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IŞIK ELEMANLARININ MODAYA ENTEGRASYONU: UYGULAMA- TEMELLİ TASARIM YAKLAŞIMI

INTEGRATING LIGHT ELEMENTS IN FASHION: PRACTICE-BASED DESIGN APPROACH

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Araştırma Makalesi / Research Article

INTEGRATING LIGHT ELEMENTS IN FASHION: PRACTICE-BASED DESIGN APPROACH

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ABSTRACT: In history, the relationship between fashion and technology has influenced the ever-changing silhouettes of the body, the quality of materials used to construct these silhouettes, and the colors giving liveliness to the material. Today, influenced by the digital revolution and innovation in advanced materials, the fashion industry benefits from the increasing possibilities of technology to develop alternative functions even to the most conventional dress forms, such as wedding gowns. This integration, which necessitates the contribution of different know-how and expertise, also provides a creative platform for developing interdisciplinary, practice-based design research and applications. In this study, an innovative wedding dress using light as a design element was produced with the joint contribution of designers and engineers based in Izmir, considered the capital of bridalwear in Turkey. This project, which considers light as a new design element that increases the expressive power of the dress, aims to offer an alternative to both the wedding dress category and the existing examples incorporating light technologies. In accordance with the main framework, research questions, and project design concept, the study conducts a literature review examining current design examples using different light technologies (LED, optical fibers, etc.). Following this, the stages of design, sample development and production processes are presented with relevant visuals. It is believed that this study, whose research, design development, and production processes are shared in detail, will set an example for future interdisciplinary projects.

Keywords: Practice-Led Design, Multidisciplinary Process, Fashion, Technology, Luminescent applications, Wedding gown

IŞIK ELEMANLARININ MODAYA ENTEGRASYONU: UYGULAMA- TEMELLİ TASARIM YAKLAŞIMI

ÖZET: Moda ve teknoloji ilişkisi, tarih boyunca, insan bedeninin sürekli değişen siluetlerini, bu siluetleri inşa etmek için kullanılan malzemelerin özelliğini ve malzemeye canlılık kazandıran renklerin elde edilme biçimlerini etkilemiştir. Günümüzde dijital devrim ve malzemedeki yeniliklerden etkilenen moda endüstrisi, gelinlik gibi en geleneksel giysi formlarına bile alternatif işlevler kazandırmak için teknolojinin artan olanaklarından faydalanmaktadır. Farklı bilgi birikimi ve uzmanlıkların bileşimini gerektiren moda ve teknoloji entegrasyonu, aynı zamanda disiplinler arası, pratiğe dayalı tasarım araştırmaları ve uygulamaları için yaratıcı bir ortak zemin sağlamaktadır. Bu çalışmada, Türkiye'de gelinlik sektörünün başkenti olarak kabul edilen İzmir'de yaşayan tasarımcı ve mühendislerin ortak katkısıyla, ışığın bir tasarım elemanı olarak kullanıldığı yenilikçi bir gelinlik üretilmiştir. Işığı, gelinliğin ifade gücünü artıran bir tasarım öğesi olarak ele alan bu projede, hem gelinlik kategorisine, hem de ışık teknolojileri içeren mevcut tasarım örneklerine bir alternatif sunulması amaçlanmıştır. Projenin ana çerçevesi, araştırma soruları ve tasarım konseptine uygun olarak bir literatür araştırması yapılmış, farklı ışık teknolojilerinin (LED, optik fiberler vb.) kullanıldığı güncel tasarım örnekleri incelenmiştir. Bunun ardından, tasarım, numune geliştirme ve üretim süreçlerinin aşamaları, ilgili görseller ile birlikte sunulmuştur. Araştırma, tasarım geliştirme ve üretim süreçlerinin detaylı olarak çerçevelendiği bu çalışmanın, gelecekteki disiplinlerarası projelere örnek teşkil edeceği düşünülmektedir.

Anahtar Kelimeler: Uygulamaya Dayalı Tasarım, Çok Disiplinli Süreç, Moda, Teknoloji, Işık uygulamaları, Gelinlik

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1. INTRODUCTION

Clothing is a portable environment that adds functionality, protection, support, healing, aesthetics, and many other so far unexplored capabilities [1]. Today, many fashion designers believe that the future of their discipline relies on technology and textile innovations [2]. Amongst these innovations, light elements are commonly incorporated by designers with their brightness, color, and poetry [3]. In addition to its strong characteristic contributing to the value of design, light acquires new functions as a visual outcome, revealing the responsiveness of the dress to certain stimuli, such as light, heat, pressure, etc. In this study, the use of light has been investigated in terms of its integration into contemporary fashion within the framework of a practice-based design project. By considering light as a new design element improving the expressiveness of a dress, this study aims to bring innovation to bridal wear with the use of luminescent technologies. The project has been developed with the joint contribution of designers and engineers based in Izmir, considered the capital of bridalwear in Turkey, and aims to attract attention to the use of technological items for this sector. The project employs a practical and exploratory research method in which the fashion design process is enriched with integrations of high-tech light elements in couture design.

In order to extend boundaries, research in various alternative paths has become an essential tool for artists and designers [4]. Considering the intersection of fashion and technology association, many issues in technology-embedded fashion remain to be investigated; therefore, practice-led research provides a constructive background for knowledge generation. Similar to the 'generative' outcomes in interdisciplinary and creative artwork [5], practice-based research within an intersection of fashion and technology will result in various contributions in different domains and provide an alternative point of departure for each field.

2. DEVELOPMENT OF A DESIGN PROCESS MODEL FOR TECHNOLOGY-EMBEDDED FASHION

Within the scope of this project, the process was designed by examining three different study models that connect research with practice. The FEA model from Lamb and Kallal (1992) defines a general design framework based on user needs [6]. In this framework, Functional, Expressive and Aesthetic (FEA) needs of users are considered. Functional needs include mobility, comfort, protection, donning/doffing, whereas aesthetic needs include design principles, body-garment relationship, and art elements; and expressive needs refer to roles, status, self-esteem, and value. The model has been applied to functional clothing research as seen in the examples of clothing needs of adolescent girls with disabilities [7], hospital gowns [8], and women's sailing apparel [9].

Labat and Sokolowski (1999) offer an alternative model to connect research and practice by identifying a three-stage structured design process, particularly for university designers conducting a project for an industry client. Their framework includes (a) problem definition and research, (b) creative exploration, and (c) implementation [10]. Using these models as a base, Chan et al. (2021) proposed a theoretical design process model specifically for 3D digital printed fashion, where the 'analysis – synthesis – evaluation' phases are suggested as three main stages, and evaluation involves the critical assessment of the solutions [11]. In the analysis phase, the problem is defined, and objectives are set; in the synthesis phase, viable solutions are generated; and in the evaluation stage, the solutions are critically analyzed.

Based on another model created by Niedderer and Roworth-Stokes (2007), four uses of practice in research are introduced with regard to (1) research problem, (2) research context, (3) research method, and (4) research outcome [12]. Choi (2016) explored origami as a tool to generate creative patterns in fashion design, employing these four steps of the practice-led design process [13].

Considering these approaches, a theoretical design process model is developed in this research for designing technology-embedded fashion products as a prototype. Figure 1 illustrates the design process model for a practice-based research framework. In the framework of practice-based research, the design process starts with a problem definition and a research question. In this phase, the design context is defined, and the conceptual context is developed through visual inspirations. An overview of textile materials, and consequently research for electronics and production technologies follow the procedures. The second phase includes creative explorations where function, expressive, and aesthetic design details are considered. Materials and production technologies are determined for the full integration of textiles and electronics, and iterative prototypes are generated as illuminated bridal wear. The third phase includes the evaluation and critical assessment of the prototype and the procedures.

3. PROBLEM DEFINITION & DESIGN RESEARCH

3.1. Research Question and Design Context

Niedderer and Roworth-Stokes (2007) explain one primary use of practice for research as posing research questions or problems for investigation [14]. The research question of the project investigates how the light elements can be combined with conventional textiles on a tight-fitting wedding gown, where space for the integration of technical components is limited. This research question is covered by developing a design context for the 'Renewed Romance' wedding gown project and a structured design development process.

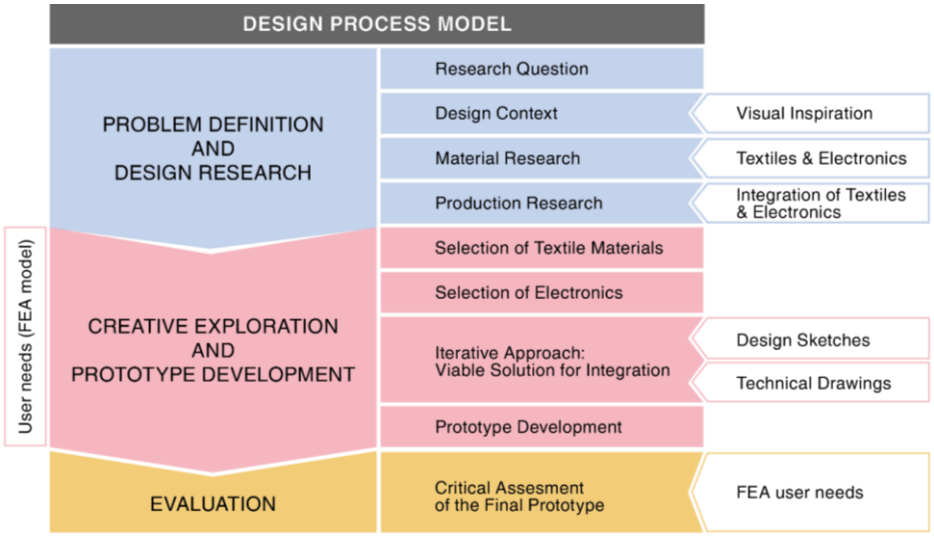

Figure 1. Design process model in this research

'Renewed Romance' is an innovative wedding dress project designed for Futurotextiles Mix Exhibition[1] (Figure 2a and 2b). In line with contemporary fashion trends that blend unexpected styles, materials, and color combinations with a hybrid aesthetic, the project combines innovative production methods and light elements with a wedding dress, an article of clothing with cultural significance. Starting from the idea that the past meets the future, the project focuses on the Library of Celsus in the ancient city of Ephesus, which stands out with its historical significance and timeless beauty in Izmir, Turkey. The repetitive structural details on the Library's façade (columns, column heads, arched pediments, etc.) and the rich reliefs surrounding them become the primary source of inspiration for the silhouette and surface designs of the wedding gown.

3.2. Material and Production Research

Practice as a research context includes investigating a variety of existing works and their interrelations supported by appropriate documentation and critical reflection or representation of these works [15]. Within the design development process of the practice-led research framework in this study, light technologies that have the potential for application to couture dresses and other existing illuminated fashion examples were reviewed. Studying relevant examples provided rationales for design choices and further analyses as research outcomes.

While investigating light technologies for possible application to the wedding dress, product portfolios of innovation companies that manufacture illuminated materials and textiles were reviewed. The examples documented in the study revealed that mainly four materials are used in illuminated couture designs: light-emitting diodes (LEDs), optical fibers (OFs), electroluminescent (EL), and photoluminescent (PL) materials. The existing applications in illuminative textiles were categorized under these four main titles in the following section. Due to the limited number of bridal wear and evening gown collections, the research was expanded to include other illuminated wearables with features applicable to the bridal wear sector.

3.2.1. Light-Emitting Diodes (LEDs)

Lumalive fabric, developed by Philips in 2006, is one of the early examples of bringing LEDs and textile-like surfaces together. In the design of the material, the low-cost LEDs are embedded into a flexible and durable laminated plastic panel with similar properties to a textile surface. This material, which aims to create "a magic lighting experience with textiles," is used in the apparel designs of Anke Loh for its ability to change in different colors and patterns [16].

The e-broidery technology developed by Foster Rohner Textile Innovations provides another design possibility enabling the integration of LEDs directly into the fabric without an additional plastic sheet underneath. In this way, the fabric itself becomes a design component rather than a cover hiding plastic and diffusing light. Another advantage of this technology is that it can be applied to fabrics of very different thicknesses and even transparent fabrics. In parallel with the material's advantages, the company has collaborated with various fashion designers and brands since 2009, testing its integration into different product groups. Climate Dress (2009) and Solar Handbag (2011) by Danish Design Studio Diffus; Corsage Lumineux (2013) by lingerie brand Valisère; programmable T-Shirt OS (2013) by Ballentine's and FW 14/15 RTW collection by Akris come to fore as innovative design projects incorporating light with e-broidery technology [17].

[1] Futurotextiles is a project initiated in 2006 to collect and exhibit innovative projects combining science, technology, art, and design in the fields of textiles and fashion. The 'Renewed Romance' project, whose research and production processes are shared within the scope of this article, was exhibited at Ankara CerModern between April 1 and May 12, 2016, Izmir Painting and Sculpture Museum Kültürpark Art Gallery between May 27 and June 25, 2016, and Wuhan Science and Technology Museum between September 30 and October 16, 2016.

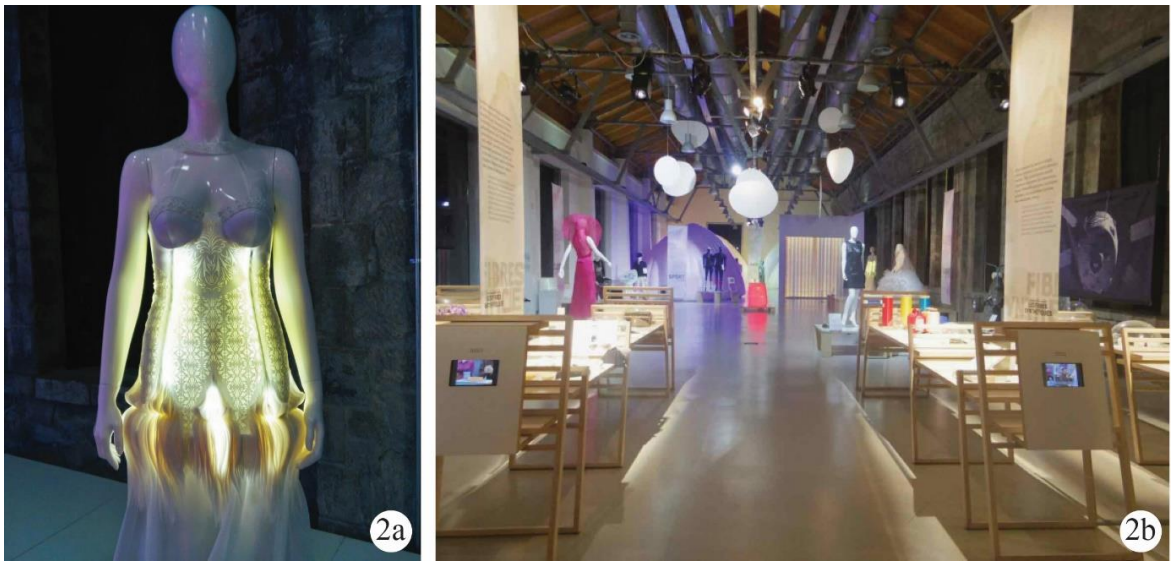

Figure 2a. 'Renewed Romance' project in Futurotextiles Mix Exhibition in CerModern
Figure 2b. 'Renewed Romance' project in Futurotextiles Mix Exhibition in Cermodern: (https://www.lille3000.eu/portail/en/evenements/futurotextiles-mix)

Textile innovators have contributed significantly to developing LED-integrated textiles with their delicate, tasteful materials appropriate to the market. Following these enterprises, LED technologies began to be used by artists and designers, receiving worldwide acclaim. Hussein Chalayan's Airborne (2007) [18] dress constitutes a significant early example of utilizing LED technology within a conceptual framework (Figure 3a). In this design, LEDs illuminate the dress's crystals to reconfigure the surface into a range of motifs [19][20]. Moritz Waldemeyer, known for his collaborations with Hussein Chalayan -for laser dresses, Airborne video dresses, and Robotic Dresses- [21], has been instrumental in bringing LED-integrated wearables to stage shows and performances. His portfolio includes LED jackets worn by the rock band OK Go (2007), LED dresses worn by Rihanna at the American Music Award (2009) and O2 arena (2010), video-capable LED stage costumes of Take That (2011), and LED video bikini of Meital Dohan (2012). He also conceived LED-embedded costumes for the closing ceremony of the 2012 Olympic Games held in London [21].

After 2010, LEDs have become a preferred choice of material for exclusive couture designs. Since Katy Perry's illuminated gown designed by Cute Circuit for the MET Gala 2010 (which is accepted to be the first LED-integrated couture garment to be brought to the red carpet) [23] - MET Gala events have become a platform showcasing LED-integrated haute-couture designs. Among these designs, the Cognitive dress worn by Karolina Kurkova at the Met Gala 2016 stands out for its smart features and design. Kurkova's dress is illuminated by 150 LED-integrated flowers, with hues matching five emotions (Figure 3b). The match-up between tones and emotions is determined by IBM's cognitive color tool, which interprets the emotional content of tweets posted with #MetGala and #CognitiveDress during the event [24]. In that sense, it also becomes a good example of integrating IoT technologies into the wearable design. Zendaya's Cinderella dress (2019), designed by Tommy Hilfiger for MET Gala 2019, is a more recent example that can be listed under this category (Figure 3c). The dress, notable for its ability to transform and change color, includes "20 carbon fiber rods, five battery packs, 40 meters of LED strips, and 6,000 controllable points of light" [25].

3.2.2. Optical Fibers (OFs)

Optical fibers (OFs) have a glass core at their center through which light signals are projected from a source, such as LED or laser. The core is covered with another layer of glass called cladding, keeping the light at the core. Similar to transparent yarns, this material is suitable for producing fabric-like surfaces. The Italian-made *Luminex Fabric,* made of optical fibers and colored LEDs, emits its own light. Solo Sposa, the Italian Fashion House specializing in wedding dresses, is one of the commercial brands using *Luminex* fabrics for their exclusive products. Also, the accessory designer Francesca Castagnacci uses *Luminex* in her shoe and head accessories (Figure 3d). The French company *Lumigram* is another important manufacturer producing fiber optic textiles. This innovative textile (also known as *Lumigram)* was Zac Posen's material of choice when designing Claire Danes' sparkling gown (Figure 3e) for the MET Gala 2016 [26][27]. This material is also used by designer brands specializing in wedding dresses, such as Elena Kozlova and Mania Modeler.

Optical fibers, primarily used in clothing after being transformed into textile surfaces, gain new possibilities of use with the contemporary interpretations of emerging young designers. One of them, Clara Daguin, uses light technology in its high-end collections, combining technological components with delicate craftsmanship. Her wearable design piece 'Aura-Inside' (Figure 3f), exhibited in Premier Vision Paris-Wearable Lab (2018),

seamlessly combines electronic components (LEDs, optical fibers, conductive threads, and circuits) with soft textile materials. In Daguin's designs, hidden under translucent circular elements of various sizes, LEDs incorporate optical fibers to create a synchronized light display.

3.2.3. Luminescent Materials

Luminescent materials are activated by various inputs, such as light, temperature, pressure, and chemical concentration. The following section examines electroluminescent (EL) and photoluminescent (PL) materials, the most preferred categories in wearable technologies.

Figure 3a. Hussein Chalayan-Airborne Dress (2007): (Seymour, 2009, p.30)
Figure 3b. Marchesa IBM Cognitive Dress was worn by Karolina Kurkova at Met Gala 2016: (https://www.ibm.com/annualreport/2016/images/story/story_dress.jpg)
Figure 3c. Zendaya's Cinderella dress (2019), designed by Tommy Hilfiger for MET Gala 2019: (https://static.dezeen.com/uploads/2019/05/Zendaya_dezeen_2364_col_0-852x1278.jpg)
Figure 3d. A shoe design that Francesca Castagnacci produced with Luminex: (http://www.zootmagazine.com/2010/10/10/interview-with-italien-designer-francesca-castagnacci/)
Figure 3e. Zac Posen fiber-optic gown worn by Claire Danes in MET Gala 2016: (https://imageio.forbes.com/blogs-images/rachelarthur/files/2016/05/zacposen.jpg?height=721&width=650&fit=bounds)
Figure 3f. Clara Daguin's 'Aura Inside' project: (https://www.claradaguin.com/aurainside)

Electroluminescent (EL) materials

EL materials are similar to LEDs in that they emit light when an electrical current is applied but dissimilar in that they are found in various shapes (wire, tape, panel, etc.), which can also be flexible and provide a more steady light without glare. *Compass Coat* (2003) of Stijn Ossevort is an early example of integrating EL materials into apparel design (Figure 4a). The coat includes 24 EL wires embroidered to the textile surface [28][29], and each starts to glow when it points North due to its magnetic resistive sensors and microchips [30][31]. Despite being a conceptual product inspired by "the lack of natural elements in the urban landscape" [32], Ossevort's design still constitutes an example with functional details. EL materials are also preferred in wearable technology products where users prioritize functionality. The electroluminescent jacket (2010), launched by Proviz, a London-based company producing high-visibility sportswear products, is designed to increase the visibility of cyclists in the dark for safety reasons [33]. The company won the Red Dot Design Award in 2013 for Triviz, a detachable electroluminescent lighting panel that can be attached to other products such as bags and jackets [34]. Light Flex, a Sweden-based company, specializing in printed active light technologies, can also be investigated under this category. In addition to its award-winning design *Light Flex Vest* (2015) (developed in collaboration with POC and Expedition Parka (2017) by Helly Hansen, *Light Flex* technology is currently applied to a wide range of products in different categories, including sportswear (Figure 4b), workwear, and accessories (helmets, belts, etc.). Electroluminescent technologies were also applied to the first illuminated Flag Bearer Jacket, designed for the opening ceremony of the 2016 Olympics held in Rio de Janeiro, Brazil. The jacket by Polo Ralph Lauren was designed for Michael Phelps from the USA team. Electroluminescent panels on the jacket were produced by Flextronics [35]. Generally preferred for sportswear, this material was also used in Vega Zaishi Wang's fashion collection *Alpha Lyrae* (2012) (Figure 4c). In the outfits, EL materials were either used under semi-transparent surfaces to achieve a hazy look or hidden between opaque volumetric layers to create an effect with light reflections [36].

Photoluminescent (PL) materials

PL materials can be found in different forms, including PL pigments, self-adhesive or thermal films, rigid sheets, or fabrics. Compared to other alternatives, they can be applied to the garments easily, requiring no technical skills in electronics. Free of cables, batteries, and switches, they are applied to various areas of fashion, including sportswear, ready-to-wear, haute couture, and street fashion, providing comfort and convenience. Japanese fashion brand Anrealage presents a good example of how photoluminescent materials can be used in a high-end fashion collection. The outfits showcased in the 'Bone' SS 2013 collection (Figure 4d) are constructed with PL surfaces (resembling grids), highlighting the 3D structure of the garments. In the 'Reflect' SS 2016 collection, the brand, this time, applied similar technology to monochrome designs. The garments, responding to the flashlights in the fashion show, glowed with rainbow-colored patterns [37]. A similar illusion was used in Alexander Wang's 2013 SS fashion show, where the lights were dimmed at the show's end to reveal the "glow in the dark beauty" hidden behind the white dresses [38].

Unlike ELs, photoluminescent materials have also found their way into haute couture collections. Rami Kadi FW 2015-16 couture collection (Figure 4e) is a successful example of integrating luminous threads and sequins with luxury materials, including silk, hand-woven mohair, tulle, ostrich feather, fox fur, and mink [39]. More recently, Yves Saint Laurent FW 2019 collection, inspired by the sophisticated female style icons of the 1980s, used glow-in-dark materials to highlight the exaggerated silhouettes focusing on shoulders, statement-making shoes, and accessories [40]. In the final section of the fashion show, the models walked in a mirrored box illuminated with UV lights emphasizing both the structural elements (giant bows and sharp shoulder edges, etc.) and the surface details (animal prints, stripes, geometrical details, and fur trimmings, etc.) (Figure 4f).

4. CREATIVE EXPLORATION AND PROTOTYPE DEVELOPMENT

Based on the design research into luminescent technologies in fashion, the wedding gown project integrates research with practice by focusing on three aspects: material choices, the combination of aesthetic and functional elements, and the construction details of the wedding gown. The project employs an exploratory approach, involving experimentation and improvisation throughout the process.

4.1. Material Selection (Selection of Light Elements)

The selection of light elements to be used in the design was determined according to three main criteria: (1) the review of the existing design products (given in Section 3.2), (2) the project budget, and (3) the accessibility of the materials in the local market.

LEDs. For the development of the wedding gown in this project, LED-integrated design solutions were implemented. In addition to the variety of possible applications of LEDs in fashion, the accessibility and affordability of the material were other factors that guided the choice of material in the design process. Although LEDs provide a highly dynamic lighting effect and rarely combine seamlessly with textiles, existing examples prove that it is possible to use the material to achieve different visual effects depending on the purpose and application of the design. For example, the design review presented in the previous section showed that costume designers prefer to place LEDs directly on the outer layers of the garment to enhance the effect of the light and thus emphasize the artist's presence on stage (e.g., Moritz Waldemeyer's stage costumes). In couture designs, LEDs either substitute shiny crystals or beads (as in the case of Cognitive Dress of Marchesa and IBM) or are combined with such materials (e.g., Swarovski

crystals) to enhance lighting quality. Hussein Chalayan, Moritz Waldemeyer, and the wearable technology brand CuteCircuit have successfully applied this technique. In some cases, in which strong light emphasis is not much desired, LEDs are also used together with translucent surfaces or design components to create hazy light effects, as in the case of Clara Daguin's design piece 'Aura Inside,' or placed under fabric which is either draped or simply gathered in great amounts (e.g., Katy Perry's light-up gown). A similar method was followed in this project due to its visuality and practicality of implementation.

OFs. Among all illuminated materials, optical fibers resemble fabric more closely than LEDs and luminescent materials. Also, their subtle, shimmering light effect (as in Zac Posen's fiber optic gala dress) makes fiber optical materials appropriate for a wedding dress design. Current fashion products in this category are mostly manufactured with off-the-shelf fiber optic materials such as *Luminex* or *Lumigram* and provide limited feasibility for post-purchase modification. They are also less likely to adapt to complex forms and slim-fitting dresses due to their fragility. Although a few designers have developed more innovative design solutions for integrating optical fibers into textiles, these methods are often labor-intensive and require long production times (e.g., Clara Daguin's Aura Inside project). In addition to all these concerns, it was decided that optical fibers would not be suitable for the project due to high material costs and long international shipping durations.

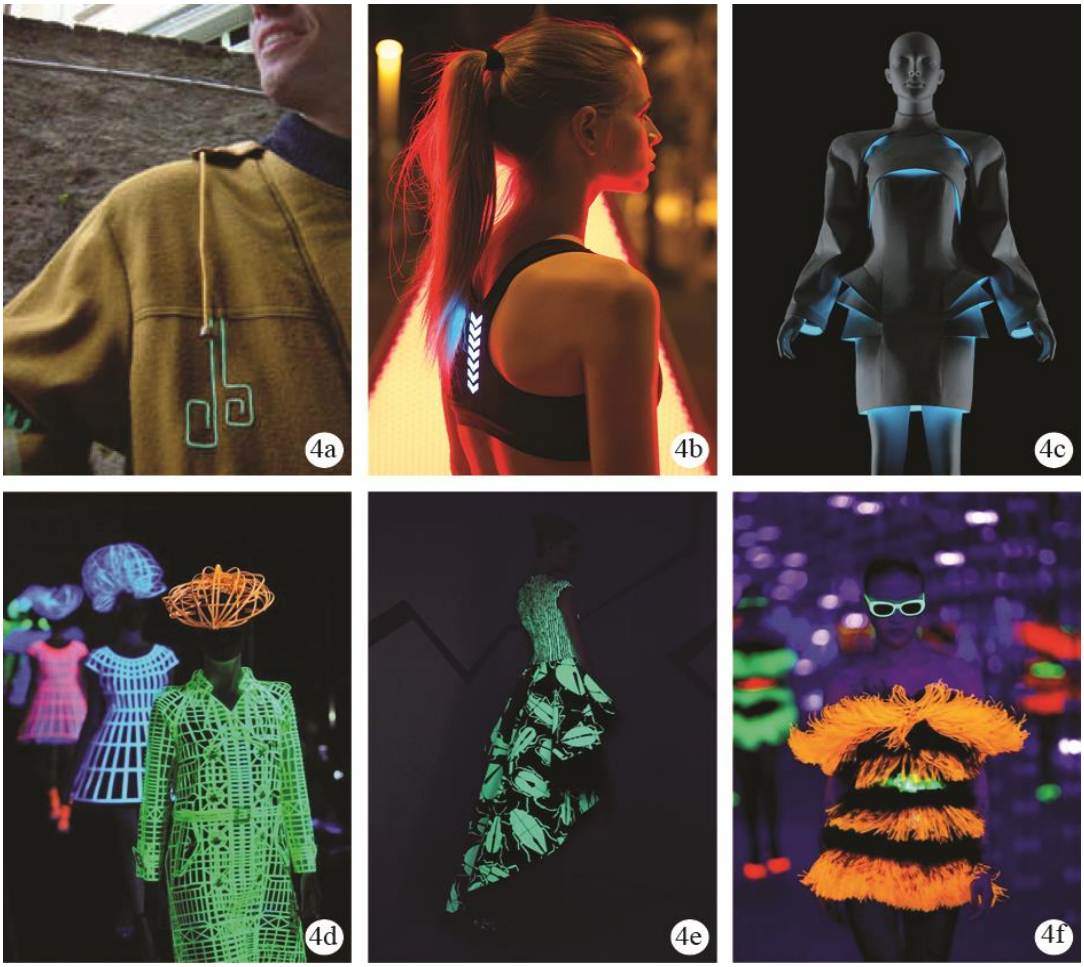

Figure 4a. Compass Coat (2004) by Stijn Ossevoort (Seymour, 2009, p.71)
Figure 4b. Light-Flex printed active light technology: (https://lightflex.com/wp-content/uploads/lft-run-b-1.jpg)
Figure 4c. An outfit from the 'Alpha Lyrae' Collection by Vega Zaishi Wang: (https://i.pinimg.com/564x/01/fd/d9/01fdd91b13b55fede20840665f920886.jpg)
Figure 4d. An outfit from 'Bone' (SS, 2013) collection by Anrealage: (http://www.japanesestreets.com/media/13959.jpg)
Figure 4e. An outfit from 'Lucioles' (FW 2015/2016) collection by Rami Kadi: (https://lumi-light.com/sites/default/files/pictures/fw16-2-glow.jpeg).
Figure 4f. An outfit from Yves Saint Laurent Fall/Winter 2019 collection: (https://www.dazeddigital.com/fashion/article/43508/1/yves-saint-laurent-ysl-anthony-vaccarello-autumn-winter-2019-paris-fashion-week)

EL and PL materials. EL materials are mostly available in neon colors and, therefore, preferred in sportswear, party wear, and performance costumes. Although being more affordable and accessible than OFs, EL materials were considered unsuitable for bridal wear due to the overly dynamic color accents they provide. PL materials, on the other hand, are widely used in fashion applications. Since the research goal is to combine light elements with textiles and develop design solutions for integrating technological components such as batteries and cables, electrically activated luminous materials are considered more suitable in this project. Nevertheless, all PL-related examples reviewed in the previous section guided the design process and further studies, revealing how light can be a design element in fashion, contributing garment's spatiality, playfulness, and ability to transform.

4.2. Prototype Development

The design development phase of the prototype required different processes to be carried out simultaneously. Based on the design concept, the project team conducted visual research on Celsus Library. Images obtained from the designers' personal archives, Internet printed sources were analyzed for interpretation in garment form and surface designs. Afterward, a series of sketches and fabric manipulations were developed, and the design team evaluated the outcomes by considering technical possibilities and challenges. The selected design was revised and finalized in line with the evaluations (Figure 5a).

Laser cutting was the major production technology used for fabric manipulations and pattern cutting. After the dress patterns and cut-out surface details were drawn with Adobe Illustrator (Figure 5b, 5c and 5d), small pattern pieces (such as the neckline or a bust panel) were tested to find the most suitable match between the production technology and the textile materials. Although the initial idea of the design team was to use Ödemiş silk or other local textiles made of natural fibers, it could not be possible to cut delicate details without losing the pure-white condition of the fabric. Therefore the tests were repeated on polyester blends to avoid burned edges and yellowing (Figure 5e).

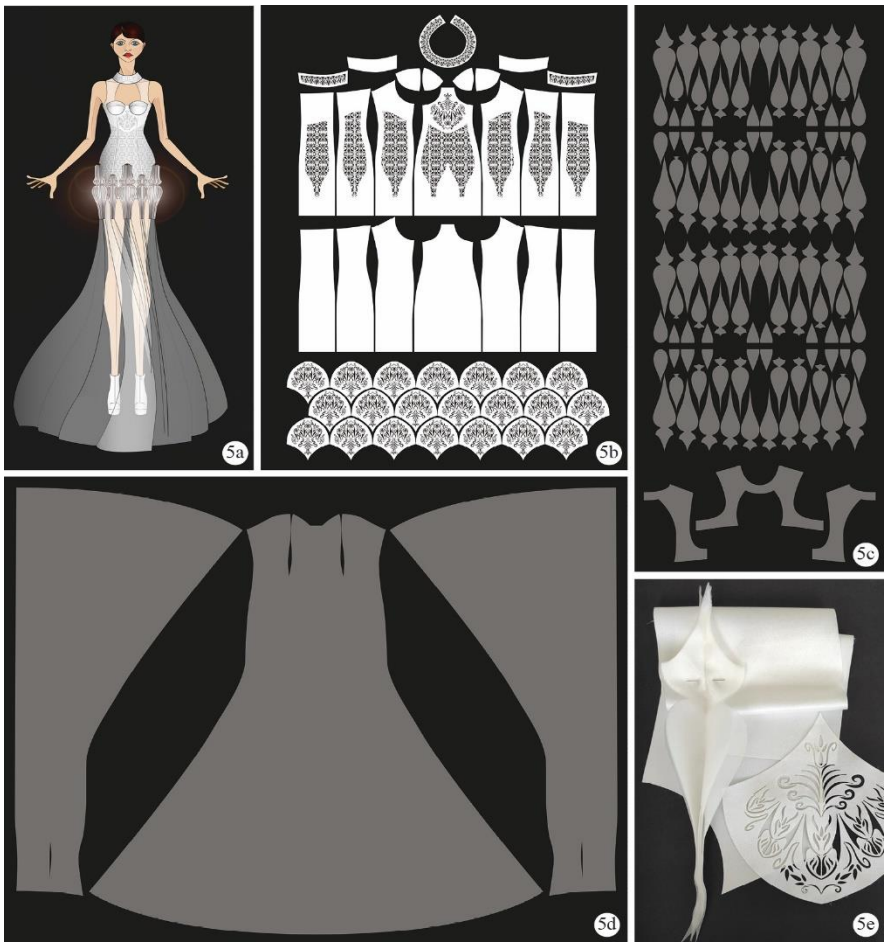

Figure 5a. Illustration of the selected design
Figure 5b. Wedding gown patterns/surface designs drawn with Adobe Illustrator to be laser-cut from satin fabric
Figure 5c. Wedding gown patterns/surface designs drawn with Adobe Illustrator to be laser-cut from organza fabric
Figure 5d. Wedding gown patterns drawn with Adobe Illustrator to be manually cut from organza fabric
Figure 5e. Satin and organza fabrics selected for the design after being tested by laser cutting

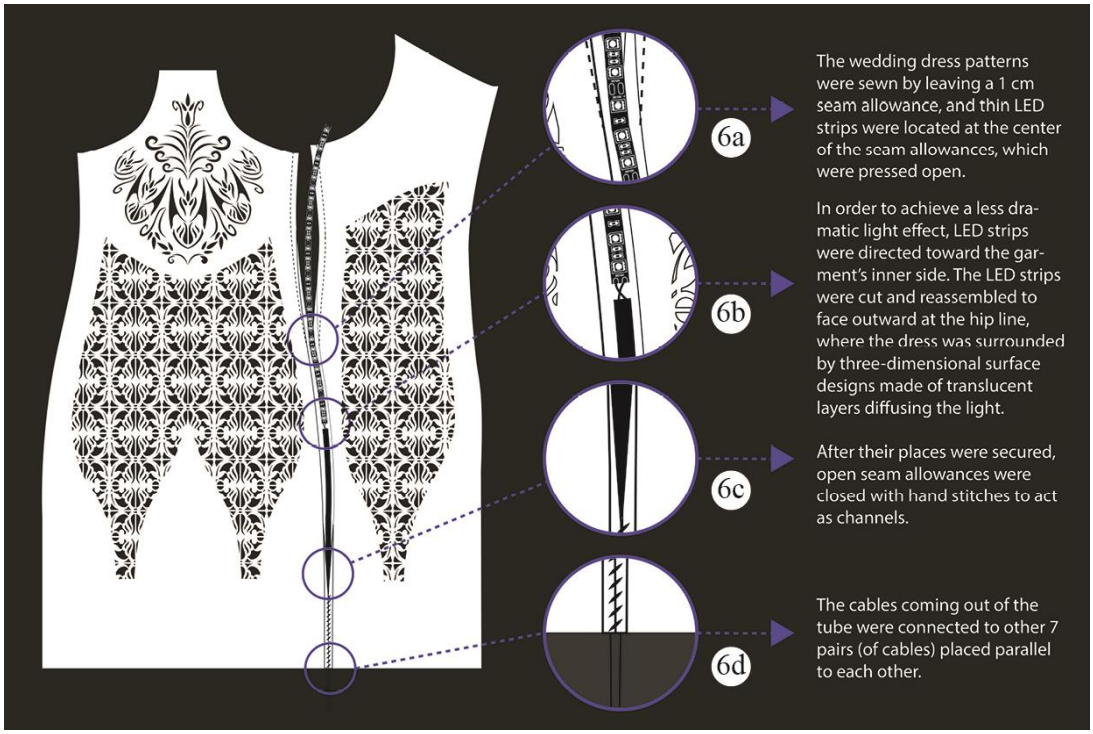

Figure 6. Integration of LED stripes with the wedding gown in four steps

Figure 7. Illuminative wedding gown, front view (7a), back view (7b) and close-up detail (7c)

The placement of light elements on tight-fitted garments was the most challenging part of the project because of the lack of space to integrate the technical components. This challenge was overcome by introducing channels/tubes located under seamlines. The wedding dress patterns were sewn by leaving 1 cm seam allowance, and thin LED strips were located at the center of the seam allowances, which were pressed open (Figure 6a). In order to achieve a less dramatic light effect, LED strips were directed towards the garment's inner side. The LED strips were cut and reassembled to face outward at the hip line, where the dress was surrounded by three-dimensional surface designs made of translucent layers diffusing the light (Figure 6b). After their places were secured, open seam allowances were closed with hand stitches to act as channels (Figure 6c). The cables coming out of the tube were connected to other 7 pairs of cables placed parallel to each other (Figure 6d).

The reliefs on the column heads of Celsus Library influenced the 3D surface designs surrounding the hip. This structure, composed of more than 1500 translucent layers, served the diffusion of LED lights placed underneath (Figure 7a, 7b and 7c). The cables from the LED strips were joined together to connect to the power supply. The illuminated wedding gown was designed to be displayed in international exhibitions. Since the lights were supposed to stay for long hours during the exhibitions, the cables were united to connect directly to the sockets. Moreover, it is planned to use lipo batteries as a power source when the garment is worn for a shorter time.

5. ASSESSMENT OF THE FINAL PROTOTYPE

Practice generates research outcomes by providing demonstrative evidence as a basis for findings [41]. In his article on how artistic inquiry can inform interdisciplinary research, Rust (2007) highlights the results of a workshop regarding "practice-led research in art, design and architecture," in which artists were reported to be more comfortable with the framework of the question, context, and method, in contrast to the 'contribution,' which is claimed as being difficult to identify [42]. The uncertainty of the 'role' or 'contribution' of creative practice in the research process is revealed as design development procedures emerging through the explorations of the intersection between fashion and technology. This project generates research outcomes in many areas. These include, but are not limited to: conceptual development, material selection, design solutions, and applications of various production techniques in order to create an aesthetic couture dress, overcoming the difficulties of integrating technical elements while using technological advances to extend design vision. In addition to being used as a method to generate knowledge or being produced as an outcome of the research, the practice needs to be accompanied by explanations and analyses as a part of the research, and with its final role, practice relates to the dissemination and communication of research [43]. By increasing the visibility of practice and research with light-integrated fashion design, this project serves as an example in this specific field for practice-based researchers. Considering the outcomes, the prototype illuminated wedding dress achieved its functional, aesthetic and expressive goals, which was evaluated by the FEA model [6].

As an outcome of the design research, using LEDs under a bulk of the fabric, i.e., gathers, pleats, and 3D fabric effects, was revealed as the most convenient and practical way of concealing electronic mechanisms behind the illuminated techno-couture designs. In the prototype dress, the desired light effect was provided by locating LEDs on the reverse side of fabrics (facing the body) through the seamlines and using vertically located transparent layers as open-end fabric cut-outs.

Concealing the technical parts by integration as design components, and eliminating undesirable features, such as heat, were deemed essential for a successful design development process. In this exploratory practice-based research, some phases that made this success possible were the use of fabric channels through seamlines and additional heat-resistant materials matching fabric properties.

Initial wear tests were conducted with the wedding dress for heat and comfort, and no specific problem or inconvenience was noted. The model wearing the prototype wedding dress for photoshoots showed a positive attitude. The feedback from the audience of the 'Futurotextiles Mix' exhibitions was also encouraging for the development of this project. Such reflections on practice and conceptual/inspirational projects contributed to building the foundations for the use of technology in contemporary fashion.

The project 'Renewed Romance' brought new alternatives to conventional applications of the bridal wear sector by utilizing lighting technologies. The local culture and history of the Izmir region were examined and reinterpreted in an innovative vision. This practice-based research is expected to create an impact for this region as the center of bridal wear sector by setting an example for high-tech fashion.

6. CONCLUSION

Technology and fashion association is becoming more widespread with developments in science and technology, but it is still challenging to realize projects and develop products. Conceptual, technical, and design targets can be achieved with a single (or limited) production; however, it is important to discuss the appropriateness of these methods for the market. Similarly, the current use of light in clothing and fashion is limited to various small-scale artistic projects and has not reached the more widely accessible ready-to-wear and couture collections. This design research covers a broad spectrum of fashion items, and the suggested design features and solutions could also apply to RTW. Therefore, in view of the lack of technical details available for techno-fashion projects, this research on the 'Renewed Romance' project has a broader value, offering an overview explicitly of the use of light technologies in fashion and introducing a transparent and detailed design development process as well as implementing a theoretical model.

In this paper, the practice-based research framework is adapted to illustrate how practice can contribute to the body of knowledge in fashion and technology through an exploratory approach. This project provides design perspectives to both local and global couture brands and manufacturers and offers new possibilities to the existing design approach by combining textiles with advanced materials. As continuing work, the authors will collaborate with the local bridal wear sector to create a platform to support the integration of design, practice, and technology, utilizing the opportunities created by local craftspeople, manufacturers, materials, and know-how.

The current direction of research and practice has been towards the more expressive end of the fashion item range rather than the more functional; nevertheless, outcomes generated from such projects can be transferred or reinterpreted to establish a basis for functionality in clothing. In addition to using light as decorative or functional elements, design development could also involve conceptual ideas, such as controlling the hue and/or saturation of light by the Internet of Things or creating an interaction between dress and space. Further uses of light will increase the garment's expressiveness and functionality and create opportunities for customization in connection with programmable devices. All these research outcomes and the developed theoretical model will provide alternative "points of departure" [44] for the audience from both fashion and technology.

Rather than focusing on the end results of fashion design, this research evaluates a mix of problem-solving and creative processes by integrating technology into a couture design. The production of the prototype wedding dress provided significant improvisation opportunities for this exploratory research. As the continuation of this project, the production of the capsule collection will allow further explorations for design solutions. Also planned are analyses of consumer interest and wear tests with participants. As well as creating design customization, the modular design is suggested for the further development of this project, which will provide ease for integration of technical items, overcoming problems such as excess weight, thickness, and hardness, and enabling easy cleaning. Modularity is offered as a solution not only applicable to couture but also to RTW applications, covering a much broader spectrum in the fashion product range.

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Figure 1: Design process model in this research

Figure 2a: 'Renewed Romance' project in Futurotextiles Mix Exhibition in CerModern

Figure 2b: 'Renewed Romance' project in Futurotextiles Mix Exhibition in Cermodern: (https://www.lille3000.eu/portail/en/evenements/futurotextiles-mix)

Figure 3a: Hussein Chalayan-Airborne Dress (2007): (Seymour, 2009, p.30)

Figure 3b: Marchesa IBM Cognitive Dress was worn by Karolina Kurkova at Met Gala 2016: (https://www.ibm.com/annualreport/2016/images/story/story_dress.jpg)

Figure 3c: Zendaya's Cinderella dress (2019), designed by Tommy Hilfiger for MET Gala 2019: (https://static.dezeen.com/uploads/2019/05/Zendaya_dezeen_2364_col_0-852x1278.jpg)

Figure 3d: A shoe design that Francesca Castagnacci produced with Luminex: (http://www.zootmagazine.com/2010/10/10/interview-with-italien-designer-francesca-castagnacci/)

Figure 3e: Zac Posen fiber-optic gown worn by Claire Danes in MET Gala 2016: (https://imageio.forbes.com/blogs-images/rachelarthur/files/2016/05/zacposen.jpg?height=721&width=650&fit=bounds)

Figure 3f: Clara Daguin's 'Aura Inside' project: (https://www.claradaguin. com/aurainside)

Figure 4a: Compass Coat (2004) by Stijn Ossevoort (Seymour, 2009, p.71)

Figure 4b: Light-Flex printed active light technology: (https://lightflex.com/wp-content/uploads/lft-run-b-1.jpg)

Figure 4c: An outfit from the 'Alpha Lyrae' Collection by Vega Zaishi Wang:

(https://i.pinimg.com/564x/01/fd/d9/01fdd91b13b55fede20840665f920886.jpg)

Figure 4d: An outfit from 'Bone' (SS, 2013) collection by Anrealage: (http://www.japanesestreets.com/media/13959.jpg)

Figure 4e: An outfit from 'Lucioles' (FW 2015/2016) collection by Rami Kadi: (https://lumi-light.com/sites/default/files/pictures/fw16-2-glow.jpeg)

Figure 4f: An outfit from Yves Saint Laurent Fall/Winter 2019 collection: (https://www.dazeddigital.com/fashion/article/43508/1/yves-saint-laurent-ysl-anthony-vaccarello-autumn-winter-2019-paris-fashion-week)

Figure 5a: Illustration of the selected design

Figure 5b: Wedding gown patterns/surface designs drawn with Adobe Illustrator to be laser-cut from satin fabric

Figure 5c: Wedding gown patterns/surface designs drawn with Adobe Illustrator to be laser-cut from organza fabric

Figure 5d: Wedding gown patterns drawn with Adobe Illustrator to be manually cut from organza fabric

Figure 5e: Satin and organza fabrics selected for the design after being tested by laser cutting

Figure 6: Integration of LED stripes with the wedding gown in four steps

Figure 7: Illuminative wedding gown, front view (7a), back view (7b) and close-up detail (7c)