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Reviving Anatolian Heritage through Technology: 3D-Printed Textile Surfaces Based on Göynük Motifs

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Abstract

Anatolian motifs remain vital components of Turkey's cultural heritage, serving as visual narratives that convey symbolic meaning, collective memory, and regional identity. Traditionally embedded in handcrafts such as weaving, embroidery, and textile design, these motifs have long functioned as a form of non-verbal communication. However, with the onset of industrialization, population growth, and the increasing demand for standardized, high-volume production, the use of such motifs in artisanal practices has significantly declined. This study explores the potential of digital fabrication to revive and reinterpret traditional designs by focusing on *Tokalı Örtmeler* (buckled coverings) from the Bolu-Göynük region. Among twenty-two original motifs documented through field research, five were selected for experimental development. These motifs were digitally redesigned and transformed into three-dimensional textile surfaces using accessible additive manufacturing tools. The process utilized 98A TPU Flex filament—chosen for its elasticity and suitability for fashion and textile applications. The experimental surfaces were produced in domestic settings using a consumer-grade 3D printer. Of the surfaces developed, two were selected for application-based testing under controlled design constraints. The study confirmed that 3D printing enables the creation of structurally innovative, culturally grounded surfaces that can be integrated into interior design or wearable products. By digitally archiving and adapting traditional motifs, this research offers a contemporary platform for the preservation, reinterpretation, and intergenerational transmission of intangible cultural heritage.

Keywords: Experimental Textile Design, Anatolian Motifs, Cultural Heritage Preservation, 3d Printing In Fashion, TPU Flexible Filament Entrance

The aim of this study is to investigate how three-dimensional printing technologies can be utilized in textile surface design, to highlight the advantages offered by this technology, and to evaluate the potential impact and contributions of cultural values within the design processes. The textile and fashion sector is a dynamic field that requires innovative solutions, particularly in the context of sustainability. Surface decorations observed at every stage of human life initially emerged with the individual painting his or her own body, then evolved with the shapes drawn on cave walls and over time manifested themselves as decorative elements on textural surfaces. This decorative practice emerged as an individual form of expression throughout history, and later developed into traditional art forms at local, national and global levels [1]. Today, Mesopotamia is more than just a geographical region; it is an important settlement that has encompassed the history of civilization and has a special place in the world with its unique natural beauty. In terms of cultural heritage, the written and unwritten, audiovisual riches of Mesopotamia that have survived to the present day and will be carried into the future reveal the historical depth of this region. The motifs that are a part of this heritage and are considered a kind of non-verbal communication tool in Anatolia are also among the cultural richness of Mesopotamia. Motifs can often be encountered in the edge decorations of a manuscript, in the pattern of a rug, or on a tombstone. When we look at the main motif types in Anatolia, various groups such as Anatolian Folk Art Motifs, Anatolian Carpet and Kilim Motifs, Anatolian Stone and Woodwork Motifs and Anatolian Hand Embroidery Motifs stand out, as well as Seljuk and Ottoman motifs [2]. Motifs can acquire various meanings in different cultural contexts and can be interpreted in different ways. In the field of art and design, motifs are important means of expression that provide integrity to works by providing them with aesthetic richness and depth of meaning. Motifs have an important place as structural elements carrying cultural meaning, especially when evaluated within Classical Turkish Handicrafts. (Duran, 2002: 158). The depth of the concept of motif adds different layers to works of art with its features such as its meaning, form and purpose of use. Motif is,

as Veselovski defines it, "the smallest indivisible building block of the story [3]. This definition by Veselovsky means that a motif has its own meaning, an independent value. Motifs are the smallest unit of a narrative or visual design, but they are complete in themselves. Motifs are considered symbols that communicate without a language [4]. Each motif carries meanings that often vary depending on the region in which it is used, sometimes universal and sometimes culture-specific. Motifs express the feelings and thoughts of societies through their colors and shapes. Motifs are pattern elements that repeat in a composition and generally provide the overall integrity of the work. This repetitive structure creates a rhythmic order and adds aesthetic integrity to the work. The "tulip" motif, frequently seen in Ottoman tile art, is repeated regularly and adds an elegant rhythm to the composition. This repetition expresses both the aesthetic integrity of the work and the artist's admiration for nature. Motifs are not only a decorative element; they are also a story carrier [5]. Every line, color and form in the motifs contains a piece of the culture of that society and reflects the user's connection with the past. The "elibelinde" motif, which extends from Central Asia to Anatolia, reflects the posture of a woman with her hands on her waist and symbolizes fertility and abundance. The use of this motif in carpets and rugs expresses the artist's relationship with nature and the cycle of life. The motif conveys the designer's or artist's personal style, subject and aesthetic values. The Göynük district of Bolu, located in the Black Sea Region, is known for a special headscarf called the "Göynük Tokalı Örtme", which contains local and traditional motifs. This headscarf contains both local motifs and symbols used throughout Anatolia. The Göynük Buckled Covering is not only a religious covering tool, but also a cultural element that expresses the identity of the region [6]. Göynük is an Anatolian town that combines Ottoman and Byzantine heritage. It has a multi-layered cultural structure, both as a classical town of the Ottoman Empire and as the host of the Byzantine Empire. The Victory Tower and old Ottoman houses in Göynük reflect the efforts to preserve the historical texture of the region. These structures, which have been preserved for centuries, are concrete examples of the town's cultural diversity. The use of traditional covers such as the Göynük Buckled Covering is also an indication that the town continues the covering habit from Ottoman culture. Traditional clothing used in Anatolia was designed to provide women with more privacy in public areas. Dark colors and thick fabrics were generally preferred in such clothes to serve the need to cover up. Headscarves and other covers used in Anatolia present a cultural identity with their local motifs and patterns and also serve as a means of communication. These motifs reflect the cultural identity of the geographical region to which the cover belongs. A woman wearing the Göynük Buckled Covering shows that she shares the cultural values of Göynük and her sense of belonging to the region. In addition to the traditional motifs added to women's headscarves, especially during the Ottoman period, symbols from Byzantium are also found on headscarves and traditional clothing. This is an expression of Göynük's multi-layered cultural structure. Covering practices are a heritage where traditional clothing is kept alive in certain ways even in modern life. These practices, which have maintained their continuity throughout history, can still exist in rural areas today. Göynük's continuation of old Ottoman houses, bazaars and headscarf traditions shows the town's efforts to preserve its unique culture. Thus, Göynük stands out as an example that maintains its historical identity in the modern world (Figure 1).

Figure 1: Goynuk Houses- Turnalar Konağı Url 1: https://www.mustafacambaz.com/details.php?image_id=15648&mode=search

Traditional headscarves such as the Göynük Tokalı Örtme are a concrete example of this cultural heritage. Such headscarves offer a valuable heritage as part of the multi-layered culture of Anatolia (Figure 2).

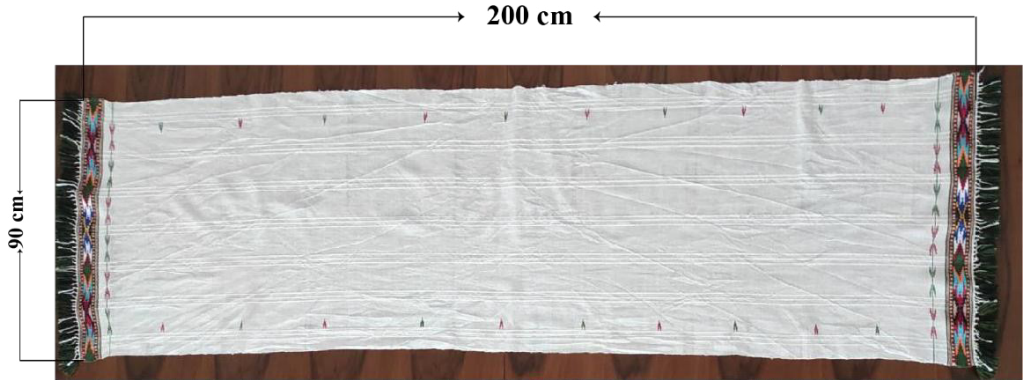

Figure 2: Göynük Tokalı Örtmeleri Goynuk Municipality Local Handicrafts Center, 2023, Serhat Güven

Although there is no clear information in historical sources about the use of "Tokalı Örtme" as a headscarf, it is known that this type of weaving has a very old history in the region. "Bolu Göynük Tokalı Örtme" consists of two pieces and has patterns on the short sides and the areas corresponding to the top of the head. On the short edges, there are colored tassels called "buckles". The covers are generally woven with twisted cotton threads in a plain weaving technique, 90-100 cm wide and 170-200 cm long, cotton is used in the warp and ground weft, and cotton or silk threads are used in the patterned parts. However, today, due to the decline of traditional handicrafts and the spread of industrial products, the production and use of Göynük Buckled Coverings has decreased.

After the rapid development of technology after the industrial revolution and the integration of automation systems into production, increasing consumption needs bring about a more dynamic process understanding. CAD and CAM are systems that both carry out the design process in a digital environment in fashion design and automate production. CAD programs accelerate the design process by facilitating two-dimensional and three-dimensional modeling. CAM, on the Adidas used CAD/CAM technologies to develop the "Futurecraft 4D" shoe model. The sole of the shoe was created through a digital design process and then produced using 3D printing technology (Figure 3). This is an important development for sustainable fashion, as it speeds up the transition from design to production, enabling the mass production of products with complex structures.other hand, enables digital designs to be put into production quickly and precisely [7].

Figure 3: Futurecraft 4D Shoe Model Url 3: https://highxtar.com/gucci-garden-nos-presenta-su-nuevo-mundo-virtual/

Another element that is increasingly used for circular production and green processes is simulations. Simulations and avatars are virtual models that can realistically show how clothes and accessories will look in a digital environment. These virtual design processes allow designers to try on products in a virtual environment without having to produce real samples, thus reducing costs and time loss. Software such as CLO 3D and Browzwear, which are used to bring fashion to life in a virtual environment, allow designers to see in advance how clothes will look on avatars by simulating fabric properties. Thanks to these software, the trial and error time in the design process is shortened and the final product is obtained quickly. These products can be presented to consumers in virtual fashion shows or used for character modeling in the metaverse world. The metaverse is a digital world where people can interact with their avatars in a virtual universe. In the fashion industry, the metaverse offers a space where users can buy and try on virtual clothes. This allows the fashion concept of the physical world to be transferred to a virtual universe [8]. Gucci has offered virtual clothing for sale in the metaverse environment and developed virtual accessories for users' avatars (Figure 4). Within the scope of the project called "Gucci Garden Experience", users can experience Gucci clothing in a virtual environment and access the brand's new collections [9].

Figure 4: An Example from the Gucci Garden Experience Project Url 2: https://stockx.com/adidas-futurecraft-4d-daniel-arsham

The technology that acts as a bridge between the virtual world created by digital characters and the real world is hologram technology. Holograms are a technology used to create three- dimensional images. In the fashion industry, holograms are utilized in product presentations, fashion shows, and exhibitions to provide a more immersive visual experience. In 2018, Burberry employed hologram technology during a fashion show held in Shanghai, where garments were showcased virtually on the runway. This offered attendees both a digital and physical experience, pushing the boundaries of traditional fashion presentations. Hologram technology enabled viewers to perceive the garments in a different dimension, adding an innovative aesthetic to the show. Another rapidly advancing technology in the fashion

world is artificial intelligence (AI). AI can analyze data to assess user preferences, provide design suggestions accordingly, and predict future fashion trends. This enables designers to create personalized and data-driven designs. The fashion brand Stitch Fix, for instance, employs AI algorithms to offer personalized fashion recommendations to its customers. By analyzing customer data, the AI system learns individuals' preferred styles and provides personalized styling suggestions Url 4: https://newsroom.stitchfix.com/blog/how-were-revolutionizing-personal-styling-with-generative-ai/.

This technology serves as a compelling example of how artificial intelligence is transforming user experience in fashion retail. Three-dimensional (3D) printing technologies represent a significant tool for adapting cultural motifs into contemporary designs. The reinterpretation of cultural assets in digital environments facilitates the integration of endangered cultural values into modern fashion. 3D printing technology creates physical objects by layering various filaments such as plastic, polymer, and biomaterials. In the textile industry, this technology enables the creation of original textile surfaces in terms of texture and pattern. Renowned fashion designer Iris van Herpen is known for her collections that incorporate intricate and organic patterns produced through 3D printing. In van Herpen's work, digitally created textile surfaces add tactile richness to the designs and make possible details that would be difficult to achieve through traditional craftsmanship. Moreover, 3D printing technologies allow for the design and production of items tailored to the individual needs of consumers, thus strengthening the trend of personalized fashion. Footwear, garments, or accessories produced for a single customer can be fabricated rapidly and efficiently using 3D printing. The American brand Feetz, for example, manufactures custom 3D-printed shoes based on users' foot measurements. This technology enables the production of personalized items that fit the customer's dimensions precisely Url 5: https://www.prnewswire.com/news-releases/feetz-brings-3d-printing-to-dsw-customers-300345621.html. This approach not only offers a personalized experience for the customer but also contributes to waste reduction. In the fashion industry, the filaments used in 3D printing directly influence the texture, flexibility, and durability of the design. The selection of elastic and soft filaments is particularly important in textile design; however, not all filaments possess these properties, which limits designers to a narrow range of material options. Flexible filaments such as FlexyFil and ThermoFlex are commonly used in the textile sector. For instance, textile surfaces produced with FlexyFil provide both softness and flexibility.

Designing with 3D printers differs significantly from traditional fabric production processes and requires proficiency in digital modeling. For designers, mastering digital modeling software is a crucial step in the creation of three-dimensional textile surfaces. Acquiring digital skills represents a new learning process for fashion designers. Software such as Clo 3D and Rhino enables designers to visualize their creations in virtual environments through digital modeling. However, gaining expertise in these tools requires a dedicated learning period, and for designers trained in conventional fashion education, these digital platforms represent new competencies that must be developed. Furthermore, 3D printers and filaments continue to be costly within the textile industry. To facilitate the widespread adoption of 3D printing technologies, it is essential to reduce these costs and increase the accessibility of the technology. While high-end fashion brands can afford to create 3D-printed collections with large budgets, smaller designers and emerging ventures often have limited access to such technologies. For instance, independent designer Danit Peleg produces 3D-printed garments but offers limited collections due to the high costs involved.

Today, fashion is creating a new aesthetic by merging the cultural heritage of the past with modern technologies. Traditional motifs, patterns, and craftsmanship are being integrated with contemporary digital design tools, simultaneously preserving ancient cultures and enriching modern fashion. Japanese fashion designer Issey Miyake, for example, incorporates traditional Japanese folding and origami techniques into his modern designs (Figure 5). Through Miyake's work, a bridge is established between cultural heritage and contemporary fashion by combining traditional Japanese aesthetics with innovative fabric technologies.

Figure 5: Issey Miyake, Collection "Pleats Please" (Url 6) https://eu.isseymiyake.com/pages/pleatsplease#section3

The reinterpretation of motifs traditionally used in Göynük Tokalı coverings through digital platforms and their application onto textile surfaces via 3D printing represents an approach that merges the traditional with the contemporary. Such projects contribute to the preservation of cultural heritage while enabling its transmission to future generations through innovative methods. In this way, these Anatolia-specific motifs can be introduced to the global fashion industry through textile surfaces developed with 3D printing technologies. In Anatolia, each motif carries its own unique meaning while also contributing to a greater composition as part of a cohesive whole. It has been noted that Turkish motifs and clothing culture reflect significant aspects of the Anatolian way of life and worldview [10]. Therefore, the significance of Turkish motif and clothing culture, as well as the profound belief in the meaning of motifs in Anatolia, becomes evident. The "Tree of Life" motif commonly found in carpets carries an independent meaning; it symbolizes life, fertility, and rebirth. However, when combined with other motifs, it conveys a broader narrative and forms a cohesive composition on the carpet. The integration of the Tree of Life with various other motifs provides a deep cultural narrative that reflects the beliefs and values of the community in which the carpet was woven. Turkish motif and clothing culture symbolize both the lifestyle and worldview of the Anatolian people. Each motif reflects the intellectual and cultural framework of the society in which it was created, offering a visual expression of specific beliefs and symbols. For this reason, motifs stand out as essential elements that define cultural identity [11]. For example, in Turkish clothing culture, the *elibelinde* motif symbolizes abundance and fertility. In Anatolia, this motif is frequently used in women's garments to represent fertility, productivity, and the significant societal role of women. The symbolic meanings embedded in these motifs contribute to the intergenerational transmission of social values. In Anatolian culture, motifs are believed to carry specific symbolic meanings that are often linked to societal beliefs. Each motif is designed with a particular purpose, such as protecting individuals from evil spirits, bringing happiness, or ensuring prosperity. This belief system positions motifs not merely as decorative elements but also as protective symbols. The ram's horn (koç boynuzu) motif, commonly found in Anatolian kilims, symbolizes strength, power, and protection. Its inclusion in kilims traditionally hung in the homes of newlyweds is thought to represent the strength required to build a family and provide protection for the couple. The meanings attributed to such motifs hold profound spiritual and cultural significance in Anatolia, making them an essential part of the intangible heritage that must be preserved within its cultural context. Motifs hold a significant place in the collective memory of Anatolian society and are utilized as expressions of cultural identity. As these motifs are transmitted from one generation to the next, they provide valuable insights into the community's way of life, values, and belief systems. The traditional motifs used in Göynük reflect the cultural identity of the region. The motifs found in Göynük Tokalı Örtmeleri (buckled coverings) bear traces of both Ottoman and Byzantine cultures, showcasing the cultural richness of the area as well as the historical periods they represent. Such motifs serve as carriers of Göynük's historical continuity and identity, preserving and conveying its heritage to the present day. This process not only preserves cultural heritage but also universalizes it by reinterpreting it through an innovative perspective. For example, contemporary fashion designers inspired by Anatolian motifs incorporate these traditional elements into modern garments, thereby introducing them into the context of contemporary fashion. The use of Anatolian motifs in the jewelry designs of Sevan Bıçakçı exemplifies how the aesthetic values of Turkish culture are presented to the global fashion scene, contributing to the representation of cultural heritage on international platforms (Figure 6).

Figure 6: Sevan Bıçakçı, Hagia Sophia Collection-Ring Url 7: https://www.sevanbicakci.com/urunler/yuzukler/mosqu%C3%A9e-magnifique

Efforts to preserve cultural heritage strengthen the identities of communities and ensure the continuity of historical values. Within the scope of cultural heritage projects conducted in Turkey, the exhibition of garments and carpets featuring Anatolian motifs in museums plays a vital role in preserving and introducing these motifs to new generations. The Mevlana Museum in Konya, for instance, houses a rich collection of Anatolian carpets and kilims, serving as a cultural repository that sustains and promotes the legacy of Anatolian motifs.

Clothing in Goynuk

Göynük stands as a living representation of history due to its success in preserving and sustaining its folkloric characteristics. In terms of traditional clothing, garments such as *bindallı, üç etek,* and *top entari* (Figure 7). have been commonly preferred in the region, reflecting its rich cultural heritage.

Figure 7: Three Skirts on the Left, Bindalli on the Right, Özdemir 2009: 96

The most distinctive feature of the traditional attire known in the region as "Ağır Kıyafet" (Elaborate Garment) is its adornment with a bindallı, complemented by a silk shirt, şalvar (traditional trousers), fes (Ottoman-style hat), and a silver belt worn around the waist. Additionally, the described üç etek ensemble is commonly observed at weddings. During religious ceremonies such as mevlit gatherings and at weddings, another traditional garment known as top entari is typically worn. These descriptions reflect the cultural richness and traditional clothing styles of Göynük. As one of the rare Anatolian towns that has preserved its unique characteristics and historical fabric through various historical periods, Göynük possesses a remarkably rich tradition of handicrafts. Among these, the Göynük Tokalı Örtmeleri (buckled coverings) hold a particularly significant place and continue to exist today as a valuable historical and cultural heritage (Figure 8). In Göynük, traditional coverings are woven on looms known as düzen. These coverings are typically produced as fine cotton cloths. The ground of the fabric is generally white and woven in a plain weave structure, commonly referred to as bezayağı.

Figure 8: Weaving Looms Called "Düzen", Goynuk Municipality Local Handicrafts Center, 2023, Serhat Güven

In Göynük culture, coverings are traditionally included in a bride's dowry and presented as gifts to the groom's close relatives. The central motif of the covering is designed to align with the top of the head when worn. In the headscarves known as Tokalı Örtme, a distinctive tying method is employed both simple and decorative featuring a buckle (toka) as an ornamental element [12]. These explanations reflect the traditional textile products of Göynük and their cultural significance. The *örtmeler* also stand out as integral elements of the dowry tradition and local clothing culture. Göynük *Tokalı Örtmeleri* hold the distinction of being the first and only geographically indicated product of the Bolu region. In Anatolia, head coverings widely used and considered essential accessories in traditional attire hold particular importance as complementary components of clothing.

Motifs Used in Göynük "Buckled Coverings"

In Göynük coverings, it is possible to observe both motifs commonly used throughout Anatolia and those specific to the region's local culture (Figure 9-10). Above all, the motif has served as a non-verbal form of communication. With their profound symbolic meanings, these motifs have not only decorated the edges of the coverings but have also elevated them to the status of historical documents.

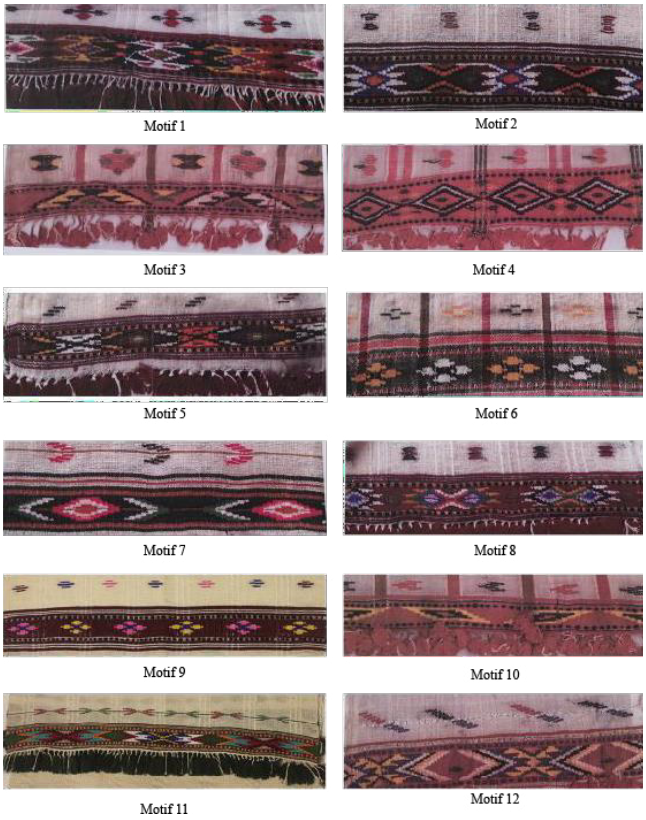

Figure 9: Motifs Used in Göynük "Buckled Coverings"-1, Goynuk Municipality Local Handicrafts Center, 2023

Figure 10: Motifs Used in Göynük "Buckled Coverings"-2, Goynuk Municipality Local Handicrafts Center, 2023

3D Printer Technologies

The idea of obtaining a three-dimensional visible print of a digitally designed object dates back to the 1970's. Although initial attempts were unsuccessful, significant progress began to emerge in 1981. Dr. Kodama pioneered the field by developing a rapid prototyping technique, producing the first successful examples in this domain. His achievement was based on the technique known as stereolithography, or SLA (stereolithography apparatus), which involves curing material with light through a scanning process. This method introduced the concept of layer-by-layer fabrication and marked a major breakthrough in additive manufacturing. As a result, the production of complex objects became feasible. In 1986, Chuck Hull played a pivotal role in the advancement of 3D printing technology by filing the first official patent for stereolithography (SLA). He also developed and commercialized the STL (Standard Tessellation Language) file format, which was essential for converting digital models into a language comprehensible by 3D printers. This innovation marked a significant step in enabling the digital-to-physical translation process in additive manufacturing. In 1988, Carl Deckard, a student at the University of Texas, developed a primitive form of what would later become Selective Laser Sintering (SLS) technology, enabling the production of simple plastic components. In the same year, Scott Crump invented the fused deposition modeling (FDM) machine, which laid the foundation for one of the most widely used 3D printing techniques today. Subsequently, in 1993, MIT professor Emanuel Sachs introduced the term "3D Printing" into the academic and industrial lexicon, replacing the previously used concept of "rapid prototyping" in reference to this emerging technology. In this study, a three-dimensional printer utilizing Fused Deposition Modeling (FDM) technology was employed in the design of experimental textile surfaces. Fused Deposition Modeling (FDM) technology was developed by Scott Crump in the 1980s and was later commercialized by Stratasys, founded in 1988. The working principle of FDM involves feeding a thermoplastic filament into a heating chamber, where it is melted and extruded through a nozzle. As the molten filament is deposited layer by layer, it solidifies upon cooling (Figure 11).

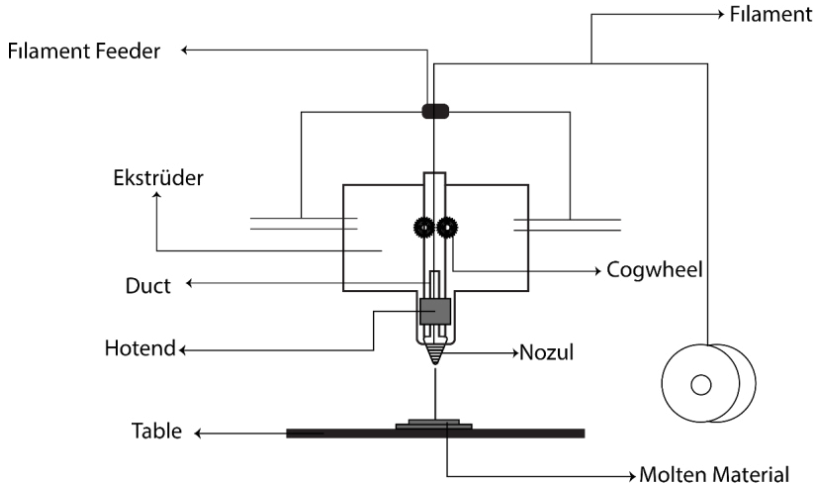

Figure 11: FDM Working Model, Serhat Güven, 2025

Methods and Materials

Experimental textile surfaces hold an increasingly significant position within contemporary textile and fashion design research. These studies enable the creative integration of diverse materials, each offering distinct physical properties and aesthetic qualities. When such materials are unconventionally selected and meaningfully combined, it becomes possible to develop innovative designs that exhibit unique color schemes, tactile textures, and functional attributes. In this study, a series of experimental textile surfaces were developed using the *Creality Ender 3 S1 Pro*—a consumer-grade, mid-range 3D printer widely preferred for home use. The materials employed in the fabrication process primarily consisted of flexible thermoplastic polyurethane (TPU) filaments with Shore hardness ratings of 95A and 98A. Polylactic acid (PLA) filament was also utilized where rigid structural elements were required. The design inspiration was drawn from traditional Tokalı Örtmeler (ornamented textile covers) originating from the Göynük district of Bolu, Turkey. These historic motifs were preserved in their authentic essence while being adapted for 3D modeling and digital fabrication. To ensure compatibility with additive manufacturing processes, the motifs were digitally transformed into printable geometries. Adobe Illustrator 2023 was used to generate the initial vector-based technical drawings. The conversion from two-dimensional design to three-dimensional models was accomplished using Autodesk's Tinkercad and Maya software. Subsequently, slicing operations were performed in Ultimaker Cura 5.4.0, which prepared the models for 3D printing by converting them into G-code files readable by the printer.

The design and production workflow followed a systematic and iterative process comprising the following stages:

Vector-to-3D Modeling

Technical motifs were drawn in Adobe Illustrator and exported as Scalable Vector Graphics (SVG) files. These SVG files were then imported into Tinkercad, where they were converted into three-dimensional forms.

Slicing and File Preparation

The 3D models were exported in STL format and processed in Ultimaker Cura. Here, key slicing parameters were

configured, and the files were converted into G-code compatible with the Ender 3 S1 Pro.

3D Printing

The final G-code files were transferred to the printer via an SD card. Numerous test prints—approximately fifty in total—were conducted to refine the material and printer settings.

Parameter Optimization

After optimization, the following printing parameters were fixed for consistent output quality:

- **Material:** TPU filaments (95A and 98A), 1.75 mm diameter
- **Nozzle Temperature:** 238°C
- **Heated Bed Temperature:** 65°C
- **Infill Density:** 15%
- **Top Layer Thickness:** 1.0 mm
- **Bottom Layer Thickness:** 0.6 mm
- **Cooling Fan Speed:** 100%
- **Surface Finish:** Ironing enabled for smoother top layers
- **Retraction Distance:** 2 mm
- **Z-Hop Enabled:** To prevent filament stringing during travel movements

The study demonstrates that by integrating traditional cultural motifs into a contemporary digital fabrication workflow, it is possible to produce innovative textile surfaces that are both functionally viable and culturally resonant. These findings contribute to the expanding field of experimental textile design, offering new directions for sustainable and culturally enriched material innovation in the textile and fashion industries.

Experimental Textile Surface Design with 3D Printer-I

In this experimental design, a motif originating from the Bolu Göynük Coverings was utilized. The primary components of the motif were combined cohesively. In Figure 12, the technical analysis of the motif used in Bolu Göynük Coverings was made for three-dimensional printing.

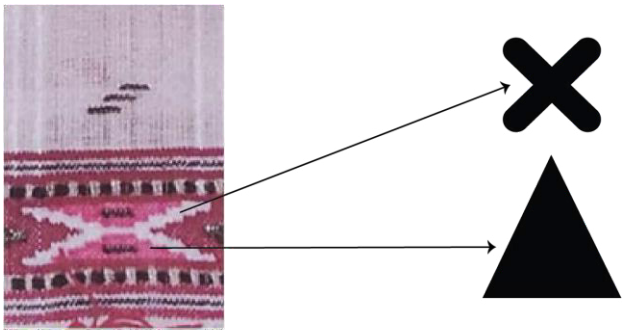

Figure 12: Experimental Textile Surface Design with 3D Printer-I, Technical Analysis, Serhat Güven, 2025

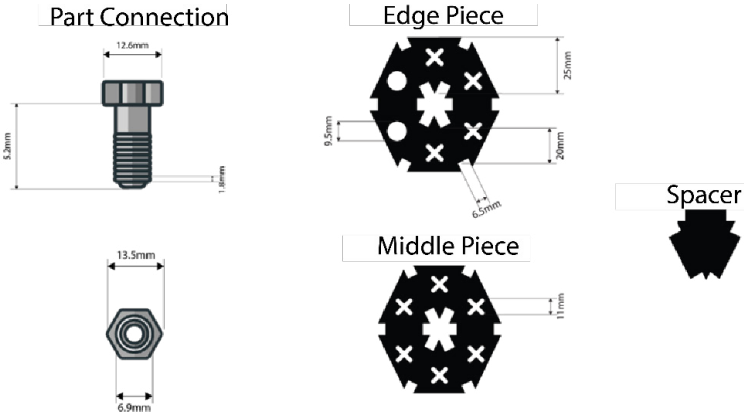

Figure 13: Experimental Textile Surface Design with 3D Printer-I, Technical Drawing, Serhat Güven, 2025

In this study, which aims to create a complete surface, connector pieces were designed to join the surfaces together (Figure 13).while intermediate components were developed to ensure sequential continuity within the surfaces themselves. The experimental textile surface shown in (Figure. 14) was attached to the product using screws without the need for any stitching. The screws on the product can be removed to allow for replacement with models produced in different colors. Due to the flexible nature of the surface, the model conforms to the body shape, and no ergonomic issues were observed.

Figure 14: Experimental Textile Surface Design with 3D Printer-I, Use of the Obtained Surface on the Product, Serhat Güven, 2025

The experimental textile surface can be produced using different materials depending on the specifications of the 3D printer. In this design, created with a consumer-grade 3D printer (Figure 14), a motif from the Bolu Göynük Coverlets was utilized. The selected motif was adapted to be compatible with the printing capabilities of the 3D printer.

Experimental Textile Surface Design with 3D Printer-II

In Figure 15, the technical analysis of the motif used in Bolu Göynük Coverings was made for three-dimensional printing.

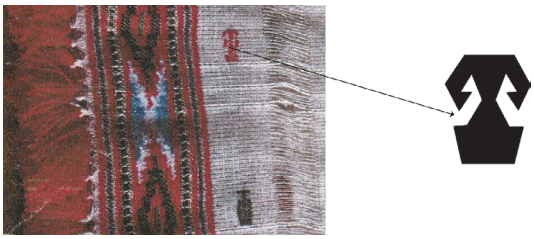

Figure 15: Experimental Textile Surface Design with 3D Printer-II, Technical Analysis, Serhat Güven, 2025

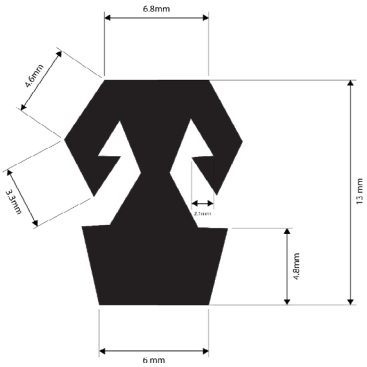

Figure 16: Experimental Textile Surface Design with 3D Printer-II, Technical Drawing, Serhat Güven, 2025

In the surface design illustrated in Figure 16, an octagonal geometric form was utilized. Connection pieces measuring 2 mm in thickness and 1.5 cm in length were arranged (Figure 16). at 30- degree intervals from the center point. Motifs were positioned at the ends of these connection pieces. The design employed 98-A TPU flexible filament. During the printing process, filament stringing issues arose due to the close proximity of the motifs. To resolve this problem, parameter adjustments were made in the Ultimaker Cura slicing software. Specifically, Z-hop was enabled, and a 2 mm retraction distance was applied. The 3D printer's bed temperature was set to 65°C. To address clogging issues experienced while printing with TPU flexible filament, the extruder's internal channel was replaced with a titanium-alloy channel. This modification prevented heat backflow to the nozzle and minimized clogging problems.

Figure 17: Experimental Textile Surface Design with 3D Printer-II, Use of the Obtained Surface on the Product, Serhat Güven, 2025

In Figure 17, the 20 cm x 20 cm lace surfaces were expanded in volume by being adhered to one another. By bonding these surfaces together, a unified form was created.

Conclusion

Mesopotamian motifs have long functioned as a form of nonverbal cultural communication, reflecting the cognitive frameworks, spiritual beliefs, and collective values of societies. These motifs have historically been expressed across various mediums—from stone carvings to handwoven kilims—offering silent yet powerful narratives of daily life. In traditional ceremonies, motif-bearing garments carried symbolic meanings closely tied to the community's spiritual identity. However, the Industrial Revolution initiated a significant decline in labor-intensive crafts, as handmade textile practices gave way to mass production. Although mechanized manufacturing offers cost and time efficiency, it also strips away the individuality and cultural depth intrinsic to traditional craftsmanship. In Turkey, for example, machine-made carpets have largely replaced handwoven kilims, reducing motifs from meaningful symbols to purely decorative patterns. Symbols such as the Mesopotamian "ram's horn," once believed to bring strength, fertility, and protection, have been simplified or omitted in factory production, leading to a weakened transmission of cultural memory. Moreover, the rise of computer-aided design (CAD) and manufacturing (CAM) systems in textile production has accelerated this erosion. While CAD-generated motifs dominate large-scale production, they often lack the personal traces and narrative richness inherent in hand-embroidered textiles. To combat this decline, cultural preservation initiatives, including educational programs and field studies, have gained prominence. In this context, the Tokalı Örtme motifs from Bolu-Göynük represent a unique Anatolian heritage at risk of fading into obscurity. Field research documented twenty-six distinct motifs, five of which were selected for experimental textile design using three-dimensional (3D) printing technologies—tools increasingly employed in contemporary fashion design. The study utilized 98A TPU Flex filament for its flexibility and suitability in textile applications, offering a strategic alternative to more rigid filaments used in prior studies. Despite limitations such as prolonged print times—approximately three hours per motif—ongoing technological advancements promise improvements in printing speed, material efficiency, and environmental sustainability. Innovations

in filament technology, including breathable, biodegradable, and non-toxic materials, further support the integration of 3D-printed textiles into fashion applications. In conclusion, when applied thoughtfully, 3D printing technology presents a powerful opportunity to reinterpret and sustain traditional Anatolian motifs within the modern design landscape. The experimental surfaces created from the selected Göynük motifs demonstrate their applicability in both decorative and functional forms—whether as standalone accessories or components of complete fashion items. These digitally fabricated textiles not only revive endangered visual languages but also contribute to their continued relevance in contemporary cultural expression, ensuring their transmission to future generations. broader applications in the fashion sector. Considering the need to reduce costs for mass production, the application areas of textile surfaces derived from motifs, and production times, challenges arise. For example, producing a detailed motif surface using a home-based 3D printer can take approximately three hours. However, advances in 3D printing technology suggest that these durations will be significantly reduced. Current trends show that newer 3D printers are designed to operate faster and utilize materials more efficiently. Developments in filament technology indicate the potential for breathable, biodegradable, and non-toxic products that are more compatible with textile surfaces, representing a valuable advancement in this field. In conclusion, when used appropriately and in suitable contexts, advancing 3D printing technologies hold the potential to reinterpret the endangered Bolu-Göynük Tokalı Örtme motifs within the fashion industry, generating added value. Experimental textile surfaces produced from five selected motifs—out of twenty-six identified in situ—demonstrate that these designs can be applied to specific parts of a product or form a complete item. Personalized products and accessories with cultural textures have been manufactured in home environments. These efforts illustrate that 3D printing technology can successfully integrate the historically significant "Tokalı Örtme Motifs" of ancient Anatolia into contemporary fashion technologies, ensuring the transmission of this cultural heritage to future generations.

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14. Daniel Arsham, adidas Futurecraft 4D

15. Gucci Garden nos presenta su nuevo mundo virtual
16. How We’re Revolutionizing Personal Styling with Generative AI
17. Feetz® Brings 3D Printing to DSW customers
18. Everyday Life with PLEATS PLEASE
19. Altın, gümüş, pırlanta, sugilite-lapis-pırlanta mozaikli ve içine kubbeli yapı oyulmuş kaya kristalli yüzük.

Footnote

[1]Creating Experimental Textile Surfaces from Bolu Göynük Covering Motifs Using 3D Printers