. Manually creating a conceptual model out of cardboard, foam, or wood might take several days depending on the size and level of detail.

Manually building a finished model requires a lengthier timeframe, which can take several weeks. This is a considerable time investment for a single model, and using a 3D printer would drastically reduce the timeframe with economical 3D printing services (Makenice, 2021). The technology eliminates all of the measuring, cutting, bonding, and other human labour required to build a complete model, giving architects more time to focus on their design.

7.4 Make multiple copies

Many different versions of the final model can be easily created, and the 3D print online image can be saved indefinitely for future reference. Given the traditional methods of model construction, the capacity to swiftly manufacture several replicas is extremely unique. This enables the interior designer to give a scale model reproduction of the project to their clients and partners (Makenice, 2021).

8. Future of 3D printing in interior design

Despite the fact that 3D printing (Stereo Lithography, Fusion Deposition Modelling) has been known since the early 1980s, it has been slow to gain traction. There are many various viewpoints on where the technology will go, but it will become more cost effective in a variety of industries, allowing for further research and mass customization in interior architecture. Despite the fact that 3D printing is still in its early stages across many industries, the potential benefits of the technology appear to be moving it forward. Some believe that 3D printers will mostly be utilised in factories or on-site to make building components and panels, while others see 3D printing as a transformative technology that will change the construction industry.

9. Conclusions

With urbanisation increasing in many developing nations, innovative approaches to improve the long-term performance of the interior in which people live and work are urgently needed. Interior designers benefit from the use of 3D printing and related technology in their creative studies, allowing them to improve their design inventiveness. 3D printing is an appealing and powerful tool for reducing manufacturing costs and exploring intricate and distinctive forms that were previously difficult to create with traditional production techniques that can only produce limited forms. In the case studies above, designers generated bar loft, chair design and lighting appliances with varying levels of originality and creativity in response to the problems of making the design. Designers are able to express themselves more creatively if this technology is used correctly and appropriately. As a result, there's no denying that 3D printing all around the globe is wonderful and useful in the field of interior design. In the future years, the technique will most likely be gradually implemented in the industry. It needs to be observed how much these gadgets are used on-site or if they are only employed as a pre-manufacturing tool. It is reasonable to expect 3D printers to join the arsenal of tools available to interior designers with the right kind of project.

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