ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

ISLAMIC GEOMETRIC PATTERNS: AN EXPLORATION OF THE SOURCES AND MODERN REPRESENTATIONS IN PRODUCT DESIGN

M.Sc. THESIS

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İSLAMİ GEOMETRİK DESENLER: KAYNAKLARIN VE ÜRÜN TASARIMINDA MODERN TEMSİLLERİN İNCELENMESİ

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Vafa Mammadova, a M.Sc. student of ITU Graduate School of Science Engineering and Technology student ID 502151930, successfully defended the thesis/dissertation entitled "ISLAMIC GEOMETRIC PATTERNS: AN EXPLORATION OF THE SOURCES AND MODERN REPRESENTATIONS IN PRODUCT DESIGN", which he/she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To the beauty that shines upon us everyday,
revealing itself through our loved ones.

FOREWORD

I would like to thank my family and thesis advisor Prof. Dr. Hümanur Bağlı, for great help and support.

May 2019

Vafa Mammadova
Product Designer

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ABBREVIATIONS

IGP **:** Islamic Geometric Patterns

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ISLAMIC GEOMETRIC PATTERNS: A RESEARCH ON SHIFTS IN REPRESENTATION AND CONTEXT IN PRODUCT DESIGN

SUMMARY

Islamic geometric patterns are reticular formations long discussed in means of construction, application, and usage. In general, geometric patterns can be encountered in different cultural contexts and various traditional applications, such as Indian, Christian, and Greek, interrelated with religious and spiritual principles. This study is particularly concerned with Islamic geometric patterns that can be regarded as continuously repeated entities filling a surface or a body of an artifact. Islamic geometric patterns are constructed on the basis of mathematical, geometrical and philosophical principles. They are incorporated in various artifacts, and used in different applications, such as architecture, textile, and crafts.

In general, discourses on the subject refer to the technical, philosophical, historical and metaphysical aspects of the Islamic geometric patterns. Yet, each differ in the manner of theoretical discussion. Some of them are primarily concerned with the cultural and historical properties, and discard the metaphysical dimension by concentrating on the technical and physiological aspects. Others, on the other hand, regard Islamic geometric patterns as representational elements having strong relations with Islamic cosmology and principles of revelation. Additionally, Islamic geometric patterns are mostly discussed in the fields of architecture, art history, and Islamic history.

This study aims to discuss Islamic geometric patterns within the scope of product design, by adopting a particular theoretical discourse based on the works of perennial philosophers. It concentrates on a particular perspective for the theoretical framework, defined as perennial philosophy, which expounds metaphysical, spiritual and religious aspects of Islamic geometric patterns and claims that patterns are tangible manifestations of the principles of Islamic revelation. According to perennial philosophy, in general, traditional and religious creative practices result in applications that are inherently universal in symbolical, and metaphysical sense. It also regards Islamic geometric patterns as the representations of “Divine Unity”. Thus, this study aims to present Islamic geometric patterns as representational elements that are greater in perception and broader in meaning, although in some cases patterns have somehow been regarded as simple ornamentations or shallow decorations covering a surface or a body of an artifact. In addition, a detailed exploratory discussion regarding symbolical, cosmological and metaphysical aspects of Islamic geometric patterns is provided.

Theoretical background presented in the study includes discussions and definitions from different fields such as history of art, architecture, Islamic cosmology, mathematics, chemistry, geometry, and philosophy. By providing a fundamental theoretical background, it aims to present a plane on which both traditional and contemporary products incorporating Islamic geometric patterns can be discussed in

detail within the scope of product design. Thus, the overall discussion is conducted through the examples of both contemporary and traditional applications of Islamic geometric patterns. Each example is analyzed in means of representational contexts, and particularly in terms of semiotics. Semiotic analysis is conducted to provide a detailed overview of possible shifts in representational contexts and connotative system of meanings of Islamic geometric patterns. Each example is discussed in four main categorizations of representational contexts: spatial, temporal, functional, and technological.

Another aim is to explore future possibilities for practical applications, as Islamic geometric patterns are profound in mathematical and geometrical sense, thus, enabling new opportunities for innovative applications and usages through the use of emerging production methodologies.

The study is based on semiotic and descriptive analysis through the use of visual examples and applications of Islamic geometric patterns.

The main premise of the study is that IGP, constructed on the basis of mathematical, cosmological, symbolical, and metaphysical foundations, are representations of the principles of Islamic revelation, manifesting in tangible forms of reticular, and repetitive geometrical formations.

İSLAMİ GEOMETRİK DESENLER: KAYNAKLARIN VE ÜRÜN TASARIMINDA MODERN TEMSİLLERİN İNCELENMESİ

ÖZET

İslami geometrik desenler sanat tarihi, mimarlık ve tasarım alanlarında biçim, uygulama, ve kullanım anlamında uzunca tartışılan sonsuz girintili örüntüler ve oluşumlar olarak tanımlanabilir. Her ne kadar bu çalışma özellikle İslami geometrik desenlere yoğunlaşsa da, geleneksel anlamda geometrik desenler çeşitli uygulamalarda ve farklı kültürel anlayışlarda görülebilmektedir. Geometrik desenler genel anlamda daha ziyade dini veya manevi anlayışla ilişkili olarak Hint, Hristiyan ve Yunan kültürel bağlamlarında görülebilirler. Bir anlamda yüzeyleri veya bir yapının gövdesini kaplayan unsurlar olarak kabul edilebilirler ve matematiksel, geometrik ve felsefi ilkeler temelinde inşa edilmişlerdir. Günlük nesnelerde, mimari, zanaat ve geleneksel ürünler gibi farklı uygulamalarda görülmektedirler.

İslami geometrik desenlerin teknik, felsefi, tarihi ve metafizik yönleriyle ilgili çeşitli anlatımlar ve tanımlar vardır. Bunlardan bir kısmı öncelikle desenleri kültürel ve tarihi bağlamlarda incelerken, diğerleri metafizik boyut ile ilintili olarak desenleri kozmolojik, teolojik ve felsefi anlamda incelemektedir.

Bu çalışma, İslami geometrik desenleri algı bakımından daha büyük ve anlam bakımından daha geniş olan temsili unsurlar olarak ele alır. Çalışmada desenler genel anlamda ürün tasarımı çerçevesinde tartışılarak temsili düzlemlerin tezahürü olarak ele alınmaktadır. Çalışma, ilk önce sanat tarihi, mimarlık, İslam kozmolojisi, matematik, kimya, geometri ve felsefe gibi farklı alanlardan edinilen teorik bir altyapı sunmaktadır. Genel anlamda "kadim felsefe" (perennial philosophy) olarak tanımlanan teorik çatı altında İslami geometrik desenlerin metafiziksel, manevi ve dini yönleri tartışılmıştır. Kadim felsefeye göre, sanat ve sanatçılığın geleneksel ve dini uygulamaları özünde evrenseldir. Bu sebepten özellikle farklı kültürel bağlamlarda benzer geometrik uygulamalar görülebilmektedir. Kadim felsefe aynı zamanda İslami geometrik desenleri "İlahi Birliğin" temsili olarak değerlendirir. Bu anlayışa göre desenler "çokluk içinde birliği" temsil etmektedir. Buna ek olarak İslam sanatını genel anlamda İslam kozmolojisi ve inanç prensiplerinin somut örnekleri olarak tanımlar. Bu anlayışa karşıt anlayışlar da mevcuttur. Özellikle sanat ve mimarlık tarihçileri tarafından eleştirilere maruz kalarak bu anlayışın tarihi anlamda geçerliliği olmadığı savunulmuştur. Ancak kadim felsefenin sunduğu anlayışın bütüncül olması ve matematik, kozmoloji, geometri, teoloji, metafizik ve felsefe gibi farklı alanlar üzerine kurulu bir teorik altyapı sunması bu çalışma çerçevesinde İslami geometrik desenlerin sadece tarihi, sanatsal veya yöntemsel anlamda değil, bahsi geçen alanlar üzerinden farklı anlamlarda da ele alınmasına olanak sağlamıştır.

Kadim felsefe çerçevesinde öncelikli olarak İslami geometrik desenlerin kullanım alanları, biçimleri ve diğer alanlarla olan ilişkileri incelenmiştir. Bu aşamada bir nebze zanaatkar-zanaat ilişkisi de irdelenmiş ve teorik altyapıya uygun olarak sunulmuştur.

Desenlerin diğer alanlarla olan ilişkisi genel anlamda geometri, kimya, matematik gibi alanlar üzerinden açıklanmıştır.
Çalışmanın ilk kısmında teorik bilgiler sağlanmaktadır. Böylece çalışmanın geri kalan kısımları bu altyapı çerçevesinde ele alınmaktadır. Bu çerçevede İslam kozmoloji, inanç prensipleri gibi kavramlar açıklanmış ve teorik altyapı kapsamında açıklanmıştır.

Bir sonraki aşamada İslami geometrik desenlerin geleneksel kullanımları sunulmuştur. Burada esas amaç teorik altyapı ile geleneksel anlamdaki uygulamaların arasındaki bağıntıları ortaya çıkarmaktır. Bu anlamda her ne kadar geleneksel mimari yapılardan örnekler verilmiş olsa da çalışmanın kapsamı ürün tasarımı alanı ile sınırlandırılmıştır. Araştırma kapsamında elde edilen görsel örneklerde zaman zaman geometrik desenlerin dini kaynaklardan türetilmiş metinsel öğelerle beraber kullanıldığı görülmüştür. Özellikle mimari uygulamalarda binanın cephesinde benzer kullanımlar görülmektedir. Bu açıdan geometrik desenlerin geleneksel anlamda din ve İslam kozmolojisi ile iç içe kullanımı vurgulanmıştır. Bu uygulamalar aynı zamanda İslami geometrik desenlerin sadece tarihi değil, metafiziksel, sembolik ve kozmolojik yönlerini de ortaya koymaktadır.

Geleneksel anlamda uygulanan İslami geometrik desenlerin temeldeki temsil düzlemi ile ilgili tartışmaları görsel örnekler üzerinden sağlanmıştır. Böylece geleneksel uygulamalar temel temsil düzlemi olan İslam inanç prensiplerinin tezahürü olarak ele alınmıştır. Çalışmanın bu bölümünde mimari, ürün ve zanaat uygulamalarındaki İslami geometrik desenlerin kullanımı tartışılmış, ilk başta sunulan teorik altyapı ile bağıntısı ortaya konsk
ulmuştur. Bu aşamada geleneksel ürünler aynı zamanda fonksiyonellik ve taşıdıkları kültürel göstergeler bağlamında ele alınmıştır. Böylece esas temsil düzlemlerine giriş niteliğinde bilgiler sağlanmıştır.

Çalışmada ilgili teorik bilgilerin sağlanmasıyla İslami geometrik desenleri içeren çağdaş tasarım nesnelerinin göstergebilimsel analiz yöntemiyle ayrıntılı olarak tartışılması amaçlanmaktadır. Temsil düzlemleri modern bağlamda tasarım anlayışıyla ilintili olup ön bilgi sağlandıktan sonra tanımlanmıştır. Bu temsil düzlemleri zamansal, mekansal, üretimsel, ve fonksiyonel olarak sıralanabilir. Bir sonraki aşamada günümüz tasarım anlayışı üzerinden İslami geometrik desenlerin günümüzdeki uygulamaları tartışılmıştır. Modern tasarım endüstrisine baktığımızda, çeşitli uygulamalarda kullanılan geleneksel İslami geometrik desenleri günümüzde de görebilmekteyiz. Her ne kadar teknik uygulamalar ve üretim metodolojileri değişmiş olsa da, strüktürel anlamda desenlerin aynı şekilde kullanıldığı tespit edilmiştir. Aynı zamanda geleneksel desenlerin yeni üretim ve tasarım teknolojilerinin de etkisiyle farklılaşarak anlam düzleminde değişikliğe uğramaları söz konusudur. Bu aşamada temelde izah edilen temsil düzleminin farklılaşarak farklı temsil düzlemlerine dönüştüğü veya onlarla beraber zuhur ettiği görülebilmektedir.

Yukarıda da bahsi geçen temsil düzlemleri göstergebilimsel analiz çerçevesinde ürünler üzerinden tartışılmıştır. Böylece, İslami geometrik desenlerin çağdaş ve geleneksel uygulamaları kuramsal çerçevede göstergebilimsel çözümlemelerle ele alınmaktadır. Göstergebilimsel analiz, desenlerin geleneksel kullanımlarına ilişkin temsili bağlamlarda ve anlamlardaki değişimlerin bir tasvirini sağlar.

Böylece çalışmanın amaçlarından biri olarak literatürde var olan tartışmaların ötesinde, ürün tasarımı çerçevesinde bir anlayış biçiminin elde edilmesi çalışılmıştır. Diğer bir amaç geometrik desenlerin matematiksel ve geometrik bağlamdaki potansiyel kullanımlarına olanak sağlayan çalışmaları ve örnekleri tartışarak çağdaş ve geliştirilen teknolojiler yardımıyla uyarlanabilecek farklı uygulamaları sunmaktır. Buna ek olarak çalışmanın sonunda yer alan sonuç bölümünde ileriki aşamalarda devam niteliğinde farklı tespitler ve öneriler yer almaktadır.

Çalışma, görseller ve basılı belgeler kullanılarak göstergebilimsel ve betimleyici analize dayanmaktadır. Araştırmada incelenmek üzere kitaplar, fotoğraflar ve günlük nesneler kullanılmıştır.

1. INTRODUCTION

1.1 Scope and Aim of the Study

Islamic geometric patterns are intricate ornaments used in various applications. It is known that geometric patterns were used in different cultural contexts such as Indian, Greek and Christian (Burckhardt, 1987). They have been and are still used in a wide range of applications, including architecture and product design.

Examples of both traditional and contemporary applications of IGP are analyzed through semiotic analysis, within the scope of product design, in terms of the theoretical background provided in the following chapters.

IGP can be categorized in two categorizations: the first one can be defined as intricate, reticular, geometric formations covering a surface or a body of an artifact, and the second one is combined with floral ornamentation. Thus, "Islamic ornament consists of two main systems, the geometric and the naturalistic vegetative, the combination of which led to innumerable variations." (Diez, 1937, p. 187). This study is concerned with the patterns in the second category, which also can be defined as the patterns of the Seljuk period.

In general, patterns are essential ornamentations for organizing two and three dimensional spaces, in all kinds of creative practices of Islamic art. In some cases, IGP seem to have a complicated structure. Nevertheless, once analyzed, it can be seen that patterns are generated by the symmetrical repetitions of geometric modules, constructed "according to an algorithm" (Bier, 2002, p. 65). IGP are defined by Titus Burckhardt (1987) as "arabesques", composed of intricate, intersecting geometric modules that form endless, reticular patterns. They are incorporated on products, architectural artifacts, textiles, and other applications. Practices of IGP and modes of application in means of production methodologies have changed, yet structural and visual aspects remain the same. Discussions regarding IGP are different in standing point. A detailed literature research was conducted to provide a general theoretical framework regarding IGP. Most studies emphasize IGP merely as extensions of

traditional Islamic Art, thus referring to artistic and historical attributes of the patterns. A different approach, defined as perennial philosophy, addresses the subject from metaphysical, symbolical and traditional standing points. As Turgut Cansever (1996) states, most of the studies conducted on this subject were carried out by Western thinkers. René Guénon, Titus Burckhardt, Ananda Coomaraswamy, Samer Akkach, Keith Critchlow, Laleh Bakhtiar and Sayyed Hussein Nasr are the few who have contributed on this subject, who also present themselves as perennialists, or, perennial philosophers. The perennial approach is based on the universal principles of metaphysics and spiritualism that is believed to be long gone particularly in the Western society (Akkach, 2012). "Divine wisdom", "inner science" or "inner essence", and "perennial wisdom" are the few terms that have great importance in the works of the mentioned authors.

Art and architecture historians mostly share a common approach that emphasizes the artistic and technical aspects of IGP. As a result, perennial approach is criticized for not having a verifiable historical foundation (Özden, 2015). Nevertheless, perennial philosophy is not concerned with historicized realities, that is, "conditioned and quantitative experience, but with universal possibility." (Akkach, 2012, p. 7). According to Chorbachi (1989), who holds a more scientific standing point, regarding patterns as "representations of the Divine" was a part of a trend back in the 70s, a view on which Özgan and Özkar (2017) agree. She also criticizes other authors such as Burckhardt and Nasr, stating that their writings were not based on historically verifiable foundations or documents (Chorbachi, 1989). Burckhardt and Nasr are known for expounding historical, metaphysical, cosmological and religious roots of the patterns in general, and IGP in particular, by presenting detailed information on how they were used, emerged and practiced through various applications. Thus, during the literature research and overview process, non-overlapping explanations of art historians, architects, and perennial philosophers were encountered.

In general, it can be said that the standing point of the perennial philosophers enabled an alternative plane on which geometric patterns can be discussed on a level that integrates different fields such as cosmology, mathematics, philosophy, theology, and so on. In fact, Bulatov (Булатов, 1978) reminds that traditional Islamic philosophers such as Al-Farabi and Al-Kindi regarded each scientific field as a part of the whole, without disassociating one from another, as in the case of mathematics and harmony, or politics and ethics. Having religious and spiritual roots, perennial philosophy

regarded IGP as a form of expression of Islamic revelation. Akkach (2012) states that perennial approach positions Divine Truth at the center of all religions, thus it is typical that different religions share common principles. In short, these principles can be regarded as the extensions of "the essence". Furthermore, perennial philosophers share their views on the differences "between modern and pre modern ways of thinking and making", by expounding the workflow of creative practices and how everything have changed in the modern industry both in motivational and ideational sense compared to the traditional modes of interpretation and production. (Akkach, 2012, p. 9).

It is also important to understand the subject on a foundational level, even from a purely semantic point of view. IGP can be described with the following terms: "ornaments", "decorations", and "artifices". A Sri Lankan art historian, Ananda Coomaraswamy, who shares the perennial approach, is a scholar well known for his works on the metaphysics of art. In his works he goes deep into the roots of the terms by presenting semantic relations among Sanskrit, Latin and English languages. He expounds the roots of the terms, such as "ornament", "artifice" and "adornment". Symbolism in traditional art is one of the essential subjects in his writings. Excerpts from his writings are presented on the following chapters as a part of the theoretical background information while defining the IGP.

According to perennial philosophers, use of ornamentation within a particular religious or spiritual context is regarded as an exclusive practice; each ornament is regarded as a representational element symbolizing universal principles (Burckhardt, 1987). Thus, IGP are artifacts with distinctive symbolical and metaphysical features that guide the viewer's conscience to a higher level of perception (a more spiritual one) by disconnecting one's primary concentration on the physical world (Burckhardt, 1987). This fact is what makes IGP more than simple decorative elements adorning all kinds of crafted and designed artifacts.

By providing theoretical background information for IGP from the standing point of perennial philosophy, the main representational context of the IGP is to be explained: Divine Unity in Islamic revelation. Kılıç (2015) states that IGP are the tangible expressions of "unity in abundance" (2015, p. 125). Regarding geometric patterns as representations of the "divine unity" eliminates the possibility of regarding them as artificial decorations, since in the traditionalistic approach symbols used in traditional art are not used merely for `sentimental purposes`, but for their `intellectual values` (Coomaraswamy, 2004, p. 107).

Throughout the study, apart from perennial approach, semiotic terms are used to formulate the overall discourse within the scope of product design. In terms of semiotics, "denotation involves a literal and detailed description of the meaning of a word or the measurements of objects. Connotation, on the other hand, involves the cultural meanings and myths connected to words and to things" (Berger, 2010, p. 15). Connotative system of meanings for IGP is based on Islamic tradition, cosmology, and principles, whereas denotative system is based on geometry, mathematics, astronomy, and even chemistry. Thus, throughout the study, both terms will be used accordingly.

In the first part, theoretical background briefly mentioned above is expounded and presented in detail. It is followed by examples of traditional practices of IGP. They are presented as an important part of the study to reveal the relations between theoretical knowledge and practical applications of traditional Islamic artisanship. Also discussions regarding representational contexts on the basis of traditional applications of IGP are briefly mentioned. The main representational context is regarded as "Divine Reality", or, *haqiqat*.

In the next part of the study representational contexts are expounded in the modern sense. Contemporary applications of IGP are provided to reveal the shifts in meaning and representational contexts. It is aimed to present the shifts in meaning on the basis of semiological discussions. Representational shifts are analyzed and categorized through descriptive semiotic analysis method provided by Bağlı (2001). Bağlı (2001) presents four representational contexts: spatial, temporal, technological, and functional. Each contemporary application of IGP is discussed within the framework of representational contexts. All contemporary applications are gathered through extensive research and observation based on both personal gatherings and online data, within the scope of product design field.

To conclude, this study discusses IGP on the intersecting planes of metaphysics, traditional art, and product design. As mentioned earlier, it adopts a theoretical approach firstly generated by perennial philosophers, on the basis of which examples of traditional applications and contemporary designs are discussed. Historical, technical and artistic aspects of the IGP are not among the primary concerns of the study. Rather the study aims to present a general overview on how IGP possibly emerged, expounding its origins with the help of different contributions on the subject from various fields such as cosmology, philosophy, theology, and history, and conduct a comparative semiotic analysis on contemporary usage of the patterns in design

industry compared to the traditional practical applications. Thus, an alternative approach combining the principles of creative, religious, and traditional principles of IGP, together with their application, and usage in contemporary product design is explored and expounded. This way the study offers a different perspective that enables other ways of reading IGP through the cosmological and metaphysical layers in which principles of design are used as tools. Also, in spite of the fact that some traditional applications include architectural compositions and elements, the scope of the study is restricted to the applications of IGP in the field of product design as the study is conducted under the roof of Industrial Product Design Department. One of the reasons is the lack of research conducted on this particular subject.

An important point is that most of the formerly mentioned sources regard IGP as traditional artifacts that have no particular purposes other than visual or decorative. This study regards IGP as purposefully designed functional, metaphysical, and cosmological elements, thus, aims to enable the grounds on which IGP can be discussed in the modern sense of functionality and usage. It is achieved through a detailed analysis of products incorporating IGP.

Another intent of the study is to present a possible blueprint for the future usages of IGP, as patterns are inherently dynamic, consistent and parametric in structure. Future considerations involve how the principles that essentially generate IGP can be integrated within design and production processes in other fields and industries. In the following chapters different applications of IGP will be presented to show how contemporary and emerging production methodologies change the ways IGP are used and produced. Academic works on the usage of IGP through various production and usage methodologies are also presented and briefly summarized to portray the overall state of IGP in the field of product design. Some of the mentioned academic works are to show examples from the textile industry, and other fields such as healthcare, engineering, and so on. Examples of the emerging innovative applications and designs will be presented in the last chapter.

The main premise of the study is that IGP, constructed on the basis of mathematical, symbolical, and metaphysical foundations, represent cosmological principles of Islamic revelation, together with the notion of “unity”. Once being used in various applications in the modern context, they become liable to transformations in meaning and representational contexts, that can be gathered under four categorizations: spatial, temporal, functional, and technological.

1.2 Methodology

In general, as mentioned earlier, IGP are mostly discussed within the boundaries of history of art and architecture, through which patterns are briefly elaborated as a part of architectural compositions, mentioned without taking into account symbolical and cosmological aspects. Peker (2006) mentions that discussions on Islamic architecture are abundant in technological, historical, and political knowledge together with compositional and architectural analyses, whereas interpretations of the cosmological and metaphysical aspects are rare. He states that it is important to conduct an intensive reading of theology, cosmology, philosophy, astronomy and mythology, in order to understand the fundamental principles Islamic architecture, particularly the artifacts that are produced during the Seljuk period. This fact acts as a definitive methodological approach towards the IGP, as sources discussing functional and semiotic aspects of the IGP are rare. Yet, most of the sources are from the field of History of Art. As formerly mentioned, these sources are abundant in historical and technical explanations, yet, are unable to address the subject in metaphysical, symbolical and semiotic standing points. Also, IGP are mostly regarded as traditional artistic artifacts rather than functional elements, particularly by art historians, although, Diez (1938) states that "besides this general symbolism, however, almost every single figure of any ornamental design, animal or plant, as well as every color, has a concrete mystic and symbolic significance" (p. 45).

Other academic works expound scientific aspects of IGP, by mostly concentrating on their technical and structural features. For example, discussions of crystallographers such as Makovicky (2016) and Memmedov (1996) emphasize IGP as having structural characteristics of crystallographic formations. Analysis of IGP on the basis of mathematical and geometrical knowledge is a discourse that most academic works elaborate.

Following the present state on methodological approaches towards IGP, it is aimed to firstly provide a theoretical background with the help of the mentioned literary sources, and then discuss the usage in means of representational contexts through product design. For the detailed product analysis, it is aimed to present functional, semiotic, symbolical and cosmological aspects of IGP used in product design. Semiotic analysis is adopted to discuss given examples on the basis of representational contexts, that will be explained in detail in the following chapters. Thus, a mixed method approach is

adopted for the study. An extensive exploratory process on literary, and visual types of sources from various fields and disciplines were implemented in detail.

The first part of the study is essentially based on textual and literary data. Printed materials, daily objects, and historical manuscripts were analyzed, organized and utilized. The second part of the study integrates both literary and visual data to present a general state of how IGP were utilized on the basis of the theoretical principles of traditional Islamic art and revelation. For this part, descriptive method is adopted to expound the underlying relation between theoretical background and practical application. The last part of the study presents visual materials of the contemporary usage of IGP. Once again, materials are gathered through an extensive research of literary, printed and visual materials from books, journals, articles, and personal visual archives. For this part, designs of both Turkish and foreign designers, design studios and companies are gathered, and analyzed. Each example in the study is discussed within the boundaries of product design field.

Semiotic analysis of products incorporating IGP is based on the method originally presented by Bağlı (2001). Bağlı (2001) presents four representational contexts: temporal, spatial, technological, and functional. Each product design incorporating IGP is discussed on the basis of the mentioned representational contexts.

1.3 Framework of the Study

Discourses related to the materialization and establishment of the IGP are essential in the study. Since IGP are mostly considered within the scope of traditional art, it is important to understand the foundational principles, in means of its tangible outcomes and triggering motivations. Thus, foundational theoretical background is provided at the beginning of the study, in which terms and definitions regarding the main discussion are included.

It is also important to note that throughout the study, IGP are discussed within the scope of product design. Thus, it is not concerned with the historical or technical aspects of the patterns. Rather, the primary aim is to assess applications of IGP in terms of semiotics, through a detailed discussion of representational contexts.

Although examples in the study are not provided according to any historical assessment, yet, if a division to be made, it can be said that the study refers to two types of applications of IGP: traditional, and contemporary. In this case, it can be said

that traditional applications of IGP refer to the artifacts produced by artisans of the pre-industrial period, whereas contemporary applications of IGP refer to the product designs of the post-industrial period.

For the foundational theoretical background of the study, René Guénon, Ananda Coomaraswamy and Titus Burckhardt can be mentioned as some of the authors whose works were analyzed and referred to in order to provide an extensive overview throughout the study. The overall approach of the perennial philosophers is mainly adopted for the theoretical background. As a part of the theoretical discussion, it is also important to understand the primary motives of traditional craftsmen. Differences in production methodologies reveal differences in traditional and contemporary practices of IGP. An overview on the workflow of traditional craftsmen is also briefly summarized in the following chapters.

When it comes to the applications of IGP, both traditional and contemporary examples are provided. Some of the visual materials are excerpted from historical catalogues, museum collections, and visual collections of architectural monuments. Others are personal photographs taken during the research process.

As mentioned earlier, the study discusses each application of IGP within the framework of product design only. It analyses each example according to its representational context, that is explained in detail in the following chapters. Although examples of applications of IGP are derived from various sources and different fields, such as architectural monuments, textile applications, ceramics, furniture, and façades, each example is analyzed from the perspective of product design. Contemporary applications of IGP are also gathered from various fields of application, produced in variable materials, production techniques, and have different usages, ranging from bathroom sinks to wide scale architectural shade panels. Thus, this study analyses each provided example in a different manner, other than that of historical, technical, or sociological. Instead, it aims to discuss IGP in relation to the provided theoretical background, and seek possible relations with particular representational contexts, namely temporal, spatial, functional, and technological. In addition, each example is discussed within the representational context of “unity”, as it is the primary representational context emphasized by perennial philosophers, considering “pre-modern” applications of IGP. In order to achieve a consistent manner of discussion, it should be noted that the study is not concerned with historical aspects of the IGP. Rather, it analyses IGP within the frame of semiotic analysis and product design.

Yet, in some cases, as studies regarding IGP in product design are rare, particular terms used by perennial philosophers and other authors are derived to define certain modes of application. For example, some examples of IGP are regarded as “traditional” or “pre-modern”, as defined by Akkach (2012).

Other examples of IGP are relatively recent and can be defined as “modern designs” or as objects of “product design”. These examples can be regarded as contemporary applications of IGP. They are also discussed within the representational contexts mentioned earlier. At this point, it is also important to mention that new terms and contributing causes such as “mass consumption” and “consumer society” are emerged. (Baudrillard, 1998). Thus, overall discussion is based on possible shifts in meaning and representational contexts, and theoretical discourse particularly present in product design literature, to analyze various applications of IGP. Through the analysis, part of the discussion includes whether an application does or doesn’t have relation to any of the mentioned representational contexts, consistent, or is innovative in means of exemplified representational contexts.

It can be said that IGP are having wider scope of usage and application considering contemporary and emerging production possibilities. At the final chapters, innovative applications from various industries, such as automotive, fashion, and architecture, together with academic works regarding innovative applications of IGP are briefly presented. At this point, IGP can be seen as independent structures that serve various functional purposes, even used as expandable materials, and are evolved to have auxetic properties.

The last chapter includes the outcomes of the study, together with suggestions for further possibilities and studies on IGP. As studies on this subject in product design are rare, perhaps even non-existent, this particular study aims to offer an opportunity for further discussions in both academic and non-academic design practices.

2. BACKGROUND INFORMATION ON IGP

2.1 IGP as Ornamentation, Decoration, and Artifice

In order to base the discussion, different approaches towards the subject are briefly explained. There is also a need for a deeper look into the sources of IGP, especially on how they have emerged. At this point the word `Islamic` is used to describe patterns that emerged at a certain pre-modern period of time (estimated between 900 to 1500 AD) within the geographical scope of Islamic revelation (Abas & Salman, 1995). There are different definitions for the patterns; Diez (1937) defines IGP in two categorizations: vegetative and geometric. Burckhardt (1987) on the other hand, defines IGP as "arabesques". On the other hand, Selçuk Mülayim criticizes this term by stating that it doesn't precisely reflect the features of Islamic geometric compositions (Mülayim, 1982). Bier (2002) states that "combined with Arabic calligraphy and stylized floral ornament, geometric pattern is recognized as a key component of the visual vocabulary of Islamic art." (p. 67).

Some academic works on IGP concentrating on historical aspects of the patterns analyze how patterns have evolved. According to Ögel (1994), Islamic patterns used in Seljuk Anatolia were mostly derived from the drawings of the well-known Sufi thinker Ibn-ul Arabi. The fundamental structural basis of the patterns consists of basic interlocking geometric shapes such as hexagons, pentagons, triangles and circles, a fact still being discussed mainly by art historians and perennial philosophers.

On the other hand, crystallographers and mathematicians tend to offer possible interpretations and suggestions for categorizing IGP. Not much have changed in the form and construction of the patterns, but a lot have changed when it comes to the scope of its application, production and usage. Much discussion emerged about the use of ornamentation in the modern design industry. At this point, an essay by Adolf Loos can be mentioned, "Ornament and Crime", written in 1908, in which he states that ornament "represents backwardness or degeneration" (Miller & Ward, 2002, p. 29). In general, the essay criticizes use of any kind of ornament, by mentioning its

representational equivalent as “the immense damage and devastation” to “aesthetic development” (Miller & Ward, 2002, p. 30). Thus, it can be said that throughout the history, use of ornamentation has been and is still being accused of representing the notion of “degeneration”.

In the case of IGP, criticism towards the use of ornament is that IGP emerged as a result of the void in Islamic traditional art, caused by the prohibition of using human and animal figures (also defined as aniconism). Burckhardt (1987), on the contrary, states that patterns are in fact unique abstract compositions that prevent the mind from being attached on the “inward idols” (p. 432). Another view on ornamentation in general and IGP in particular is that they are `artifices` that have no functional purpose. Diez (1937), on the other hand, states that “Islamic ornamentation has (this) spiritual function” (p. 45). Plato favored Greek geometric art not for its “decorative values”, but for its consonance with the “natural language of traditional philosophy”, thus revealing the spiritual necessity that traditional art possesses (p.10, 1944).

This chapter is concerned with terms and definitions used to describe IGP that have other purposes than that of aesthetic. Art historian and Sri Lankan scholar Ananda Cooomaraswamy’s works on semantics expound the roots of the terms used to define the IGP. In this case, “ornamentation”, “adornment”, and “artifice” are some of the terms used to describe patterns. In order to be able to understand the distinction between different terms and expressions a more fundamental approach is needed, which is presented below.

Coomaraswamy (1946) states that art is “a transformation of a shapeless material”, and defines the act of formation itself as the “work of adornment” (p. 3). He extends his rhetoric by expounding the roots of the terms and semantically deciphering their broader meanings. He states that above all, “decorating” an object or an individual implied empowering the subject, or emphasizing its attributes. It can be analogous to the king wearing a crown, or a judge being a judge once in his outfit. In general, “the aesthetic senses of the words are secondary to their practical connotation” (Coomaraswamy, 1946, p. 72). The word “artifice” implies “trick”, thus “artificial” implies “false”, but originally “artificialis”, meaning “of or for work”. When it comes to the word “adornment”, It means “the furnishing of anything essential to the validity of whatever is ‘adorned’, or enhances its effect, empowering it. For example, ‘the mind is adorned by learning’” (Coomaraswamy, 1946, p. 73). The word “cosmos” in Greek

means “order”. “Cosmopoesis” means “architectural ornament”, thus, “Doric, etc., orders”, which shows the intended relation between the “order” and “ornament”. He also criticizes the naming of artistic forms by stating:

> *“From that moment when the deep symbolic meaning of the Ionic column was forgotten, when it was changed into “architecture” and “art,” its truthfulness was at an end. Then there came out of it an “architectural form,” and “art form”; it became an element of construction, a form without any legitimate function. We learnt this even before the discovery of “modern realism,” and it is a service that the latter has rendered, to have dispensed with what had nothing more to tell. But there we merely compromised with the ignorance and stupidity of our times.”* (Coomaraswamy, 1946, p. 229)

Another notion of ‘order’ is mentioned by Akkach (2012), who’s views on architecture summarize the position of the term ‘order’. He makes the following statement: “the essence projects itself into the world as the main cause of existence and principal element of order”, by which he relates the term “order” with the notion of “Divine Essence” as generally used in the perennial philosophy (p. 162). Coomaraswamy (1946) defines “Ornare” as “‘to fit out, furnish, provide with necessary embellishments’, and only secondarily ‘to embellish’” (p. 79). Explanations provided by Coomaraswamy suggest that originally the primary purpose of ornaments was to strengthen the expressional and representational impact of whatever it is being a part of. Thus, the aim for the use of ornaments in traditional sense is more of functional purposes, rather than aesthetic. It is also important to remind that excessive usage of ornamentation degrades the meaning and diminishes its effectiveness. Thus, Coomaraswamy (1946) offers a more accurate expression by stating that an object is “provided” with an ornament, rather than covered or decorated.

2.2 IGP as Traditional Symbols

In the previous chapters it was mentioned that in traditional context patterns were used as representational elements, thus, acted as metaphysical symbols. In this chapter, the notion of “symbolism” is explained.

Definitions of “symbolism” are present in many fields and disciplines. According to Durand (1998), a symbol is an adressor of the inexplicable and invisible. As a result, it is an embodiment of a long forgotten equation that appears in forms of iconographic, mythic, and ritualistic repetitions. A symbol consists of two directions: abstract and

tangible. In a way, the abstract becomes tangible in form of a symbol. Additionally, symbolic vernacular is mostly used in religious sources, and symbolism in religious and non-religious contexts differ in many aspects. It can be said that religious symbols incorporate religious practices to some extent (Yavuz, 2005). Аверинцев (2001) states that semantic structure of a symbol is multi-layered and it depends on the internal state of the active perceiver. In fact, symbols enable the recognition of those who are "one of us". In contrast to the allegory, which can be decrypted by the "outsiders", a symbol incorporates warmth of the rallying secrets (Аверинцев, 2001). "Symbolism" in general is too wide in scope to be discussed in this study. This chapter focuses particularly on a certain approach regarding "symbolism", namely perennial philosophy, founded by a well-known French mathematician, philosopher and scholar, René Guénon (1887–1951) (Akkach, 2012). Akkach (2012) states that "symbolism, the perennialists argue, is the most appropriate approach for comprehending the inner meanings of traditional art and architecture and for penetrating deep into their worlds of spirituality and metaphysics." (p. 10). According to perennial approach, Sufi spirituality can be trailed in different tangible artistic practices, particularly in architecture. Achieving beauty is the most essential aim in Islamic art and architecture (Ardalan, 1980). Dabbour (2012) states that "geometry is both quantitative and qualitative in nature. Its quantitative dimension regulates the order and construction of design forms. Its qualitative nature sets the proportions of design forms and represents an expression of the order of the universe as a visual representation of the truth" (p. 381). Ardalan (1980) expounds this claim by stating that "meaningful beauty in Islamic architecture requires both a quantitative dimension of concern, achieved mainly through a process of pragmatic environmental adaptation, and a qualitative dimension, expressed principally through Islamic aesthetics." (p. 18). Nevertheless, the so called "qualitative dimension" or "Islamic aesthetics" mentioned by Ardalan (1980) needs a deeper research, since Peker (2006) states that research on Islamic architecture and art is mostly concentrated on the technological, technical and historical aspects, or as Ardalan (1980) puts it out, the "quantitative dimensions" of the subject. It can be said that this statement is valid for all kinds of creative practices of Islamic art. According to Kılıç (2018), the definition of art can be described as an act of outpouring a particular thought, or intent, with a particular methodology. In other words, it is an act of external projection of an intention or thought that occurs internally. Consequently, one can see the dichotomy, particularly described as the

"internal" and "external", in which case, the "internal" is manifested through the "external". Thus, it is an act of incarnation or solidification of a particular thought or intent (Kılıç, 2018).

Burckhardt (1987) defines traditional art as *contemplative,* by stating that in a traditional artwork the subjectivity of the artisan is vanished and the artwork maintains only timeless aspects that are undisturbed by subjective complications of the individual (p. 421). Thus, the aftermath of such an artistic workflow is concentrated on things that are not personal, and is unconcerned with the tangible aspects of the forms, but rather concentrates on the central essence. The creative workflow is neither empirical nor rationalistic, rather it acts as a link between the visible, physical world and universal principles achieved through contemplation and wisdom (Nasr, 1990). Today, in most cases we see the form and external qualifications of the artifacts that represent the essence, but not the essence itself (Akkach, 2012). The term "essence" mentioned here by Akkach (2012) is used in relation to the definitions in the works of Ibn Arabi. The relation between the "intangible essence" and the "tangible representation" is similar to that of an object and its shadow. Accordingly, the "essence" is projected by the shadow, that is "the embodiment of the immutable essences into the physical world." (p. 34). Bakhtiar (1976) states that "symbols are vehicles of transmission of Divine Realities, which transform our consciousness by leading it to higher states of being, from which they originate" (p. 25). She also claims that symbols are tools of the awakening that help us to constantly remember of the greater matters that are internally present within the external forms, which is why "symbolism is the most sacred of the Sufi Sciences" (Bakhtiar, 1976, p. 25). In fact, it is not restricted to a particular cultural or religious context; Bakhtiar (1976) states that mathematics is a channel through which the individual can reach the intangible by distancing the self from the physical world. This aspect can also be seen in Chinese and Japanese artworks, Zen, mandalas of the Hindu, Tibetan and Buddhist art, and in many other cultural contexts, all of which are established for the sake of the viewer's "active or passive involvement" (p. 8). In the case of IGP, this aim is reached by directing one's mind into the divine world (Critchlow, 1976). Burckhardt (2009) defines symbols by stating that "a symbol is whatever, on the planes of the soul and the body, reproduces spiritual prototypes." (p. 92). Akkach (2012) also describes symbols as tools through which "the inferior (is) reflecting the superior, visible (is) materializing the invisible, and the physical (is) representing the spiritual" (p.11). Critchlow (1976) expounds

symbolism in IGP through the use of IGP in an entrance of a mosque. According to Critchlow (1976), a door alone is of a great importance in various cultural contexts in purely symbolical sense. Thus, adorning the entrance with geometric patterns evokes the viewer by reminding that he/she is about to enter a different place; a place of spirituality and revelation. The entrance of a mosque is where an individual is required to leave all the daily and earthly matters only to be able to enter the spiritual and divine (Critchlow, 1976). Definitions presented above refer to the notion of using ornaments as a way to produce symbols that have metaphysical purposes such as lifting the viewer's perception to a higher degree, so that the inner essence is present and revealed. Once again, one can see the relation between the "internal" and "external", "tangible" and "intangible". In the context of IGP, it can be said that geometric shapes are practiced to embody symbolical meanings, as "material objects, tectonic or otherwise, are capable of embodying abstract concepts that lie beyond the confines of their materiality." (Akkach, 2012, p. 11).

In the modern context, the "inner essence" is less evident and understandable, so we choose to call ornaments as basic decorations, and degrade it to a lower level of perception (Coomaraswamy, 1946). Perhaps it is best summarized by Coomaraswamy, as he expounds his standing point with the following statement:

> *"In order to bring the realm of the spiritual and the divine within the range of perception, humanity is driven to adopt a point of view in which it loses the immediate union with the divine and the immediate vision of the spiritual. Then it tries to embody in a tangible or otherwise perceptible form, to materialize let us say, what is intangible, and imperceptible. It makes symbols, written characters, and cult images of earthly substance, and sees in them and through them the spiritual and divine substance that has no likeness and could not otherwise be seen."* (Coomaraswamy, 1946, p. 227)

2.3 IGP in Traditional Modes of Thinking and Making

"Islamic aesthetics", is deeply integrated with the principles of Islamic revelation (Ardalan, 1980). Thus, Peker (2006) claims that in order to understand and interpret Islamic art in general and architecture in particular in an accurate manner, one should embody theological, philosophical, and cosmological knowledge in relation to Islamic revelation. Works of the perennial philosophers aim to integrate different fields and sorts of knowledge to offer a universal understanding present in all religions and

cultural contexts. By doing so, they also enabled the grounds on which art and architecture can be discussed separately from the conventional constraints of art history (Akkach, 2012). Akkach (2012) states that "In the perennialist project, Sufism becomes more than an object of academic interest: it becomes a way of life and a pursuit for knowledge, hence, the great passion and conviction with which they write." (p. 5). This chapter aims to present a portrayal of the Islamic traditional creative workflow, from the perspective of perennial philosophers. Artisans of the pre-modern times used various tools for achieving geometrically accurate and analytical patterns. Knowledge of mathematics and geometry was essential for the artisans to be able to produce precise outcomes. Hogendijk (2012) describes mathematicians as theoreticians and artisans as practitioners. He states that craftsmen were familiar with the fundamental mathematical methodologies for constructing the required geometric shapes. Chorbachi (1989) also emphasizes the importance of manuscripts used by the craftsmen. Accordingly, Chorbachi (1989) states that manuscripts can be found in artisans' workshops as well as in museums, showing the overall workflow for constructing a particular geometric pattern. Additionally, geometrical equations are provided together with literal explanations on manuscripts. According to Chorbachi (1989), manuscripts were used to guide the practitioner or the reader, step by step, on how a certain geometric shape can be constructed and achieved. Each step is verbally explained in detail as well. As a result, the practitioner, or the artisan, utilizes the given directions, as it becomes easier to acquire the intended outcome on which the IGP are constructed later on (Chorbachi, 1989). According to Chorbachi (1989), her research on manuscripts led to greater outcomes that show how such intricate patterns were constructed. In addition, "the true patron of the scientists who wrote these ancient manuscripts was art." (p. 788). It is known that manuscripts of the geometers, mathematicians and thinkers were useful sources for the practitioners (Chorbachi, 1989). Another drawing of Abu'l-Wafa is mentioned to offer a solution for the "artisans and geometers" while in a gathering attended by himself (Necipoğlu, 2017, p. 23). In a way, scientists and artisans assisted each other on solving theoretical and practical problems (Chorbachi, 1989). Figure 2. 1 shows a manuscript by Abul'l-Wafa' aI-Buzjani, incorporating both geometrical drawings and literary explanations. Thus, it can be said that geometry, mathematics, art, and artisanship were hand in hand, assisting each other through the practical problems of the traditional creative workflow.

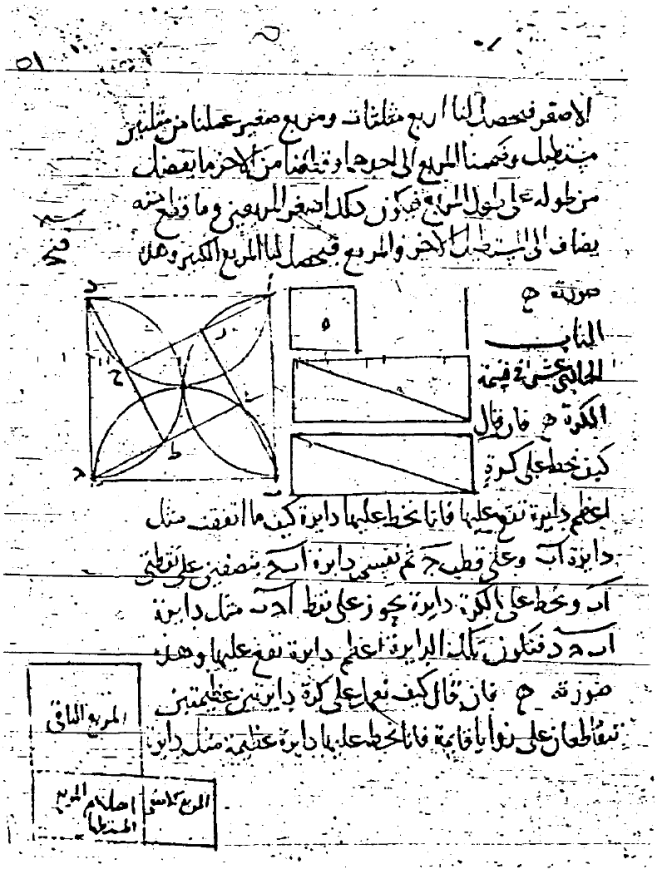

Figure 2. 1 : "Illustration showing one of the problems treating the construction of a large square. From the manuscript of Abul'l-Wafa' aI-Buzjani, Cairo, Dar al-Kutub" (Chorbachi, 1989, p. 769)

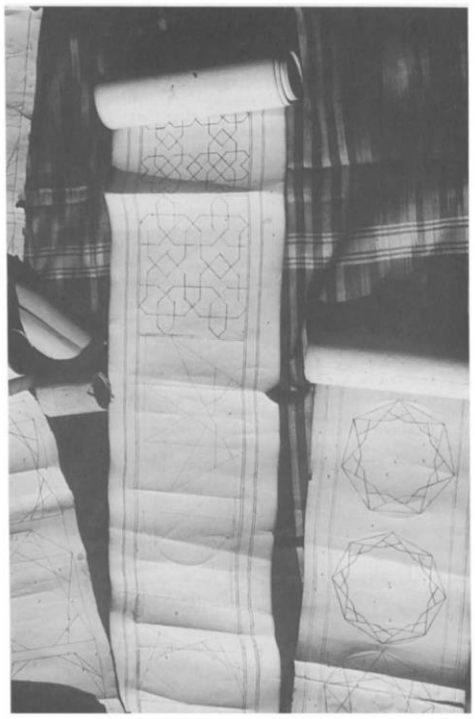

Figure 2. 2 : "Paper scrolls with geometric patterns and drawings from the master-artisan's workshop in an Arab town 1982." (Chorbachi, 1989, p. 756)

A well-known mathematician, Hardy (1992), states that "a mathematician, like a painter or a poet, is a maker of patterns. If his patterns are more permanent than theirs, it is because they are made with ideas. A painter makes patterns with shapes and colors, a poet with words" (p. 13). Akkach (2012) points out the importance of mathematical knowledge by relating it to spirituality and stating that it is a kind of knowledge that helps us to understand the inner realities of the physical beings. Nasr (1976) claims that this understanding existed in traditional sources of the Pythagorean doctrine. According to Булатов (1978), Al-Farabi claimed that arithmetic and geometry are integral parts of any science and art. In fact, once implemented in accordance with the musical knowledge, it results in the mathematical theory of music, and once implemented with the geometrical knowledge, it results in architectural forms- a geometrical harmony. It is also known that Al-Farabi and Al-Kindi were highly concerned about the notion of "harmony", and regarded it as an essential field of science. By stating that skills of using geometric forms constitute the fundamental principles of architectural projections, Al-Farabi writes a treatise, named as "The book of spiritual skillful techniques and natural secrets about the intricacies of geometric shapes". It consists of ten volumes, and each of them expounds principles of achieving perfect geometric forms such as triangle, circle, and square. The tenth book explains the division of the sphere. This is important because of the relation it has to the techniques used by the traditional artisans. Also, it can be seen that the so-called traditional mathematicians, astronomers and scientists were highly engaged in metaphysical matters such as harmony and aesthetics, and regarded each field as a part of the whole.

According to Chorbachi (1989), original manuscripts that served as guidelines for the artisans are not common, and most of them include calculations and technical details for obtaining the required practical outcome, but not the spiritual explanations or metaphysical meanings. These manuscripts show how the pre-modern artisans were engaged in mathematical, geometrical and technical knowledge required for the creative workflow. Yet, Coomaraswamy (1951) claims that work of an artisan requires and contains divine motivations. He states that in any theological concept, be it Indian, Greek, or Christian, the artist continually interrelates the "divine and humane" in his work. He claims that this particular point of view is universal and can be seen in different cultural contexts, even if it might seem as Platonic or Neo-Platonic. Peker (2006) shares a similar view by stating that in order to design a building in the 13th

century of Anatolia, artisans and architects did not develop a contextual framework based on historical studies of art and architecture, as it is in the modern design process. On the contrary, the workflow of the traditional artisans was coherent with universal cosmological knowledge provided by the Holy Books.

Guénon (2001) distinguishes the traditional artisan from the workman in the modern creative industry, by claiming that traditional artisan was engaged in spiritual endeavors and sustained characteristics that the modern industry is unable to either reach or understand today. Guénon (2001) also criticizes how the so called artist is bounded to sensibility, and that he is nothing but an easily countable and disposable entity today in the modern industry. In fact, it is the traditional science, through which an individual reveals the "virtues of essential qualities" of the self, that are essential to a pre-modern artisan (p. 12). In the context of Islamic traditional art, the artisan was engaged in the essential principles of Islamic revelation, which also involved various social customs and conventions. Most of the customs are also part of the Sufi tradition. In the Sufi tradition, it is the "concept of self" and the saying of "I" that leads to the "idolatry and polytheism" (Coomaraswamy, 1951, p. 3). Thus, it can be said that IGP in particular were used as representations of the Divine Revelation, that detract the consciousness of the viewer from the "self". As Plato states, "two acts, then, one of contemplation and one of operation are necessary to the production of any work of art" (p.12), through which "the realities are seen 'by the eye of the soul". (Republic 553D, as cited in Coomaraswamy, p.13, 1944). Bakhtiar (1976) states that conventional chief artisans were also the head of a Sufi order. Nevertheless, for the modern workman the only important thing is to produce in masses, preferably in a perfectly identical manner (Guénon, 2001). To conclude, it can be said that the traditional artisan was not only different in the modes of making, but also in the modes of thinking, as engaging in spiritual practices alone was a part of the creative workflow.

3. IGP AND OTHER RELATABLE FIELDS

As formerly mentioned, IGP are related to different disciplines such as chemistry, philosophy, mathematics, and cosmology. Traditional thinkers such as Al-Farabi and Al-Kindi have evaluated different scientific fields as parts of a whole. This chapter aims to expound the origins of IGP through a brief overview of relations with the fields expounded below.

According to Al-Farabi, beauty and use value are harmoniously fused and cannot be separated. His aesthetic ideas develop in the writings of scientists - encyclopedists such as Al-Biruni, Ibn Sina, Omar Khayyam and others. Al-Biruni, dealing with the morphology of plants, crystals, snowflakes, honeycombs, comes to the conclusion that the nature operates according to certain rules of numbers and geometry (Булатов, 1978). It can be said that this chapter is more concentrated on the connotative system of meanings of IGP. Yet, some visual and tangible examples are provided to further clarify the argument.

3.1 Relations of IGP with Cosmology

This chapter aims to reveal and discuss the possible relations between IGP and Islamic cosmology, together with other cosmological elements such as the Platonic solids. It includes principles of Islamic cosmology, particularly established by the great Sufi-thinker Ibn' Arabi.

Hourani (1966) states that "in modern times cosmology I s no longer studied as a single science, but is fragmented into astronomy, physics, biology, psychology and theology" (p. 18). Islamic cosmology integrates various sorts of knowledge including mathematics, geometry, astronomy and cosmography. It is mostly based on the Holy Book of Quran, and all creative practices in Islamic art is in accordance with the principles of Islamic revelation. Ibn Arabi's works are essential in Islamic philosophy since "nearly all later formulations of Sufi metaphysics and cosmology rest" upon his works (Schuon, 1985, p. 9).

In Islamic cosmology, mathematics, geometry and astronomy were regarded as tools used to understand the universal principles. Geometry is an important subject of

discussion in this aspect, as “geometrical proportions in architecture … address and reflect the natural laws that govern the basic harmonies of nature, being describable by means of mathematics and geometry” (Dabbour, 2012, p. 381).

According to Nasr and De Santillana (1968), mathematics administered a plane on which symbols perform as guides that enabled Muslims to read the universal principles. Nasr also divided mathematics practiced by Muslims in two categories: the first one related to algebra, trigonometry, and geometry, and the second is in the “Pythagorean sense” (p. 26), which is not concerned with the “quantity” and became a tool for the interpretation of the essential principle in Islamic revelation, “unity in multiplicity” (Critchlow, 1976, p. 146). Critchlow (1976) also expounds the relation between IGP and cosmology in his works by presenting symbolical meanings for each basic geometric shape and its equivalent in terms of mathematical equations.

One way of constructing IGP is by using circles, or circular guidelines. An example for this method can be seen below in Figure 3.1.

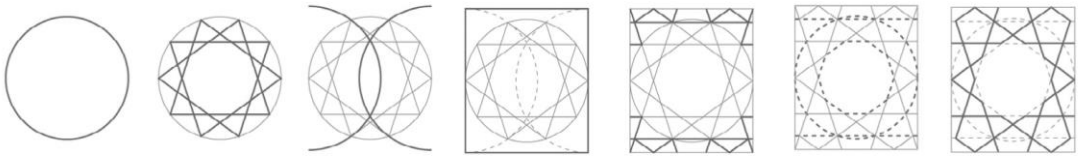

Figure 3.1 : “Graphical evolution of a pattern”, (Riether & Baerlecken, 2012, p. 3)

Hexagons, squares, triangles, and pointed stars all occur with the help of different linear connections and intersections between circles. A circle alone has various symbolical meanings in different cultural contexts, most of which are related to Divinity, thus, it is an essential geometrical component of IGP.

One of the reasons for the IGP being related to the principles of Islamic cosmology and revelation is the use of geometry in the works of great thinkers, such as Ibn’ Arabi. In fact, according to Kılıç (2015), IGP discussed in this study are based on the particular diagrams of Ibn’ Arabi, (or cosmograms, as Akkach (2012) defines it), an example of which is given below, in Figure 3.3. Burckhardt (2001) explains the works of the well-known, great sufi Ibn’ Arabi on astrology together with the diagrams excerpted from his works. Diagrams geometrize layers of the universe in circular forms that coincide with each other around a central point. This diagram is in fact a plan of our star system (Ögel, 1994). An example of such a statement can be seen in Figure 3.2, showing the rotational movement of the star systems.

Sivas, Şifahâne, taçkapıda yıldız sisteminde dönüş hareketi.

Figure 3.2 : Star system diagram on a portal door in Sivas, Turkey (Ögel, 1994, p.129)

Figure 3.3 shows an excerpt from Ibn' Arabi's work, Futuhat. Fundamental universal principles are written around the circles. In the outer circles: air, water, soil, and fire are written (Ögel, 1994).

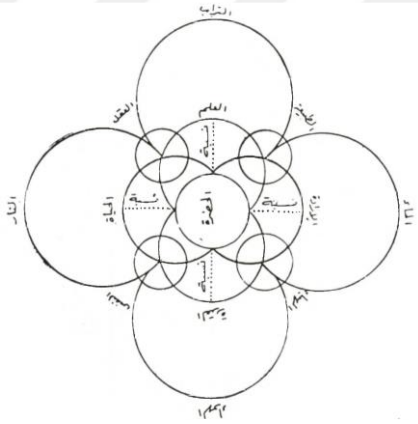

Figure 3.3 : A diagram by Muhyiddin Ibn' Arabi, in *Futuhat.* (Ögel, 1994, p.126)

Akkach (2012) explains the relation between cosmological principles established by Ibn' Arabi and IGP, as he defines diagrams as "cosmograms", and explains how they "geometrize the cosmic structure at the spiritual, angelic, and human levels of being" (p.115). Geometry played an essential role in Islamic science and it was practiced to understand the intangible, divine cosmic principles. In this sense, geometric patterns are related to the Islamic view of cosmology that manifests divine principles both on visual and spiritual levels. Bakhtiar (1976) presents a table showing numbers with their corresponding geometric shapes and meanings. She states that geometry helps us to recognize the celestial orders in nature (Bakhtiar, 1976). Figure 3.4 shows particular geometric figures and explanations.

Number	Geometry Static	Geometry Dynamic	MACROCOSM		MICROCOSM		MATHEMATICAL ATTRIBUTES
0			Divine Essence		Divine Essence		
1			**Creator**	One Primordial Permanent Eternal	**Creator**	One Primordial Permanent Eternal	The point The principle and origin of all numbers
2			**Intellect**	Innate Acquired	**Body divided into two parts**	Left Right	One-half of all numbers are counted by it
3			**Soul**	Vegetative Animal Rational	**Constitution of animals**	Two extremities and a middle	Harmony First odd number One-third of all numbers are counted by it
4			**Matter**	Original Physical Universal Artifacts	**Four humors**	Phlegm Blood Yellow bile Black bile	Stability First square number
5			**Nature**	Ether Fire Air Water Earth	**Five senses**	Sight Hearing Touch Taste Smell	First circular number
6			**Body**	Above Below Front Back Right Left	**Six powers of motion in six directions**	Up, down, front, back, left, right	First complete number The number of surfaces of a cube
7			**Universe**	Seven visible planets and seven days of the week	**Active powers**	Attraction Sustenance Digestion Repulsion Nutrition Growth Formation	First perfect number
8			**Qualities**	Cold, dry Cold, wet Hot, wet Hot, dry	**Qualities**	Cold, dry Cold, wet Hot, wet Hot, dry	First cubic number and the number of musical notes
9			**Beings of this world**	Mineral Plant Animal (Each containing three parts)	**Nine elements of the body**	Bones, brain, nerves, veins, blood, flesh, skin, nails, hair	First odd square and last of single digits
10			**The Holy Tetractys**	First four universal Beings	**Basic disposition of the body**	Head, neck, chest, belly, abdomen, thoracic cavity, pelvic girdle, two thighs, two legs, two feet	Perfect number First of two-digit numbers
12			**Zodiac** Aries, Leo, Saggitarius Taurus, Virgo, Capricorn Gemini, Libra, Aquarius Cancer, Scorpio, Pisces	*Fire, hot, dry, east* *Earth, cold, dry, south* *Air, hot, wet, west* *Water, cold, wet, north*	**Twelve orifices of the body**	Two eyes, two nostrils, two ears, two nipples, one mouth, one navel, two channels of excretion	First excessive number
28			**Stations of the Moon** (divided into four quarters)	Each quarter equals one week, seven days represent seven planets	**Twenty-eight vertebrae**		Second complete number
360			**Number of solar days**		**Number of veins in the body**		Number of degrees in a circle

Figure 3.4 : A table of geometrical shapes, numbers and symbolical meanings (Bakhtiar, 1976)

Importance of geometry in Islamic philosophy perhaps is best summarized by Necipoğlu (2017, p. 61):

> *"Since the professional training of Islamic geometer-astronomers, artisandesigners, and master builder-architects was connected to the epistemological-metaphysical background of the mathematical sciences, it may not be unreasonable to suggest that star-and-polygon patterns potentially resonated with cosmological notions of order and absolute beauty. Such a resonance certainly permeates Kubanani Yazdi's postface to the Persian translation of the Geometrical Constructions, capturing his conviction that geometry is a source of wisdom and truth capable of unveiling the wonders of the divine creation."*

Use of geometry in metaphysical sense can be seen in other contexts as well, such as

in Plato's cosmology. Platonic solids are geometric forms mentioned by Plato in his work "Timaeus", written in 360 B.C. His work integrates philosophy, theology, and science, thus relating geometric solids to these fields, which in general can be described as "Pythagorean Cosmology" (Critchlow, 1969). To summarize, platonic solids are five perfect geometric solids, each representing an essential principle of the universe. Earth, water, fire, air and additionally, heaven (or Ether, defined by Critchlow (1976)), are the five principles each corresponding to a Platonic solid: cube stands for the Earth, icosahedron for water, tetrahedron for fire, octahedron for air, and dodecahedron for heaven or ether. Platonic solids date long before Plato, in fact, some archeological findings show that platonic solids date back to 3200 BCE to 2500 BCE (Lloyd, 2012). But Plato was the one to reveal the connection between the universal principles and geometric forms (Emmer, 1982). The reason behind matching each polyhedral shape with a principle lies in the structure of the geometric shape. Critchlow (1969) expounds this relation in his works by analyzing each polyhedral shape in means of geometric principles. He states that the cube is the corresponding polyhedral shape for the Earth, as the square is a conventional representational shape for the Earth (Critchlow, 1969). In general, each platonic solid is based on basic geometric shapes such as triangles, pentagons, and hexagons (Critchlow, 1969). Thus, each is related to a particular geometric shape in one way or another. Five Platonic solids can be seen in Figure 3.5.

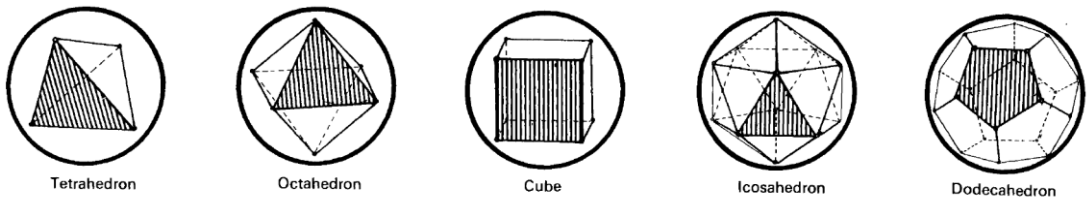

Figure 3.5 : Five Platonic solids (Critchlow, 1969)

There are five main solids each representing a substance. It can be said that knowledge of polyhedral geometry played an essential role in the practices of Islamic architecture. Hisarligil and Hisarligil (2018) claim that cuboctahedrons were used in the medieval-era buildings of Anatolia. Cuboctahedrons can be seen in many different architectural monuments in Anatolia, most of which are presented by Hisarligil and Hisarligil (2018). Most of the monuments include cuboctahedrons integrated with geometric patterns or modules either engraved or painted. Hisarligil and Hisarligil (2018) state that cuboctahedrons are named differently throughout different studies.

Cuboctahedron is “ascribed to Plato” (Hisarligil & Hisarligil, 2018, p. 127), an example of which can be seen below in Figure 3.6. In general, polyhedral structures can be seen in many different medieval applications all around Anatolia, and Hisarligil and Hisarligil (2018) analyze and present most of the applications in the study. In this study, however, only few are included.

Figure 3.6 : A Cuboctahedron as architectural element
(Özgan & Özkar, 2017, p. 462)

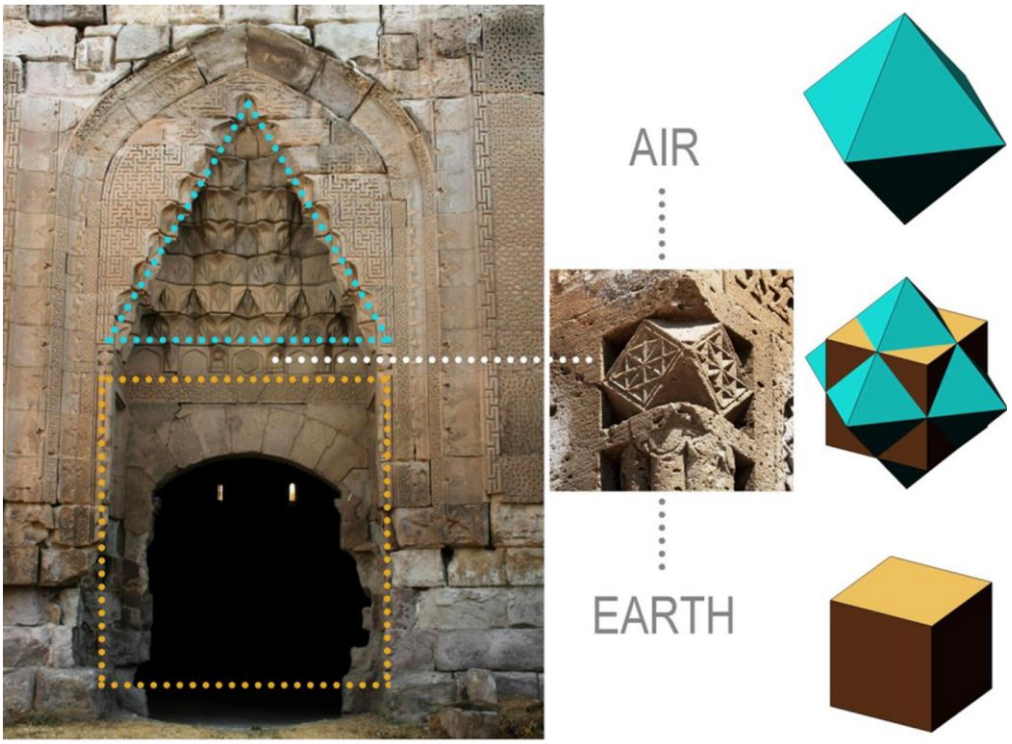

Figure 3.7 : Symbolical resolution of a cuboctahedron
(Hisarligil & Hisarligil, 2018, p. 138)

Hisarligil and Hisarligil (2018) state that if a cuboctahedron is analyzed in a more symbolic manner, it can be said that “in Platonic terms, the cuboctahedron, generated from the octahedron (representing air) and the cube (representing earth), metaphorically represents a phase of a transformational process between earth and sky” (p. 137). This statement is visualized in Figure 3.7.

Cuboctahedrons are not the only polyhedral structures used in Islamic architecture. Dodecahedrons, being one of the five so-called Platonic Solids, are encountered in architectural monuments in Anatolia as well, according to Özgan and Özkar (2017). Özgan and Özkar (2017) claim that in general, platonic solids are not commonly used in Anatolia, but dodecahedrons were used in several traditional buildings as architectural decorative elements.

Figure 3.8 : A Dodecahedron in a Mosque (Özgan & Özkar, 2017, p. 460)

As mentioned earlier, a dodecahedron is the fifth Platonic solid, representing Ether, or Heaven (Critchlow, 1976). Although dodecahedrons in Islamic architecture are as much as cuboctahedrons, some examples remain. An example of a dodecahedron as an architectural element can be seen in Figure 3.8.

Use of polyhedral structures in various applications reveals the connection between different cosmological elements and IGP, and how it all blended with geometrical and mathematical knowledge.

To sum up, it can be said that elements of Plato's cosmology are present in certain examples of Islamic architecture, particularly in Anatolia. Such elements incorporate IGP in various applications as well as symbolical meanings, based on the cosmological principles briefly presented above.

3.2 Relations of IGP with Crystallographic Formations

Crystallography is a branch concerned with the structural and internal properties of crystal formations. According to Benz and Neumann (2014), "all the fundamental macroscopic features of crystals such as homogeneity, anisotropy, and morphological symmetry are the results of the internal order of the crystals at the microscopic level." Crystallography, in general, is concerned with the namely "internal order" mentioned above.

IGP have long been discussed by crystallographers such as Emil Makovicky and Khudu Mamedov, as they have similar characteristics with crystallographic formations. This discourse is not particularly limited to IGP, as Makovicky (2015) states that patterns that bear properties of crystallographic formations are present in cathedrals and churches in Italy as well. For a long time, researchers have been looking for different ways of categorizing and grouping IGP in an accurate and analytical manner. Bonner (2017) states that "the application of Islamic geometric patterns to the parameters of the 17 plane symmetry groups is a particularly interesting development in the efforts toward methodical categorization." (p. 155), and that in the latest works, "studies have classified patterns according to their crystallographic plane symmetry group" (p. 11). According to Makovicky (2015), there are several conditions for an Islamic geometric pattern to be described as crystallographic, and patterns in Alhambra meet these requirements. Prof. Khudu Mamedov is a crystallography professor who presented the term "crystallographic patterns", which are basically geometric patterns having crystallographic features. He claims that IGP have visual and structural similarities with particular crystallographic formations. An example for this kind of similarity is shown in Figure 3.9 and 3.10. As seen in the figures, the former shows the stereographic projection of SiO_2, and the latter is a pattern encountered on a wall in Mardin, Turkey. These examples are presented by Mammadov et al., (1996) in his book 'Nahışların Yaddaşı' (Memory of Ornaments). Similar pattern can be seen in Figure 3.1, from a mosque in Turkey. Another application of a similar pattern can be seen in Figure 3.10.

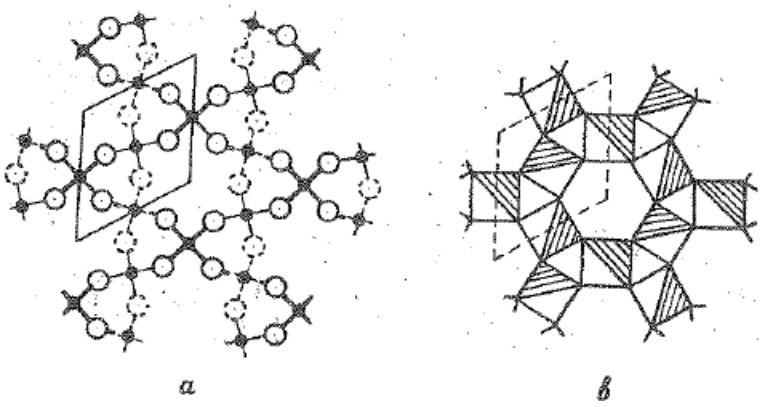

Figure 3.9 : Two-dimensional structural projection of SiO_2, (Mammadov et al.,1996, p. 29)

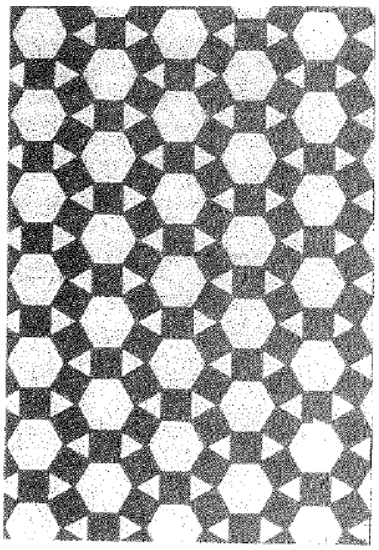

Figure 3.10 : "Structural representation of Silicium Oxide, as a Islamic geometric pattern on a wall" (Mammadov et al.,1996, p. 60)

Figure 3.11 : Same pattern in Bursa Green Mosque.

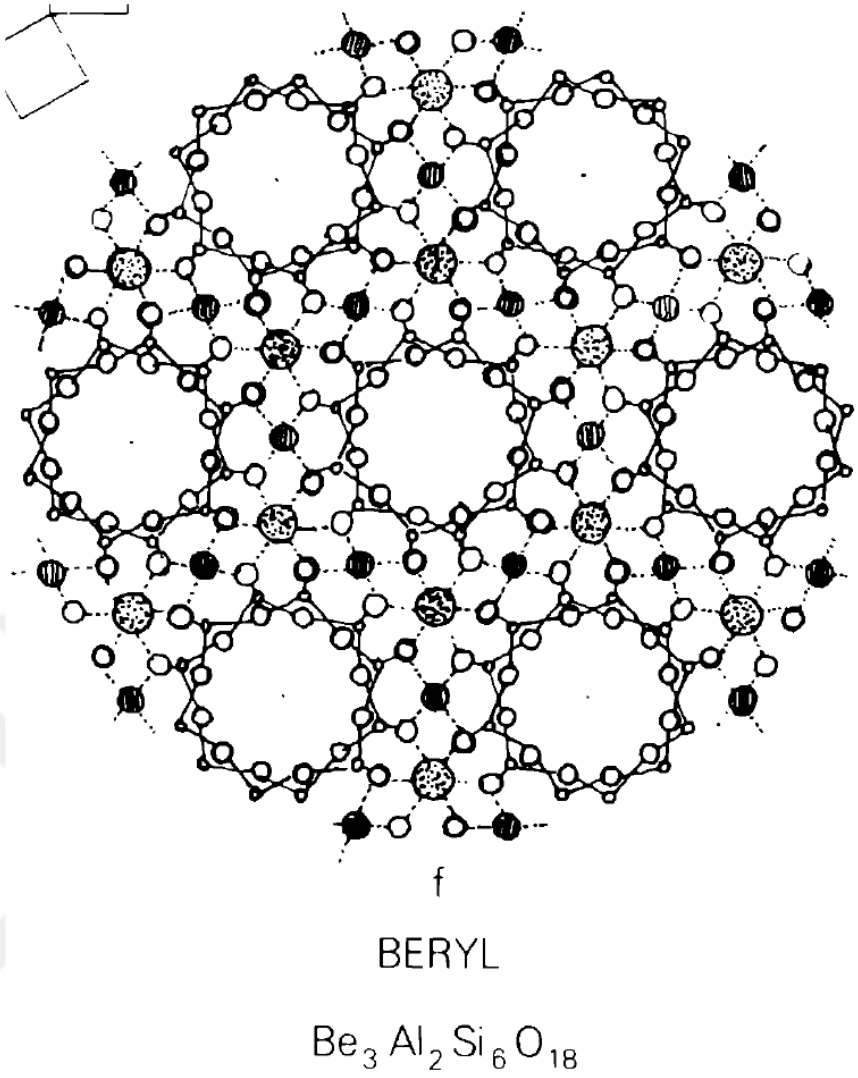

Figure 3.12 : Stereographic projection of Beryl, (Nasr, 1976, p. 90)

Nasr (1976) also mentions another similar relation between Beryl, and traditional twelve folded Islamic geometric pattern. A stereographic projection of Beryl can be seen in Figure 3.12.

Makovicky (2016) claims that geometric patterns are constructed according to particular rules that "can be expressed by the exact language of crystallography instead of the less precise artistic definitions" (p. 14-15). According to Mammadov et al., (1996), two different conclusions can be made out of the relation between IGP and crystallographic formations. On any creative matter, the primary starting point is the principles of nature itself, and we can't create what doesn't already have a prototype in nature. Figure 3.13 shows a table of stereographic projections. This table shows how a crystallographic formation is projected on a two dimensional plane, formed by the divisions of a circle.

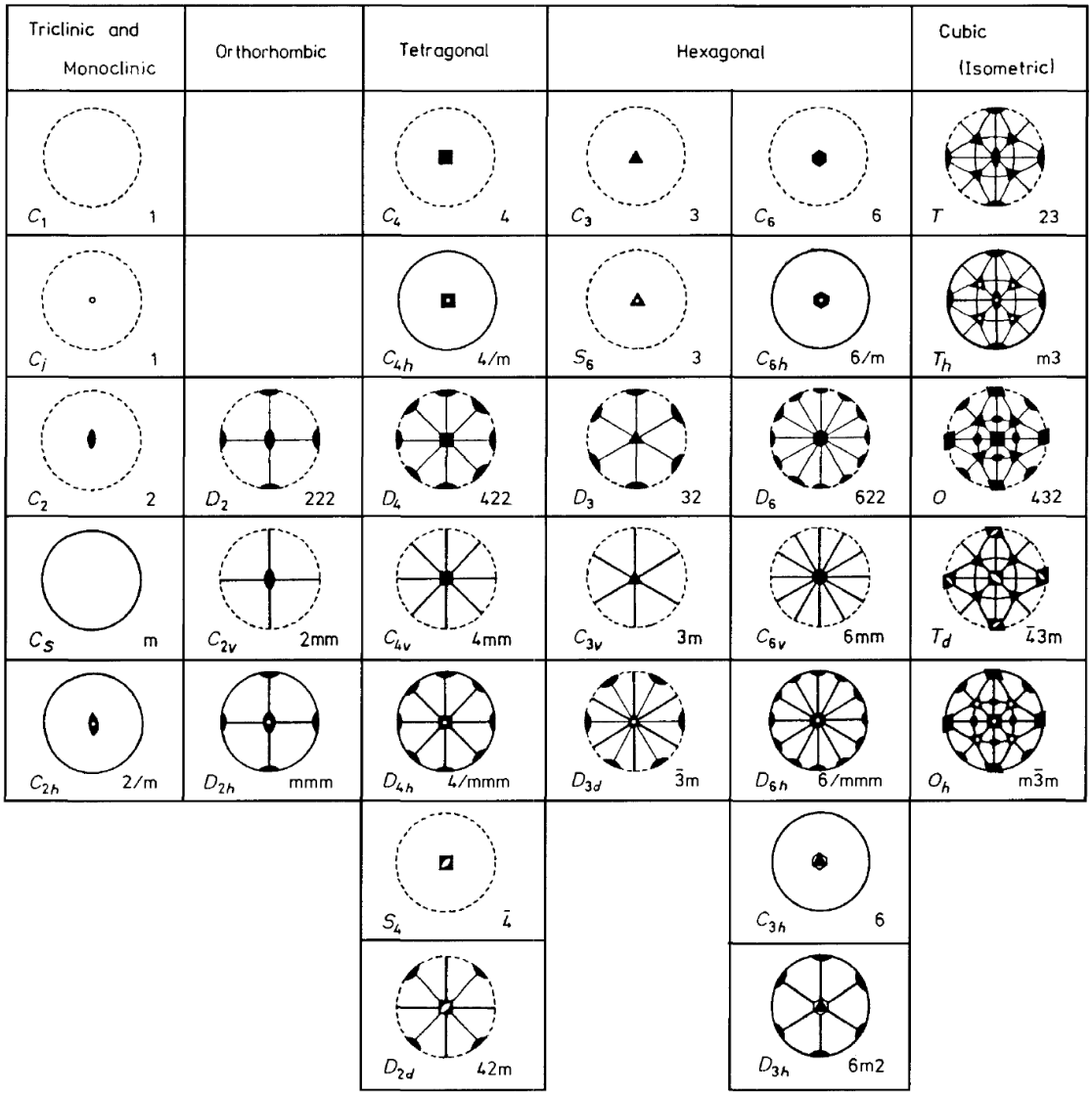

Figure 3.13 : The 32 Crystal Groups can be represented by so-called stereographic projections (Hargittai & Hargittai, 1994, p. 217)

4. IGP IN PRACTICE: TRADITIONAL APPLICATIONS

Traditional Islamic artifacts incorporate IGP in various modes of creative and practical applications. Architectural artifacts, textiles, and products can be seen incorporated and adorned with IGP. In previous chapters it was aimed to provide a theoretical background for IGP in means of their usage, production, application and primary motivation, with the so-called "theoretical model" of the perennial philosophers.

In this chapter, it is aimed to reveal the relation between theoretical background provided in the previous chapters and its practical applications.

Firstly, cosmological and symbolical aspects of IGP were presented and expounded in detail at the very beginning of the study. In this chapter, examples are analyzed in means of cosmological relations, symbolical meanings, and in some cases, functional properties.

From the standing point of perennial philosophy, traditional artifacts incorporating IGP represent principles of Islamic revelation, that embody the notion of Unity within multiplicity, as explained by several authors such as Burckhardt, Bakhtiar, and Akkach. Each geometric form having a symbolical meaning is used for a particular purpose. In case of architecture, religious monuments based on the sphere and cube can be encountered in different cultural contexts, where the circle is a symbol for the "cosmic unity", and its center is "the dimensionless point of the encompassing space" (Critchlow, 1976, p. 58). In other words, in many applications, including Christian and Hindu, the sphere and the cube are integrated to form a religious architectural artifact, in which sphere represents the immeasurable sky, and cube represents the inflexible order. The integration of the two can be described as the transformation of the former into the latter (Burckhardt & Fitzgerald, 2009). Another view is presented by Orselli-Dickson (2017), as she states that "the number and size of cupolas in a mosque can vary greatly, but each modulates the same fundamental truth, based on the conjunction of a rectangular (human) dimension with a circular (celestial) dimension" (p. 282). Mimar Sinan's mosques can be considered as examples of such architectural compositions that are generally constructed on the basis of geometric form such as squares, hexagons and octagons, centered under the dome (Necipoğlu, 2014). From this point of view, it can be said that geometry was used in many creative practices be

it for the functional or aesthetic purposes. In fact, similar geometric resolutions are encountered in other applications of Islamic architecture as well. When the general structure of the building is analyzed, more geometrical relations and proportional considerations are revealed. A statement by Булатов (1978) can be given as an example for such a case. According to Булатов (1978), after a detailed geometrical analysis of the Khodabanda (Hüdabende) mausoleum, archeologist M. Dieulafoy stated that the proportionality of the mausoleum was achieved by the geometry of construction in all three dimensions of the structure. Intersections and relations of geometric forms established key constructional points that assisted the construction process. An example of such an instance can be seen in Figure 4.1.

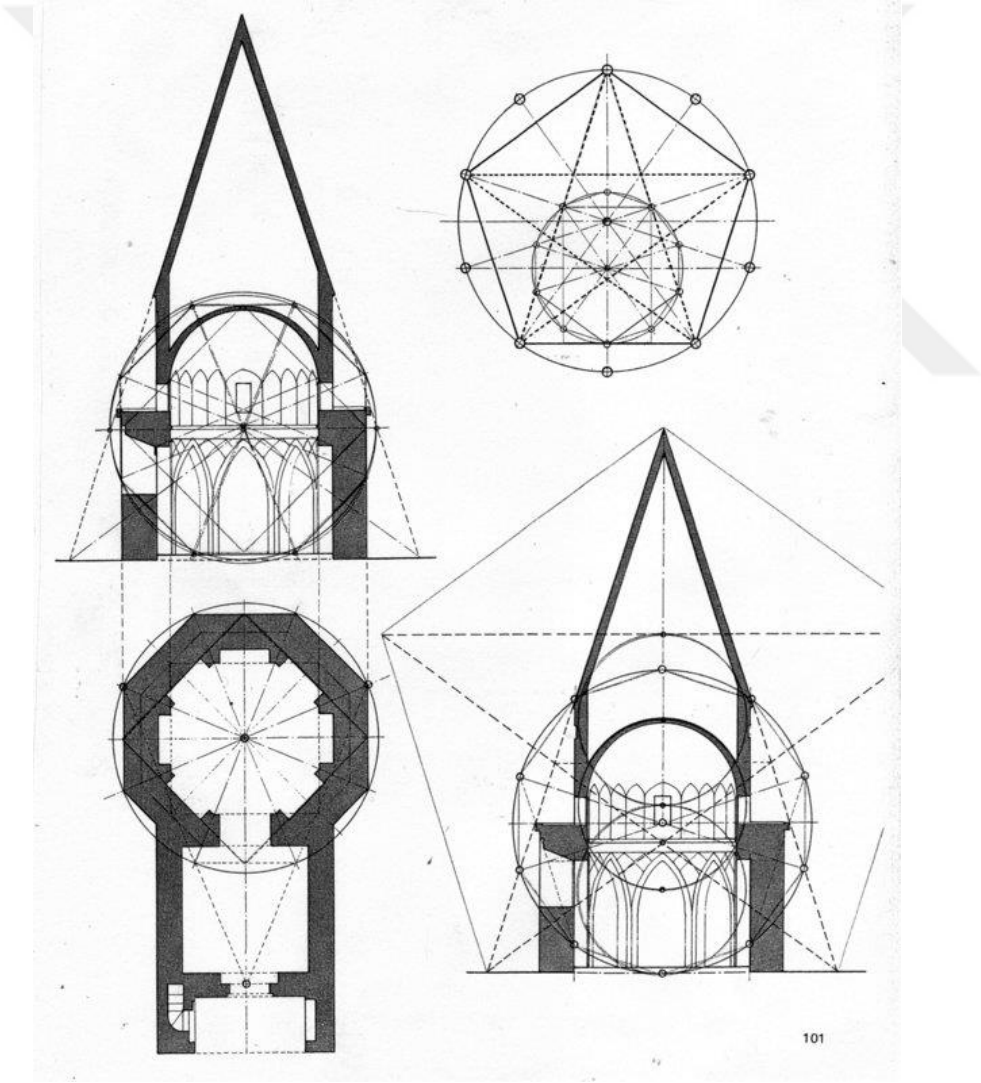

Figure 4.1 : Tomb of Imamzada ‘Abdullah at Farzajin, (Critchlow, 1976, p. 101)

All presented views; top, side and front, show geometric proportionality among the parts of the building. It is also important to note that similar guidelines revealing

geometrical resolutions can be seen in traditional manuscripts as well, only this time used as constructional guidelines for the IGP. Looking from a wider perspective, it can be said that a traditional building of Islamic tradition incorporates geometrical proportions generated by the use of geometrical and mathematical knowledge. Thus, it can be said that certain uses of geometry are present in various modes of creative practices and applications, and in different scales: it can be seen both in the construction of an architectural building, and of a geometric pattern. It can be said that similar practical methodologies were used in different modes of creative applications. Thus, a consistent correlation between Islamic cosmology and its creative practices is revealed through the use of geometrical and mathematical knowledge.

Figure 4.1 shows how the construction of this particular building was planned, designed and established based on the intersection points and geometrical proportions achieved by using hexagons, circles and triangles. Critchlow (1976) states that the use of geometric shapes as constructional guidelines can be regarded as metaphysical entities bearing symbolical meanings. He states that intersectional points achieved by the circles seen in the lower right corner in Figure 4.1, represent the relation and interaction between "heaven, mankind, and Earth" (Critchlow, 1976, p. 100).

Critchlow (1976) makes a categorization for the types of knowledge in geometry: sensible and intellectual. The latter leads to the former in return of which the former makes it possible to reach the "root of all knowledge" (Critchlow, 1976, p. 102). Once again, it can be said that the aim of using geometrical proportions and geometrical guidelines is to reach the divine both in visual and metaphysical sense. Also, the notion of 'order', previously mentioned and expounded by Coomaraswamy (1946) can be seen in similar applications.

Bier (2002) states that architectural monuments provide a guidance for us to understand the "original artistic intent", "whether through empirical experimentation or by the application of theoretical models" (p. 69). This study shows that geometrical relations and proportions become essential features in traditional creative applications of IGP. These relations are particularly encountered in architectural monuments, especially when analyzed from different orthographic views. Below in Figure 4.2, each arc is structurally visualized to reveal the two-dimensional properties as projected on the ground plane. Each arc is an absolute equivalent of the two dimensional geometrical projection. As Messina and Chiarenza (2018) puts it out, there is a certain move from "plane to space" (p. 894).

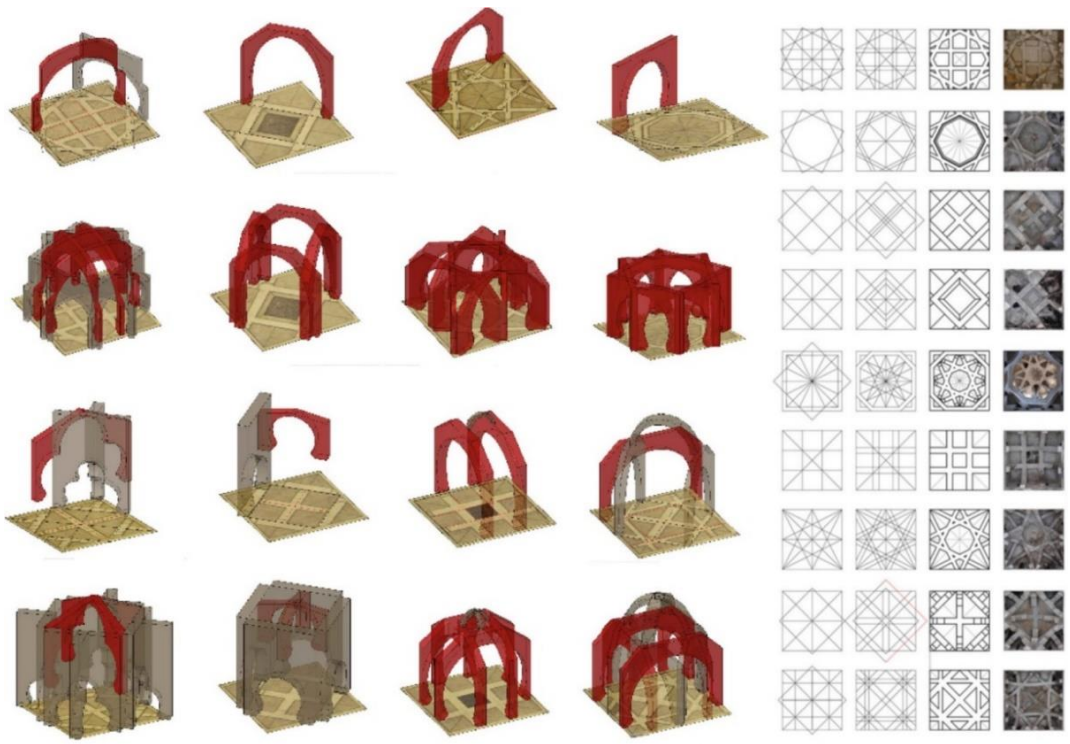

Figure 4.2 : "Toledo, Bib Mardum Mosque. Some examples of variations on the theme of interlacing arches (edited by Dalila Fortunato. Coordinator Barbara Messina)" (Messina & Chiarenza, 2018, p. 893)

This phenomenon is not constrained to the example presented in Figure 4.2 and can be seen in different cultural contexts, which can also be regarded as an indication of the fact that geometrical proportions played an essential role in traditional architectural buildings. It is also important to mention that such structural considerations are not noticeable at first sight, and can be easily disregarded. Nevertheless, a detailed analysis on the construction of traditional monuments can reveal many details and deliberately considered properties once executed by the pre-modern artisans (Messina & Chiarenza, 2018).

Akkach (2012) refers to another view by stating that pre-modern Islamic architecture can be defined as "concentric" as the general structure is symmetrical around a central point. He also mentions that in all kinds of architectural applications, the primary aim of the Sufis is "to understand how the world unfolded from its primordial principle" (Akkach, 2012, p. 159). Also, this exploration is what enables us to understand the "ordering principles" of the Muslims (Akkach, 2012, p. 159). This way the perpetually consistent consideration of the principles mentioned and explained throughout previous chapters becomes self-evident in all modes of creative applications.

Another important point is that such geometrical resolutions reveal the two-dimensional properties of other geometrical and architectural elements in Islamic

architecture as well. Once analyzed, it is noted that muqarnas structures also have precise geometrical proportions and symmetrical properties similar to those seen in IGP. To define muqarnas structures, Burckhardt (2009) states that muqarnas provide a leveled transition between the sphere and the cube. According to Tabbaa (1985) the use of muqarnas structures is not only for aesthetic purposes. In fact, mathematics, geometry, and architectural techniques were used simply as the means to accomplish the desired outcome, since "mathematics and architecture were simply the tools used to flesh out a major theological concept about the nature, the universe and its relationship to God" (p. 72). Thus, these structures should be seen and regarded as manifestations of Islamic theology of that particular time. (Tabbaa, 1985). It can be said that geometrical knowledge was used in different traditional creative practices for the purpose of revealing the essential principles of Islamic revelation both visually and spiritually, aside from the functional and aesthetical concerns. Tabbaa (1985) also states that muqarnas structures are the "architectural manifestations" of the "Islamic concept" (p. 69). Muqarnas structures can be given as examples of two-dimensional IGP practiced in the form of three dimensional compositions, which will be expounded in detail later in this chapter. They are seen and used in many architectural applications, both contemporary and traditional. Nevertheless, to point out the aimed proposition, which is the use of muqarnas in means of a leveled transition from a "cube" to a "sphere", a single example is included, seen in Figure 4.3.

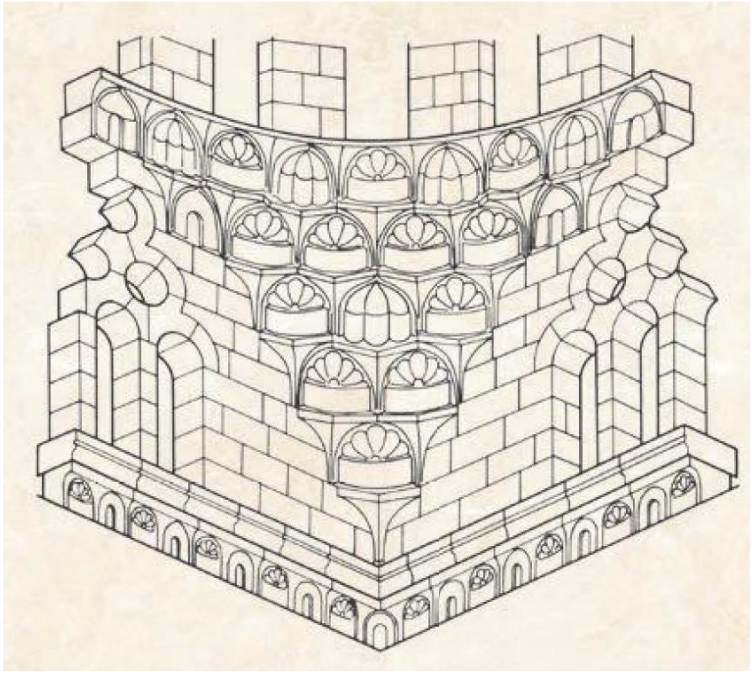

Figure 4.3 : "Muqarnas forming a transition from square to circle" (Burckhardt, 2009, p. 75)

Having a strong geometrical foundation, it can be said that dimensional transitions in IGP are best revealed in the works of Uluengin (2018), shown in Figure 4.4. In fact, he is the one stating that muqarnas structures can be regarded as a result of the transposition of IGP, into the third dimension. He presents muqarnas structures from different views so that both two-dimensional and three-dimensional properties of IGP are discerned in detail. Such resolutions can be made for various examples of muqarnas structures. Yet, few are included from the work of Uluengin (2018).

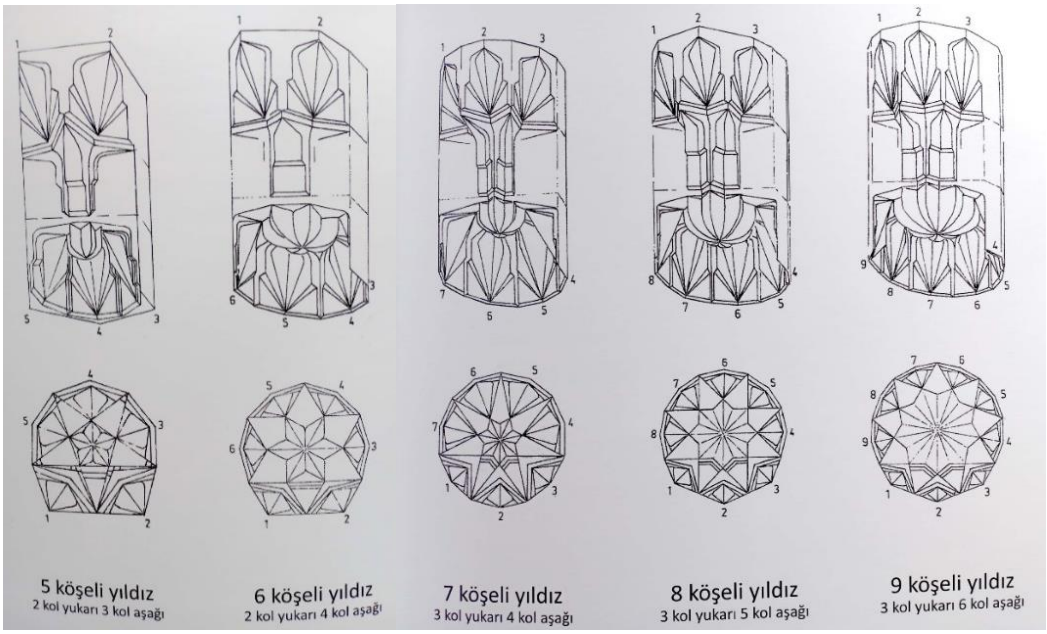

Figure 4.4: Muqarnas structures in different views. (Uluengin, 2018, p. 55)

Uluengin (2018) states that muqarnas have intertwining structural features very similar to that of a telescope, that establish geometric patterns once collapsed in a certain axis. Thus, viewed from the bottom, it can be seen that IGP are almost present within the muqarnas structures, when analyzed in terms of two-dimensions. Essentially, geometrical properties of muqarnas structures in such manner are revealed by Uluengin (2018). But perhaps more resolutions can be made on the subject in relation to Islamic cosmology and its principles, detached from the historical, and technical aspects.

Throughout the previous chapters, IGP have been discussed mostly in theoretical aspects, by taking into account various relations with Islamic cosmology, mathematical and geometrical principles, together with the use of IGP in architecture. When it comes to the examples and applications of IGP in products and artifacts, Shalem (2017) addresses a general problem, by stating that traditional items have been and are still debated in addition to architecture, as if auxiliary objects. He claims that

“the history of Islamic art is mainly told through the history of architecture. Objects in multiple media, such as ceramics, metalwork, glass, carved wood, ivories, and even textiles, are usually presented as additional visual data linked to sacred structures, palatial spaces, and profane, quotidian edifices.” (Shalem, 2017, p. 559). This statement can be regarded as another aim of the study: to present an alternative approach from the perspective of product design according to which both traditional and contemporary artifacts incorporating IGP can be discussed. In this chapter, all items presented are the outcomes of traditional craftsmanship produced by the artisans in different locations, yet within the geographical scope of Islamic revelation. The important point is that in some cases IGP are used together with religious elements such as Arabic scripts from Quranic verses and talismanic elements defined as “magic squares”. In other cases, IGP are used as compositions covering various surfaces such as on a façade of a building or interior walls. Additionally, some examples of IGP incorporated with daily objects such as tableware, boxes or pyxis, and textile products are also presented in chapter.

Be it on a large scale, or small, geometrical proportions can be traced in the practices of traditional craftsmanship, in which both structural and visual properties of IGP are preserved. Thus, aside from structural and visual properties, each example in this chapter is selected according to the manner of use of IGP on the presented example. The primary concern is to present selected examples and applications of IGP, to expound the relation between theory and practice. Historical and technical aspects are disregarded, as this study is mainly concerned with the use of IGP in various modes of application.

Another example in Figure 4.1 shows how IGP is incorporated in a simple object, used for filtering water. Bağlı (2001) states that functionality is achieved by continuation of the form in case of artisanship. Thus, functionality in artisanship is a self-generated notion. Also, artisanship in its ideal approach serves the purpose of entirely satisfying a particular need (Bağlı, 2001). A water filtering item, unglazed pottery seen in Figure 4.5, incorporates IGP so that the spaces between the rays of the star pattern can be used for filtering the water. In this particular application functionality is achieved through the use of IGP (Kelsey Museum of Archaeology). The importance of this particular example lies in its use of IGP as an element enabling its functionality. It also shows that in traditional context, IGP were not only used for the purpose of adornment, or incorporating principles of Islamic revelation, but also to achieve a certain

functionality in modern sense. Additionally, IGP is incorporated only partially, in form of a single module, rather than a complete pattern, on a planar surface. This particular choice of material and mode of application perhaps is what enables the “affordance” of filtering the water.

Figure 4.5 : “A water filtering object incorporating IGP”, (Url-1)

A similar use of IGP on a planar surface can be seen in Figure 4.6. One can see a glass plate incorporating IGP without any additional religious or metaphysical elements. The plate is “glass; free blown, enameled and gilded”, and is part of The MET online catalogue collection (The Metropolitan Museum of Art). It can be said that in contrast to the former example, this particular application of IGP bears no references of the notion of functionality. IGP are only incorporated visually, supported by the use of color. Yet, almost an overlapping visual effect can be seen in the use of colors, as it amplifies the rays. A similar effect can be discerned in the former example, as the manner of application is resulted in gaps composing the rays, amplified with the linear strokes. Another similarity is in the use of IGP in form of a module, rather than a complete pattern. Conclusively, Figure 4.5 and Figure 4.6 reveal the shifts in different modes of application of IGP, whereas some similarities still remain.

Figure 4.6 : "Plate, 14th century", (Moore, 1891)

In traditional context, IGP can be seen to be used together with other elements such as Quranic verses, numbers and symbols. Use of IGP together with the Quranic verses can be regarded as an indication of metaphysical and cosmological principles contained within the materialized outcomes. Nasr (1990) states that traditional artifacts incorporating IGP had an aim of reminding the presence of God to the viewers. In this case, such applications of IGP can be regarded as the signifiers of the metaphysical and cosmological principles.

Traditional artifacts such as "healing bowls" and "talismanic shirts" also incorporate geometric patterns and Arabic scripts from Quranic verses. In general, these items are believed to have protective properties for the user. According to Acar (2011), talismans are based on faith, thus being highly religious elements embodied in traditional products. It was also believed that healing bowls cured diseases. Some of these objects incorporate astrological elements together with other mystical symbols (Acar, 2011). As it was previously mentioned, geometric patterns are related to Islamic cosmology, thus incorporating the knowledge of religion, astronomy, mathematics, and geometry. In Figure 4.7, a healing bowl can be seen incorporating various calligraphic elements and geometric compositions.

Figure 4.7 : A healing bowl incorporating Quranic verses and IGP (Acar, 2011, p. 103)

Healing bowls are not specific to Islamic culture, as Acar (2011) states that similar bowls were encountered in Phrygian valley of 8th century B.C. Some other examples of healing bowls can be found in variable shapes, and sizes. In Islamic context, healing bowls incorporate Quranic verses, talismanic elements called "magic squares" and geometric compositions carved on the both inside and outside of the bowl. Moreover, this particular use of IGP can be defined as specific, as once incorporated with the magic squares, an object becomes related to a purposeful act of providing a healthy benefaction for the user. Thus, in this case, IGP are used as auxiliary elements complementing the overall composition crafted on the healing bowl.

A similar use of IGP can be seen on talismanic shirts of the Ottoman period. These shirts also incorporate magic squares. In general, both healing bowls and talismanic shirts can be regarded as physical items having mystical, metaphysical and religious properties incorporating visual elements of Islamic cosmology and revelation. Once again, Arabic scripts, together with numbers and geometric compositions can be seen written on the textile material with special inks. Each number has a special meaning in means of its cosmological correspondence and is written in a particular order (Bakhtiar, 1976). The previously mentioned magic squares can be seen in Figure 4.8 below. According to Tezcan (2011), talismanic shirts were believed to keep the owner secure and unharmed, provided by the religious and mystical visual compositions of geometric patterns, Quranic verses, and "magic squares" (Bakhtiar, 1976, p. 114). Once again, different examples for the use of IGP on talismanic shirts can be exemplified. Nevertheless, as talismanic shirts are not a part of the main concern of this study, a single example to show how each element is composed on a textile

material is included below in Figure 4.1. It should be noted that each element is purposefully integrated according to certain principles of Islamic cosmology (Tezcan, 2011).

Figure 4.8 : A talismanic shirt, (Tezcan, 2011, p. 47)

To summarize, it can be said that both healing bowls and talismanic shirts have unique and specific visual features purposefully crafted and geometrically composed for religious and mystical purposes.

Quranic verses can be seen in other materials and objects as well. Carved on a surface of an artifact, IGP on the item shown in Figure 4.9 is used together with Arabic calligraphy. It can be said that in some cases of traditional applications IGP are used in relation to religious elements emphasizing its effect, thus, ceasing to be regarded as two-dimensional, simple graphical decorations. For example, the pyxis in Figure 4.9 incorporates a poem together with the IGP (Dodds, 1992). In fact, according to Dodds (1992), “The poem on the body refers to the object itself, as often happens in Al-Andalus, whether a small work of art or an architectural monument is involved.” (p.266). Similar examples and other objects incorporating IGP and Quranic verses can be found in museum catalogues, studies of History of Art, and within the scope of Islamic traditional art.

Figure 4.9 : “Pyxis” (Dodds, 1992, p. 265)

These particular application in Figure 4.9 and Figure 4.10, on the other hand, are provided to show the coherent relation among different modes of application of IGP.

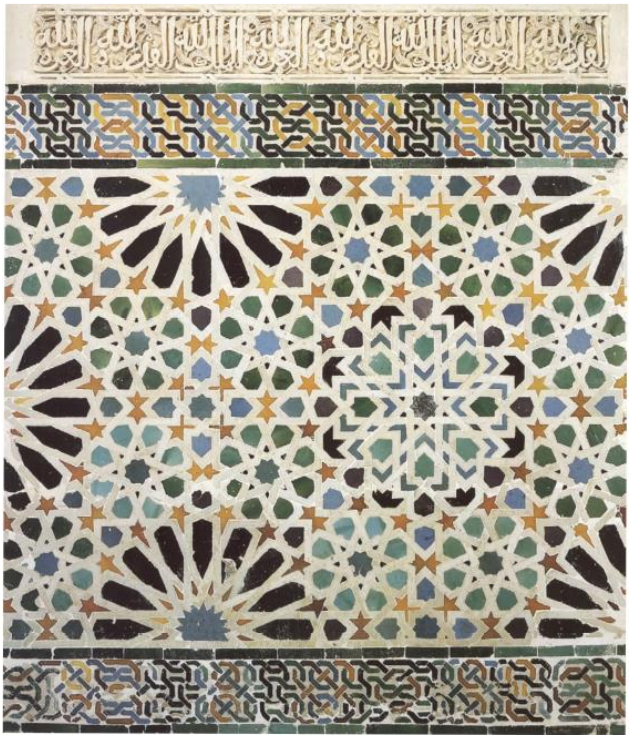

Figure 4.10 : “Panel from Mexuar, the Alhambra, Granada” (Dodds, 1992, p. 375).

Example shown in Figure 4.10 is also from Al-Andalus, and it combines Arabic calligraphy with IGP. In general, this example can be regarded as a two-dimensional application of IGP. The Arabic calligraphy on top of the pattern tiles is translated as “Power is God' s, Glory is God's, Dominion is God's” (Dodds, 1992, p. 375). Comparisons between the two applications seen in Figure 4.9 and Figure 4.10, reveal the similarities in visual hierarchy achieved by the use of the calligraphy and IGP, as one is placed above another. Additionally, it can be said that the visual hierarchy in both applications is preserved in spite of the differences in scale, shape, and function.

Another important point is the amplified notion of depth achieved by utilizing material properties in Figure 4.9. It can be seen that material properties enabled the craftsman to basically carve the IGP on the surface of the object, while highlighting the rays and intersections in between. A similar effect is achieved with the use of colors in Figure 4.10.

This example is important in means of IGP being used in relation to Arabic calligraphy while incorporating religious notions of Islamic revelation on a wider scale. The vertical distribution of geometric and calligraphic composition makes it easier for the viewer to discern each element. It can be said that in this example, once again patterns are used as compositions amplifying and emphasizing the main premise, which is written in Arabic. The script in Arabic is derived from Islamic religious sources, and IGP partaking on the panels in relation to such a statement can be assumed to be an indication of the fact that patterns are indeed elements of a certain order based on the principles of Islamic revelation. Consequently, IGP are applied in consistency with the theoretical background provided in the previous chapters. In the context of production, each item is crafted according to the local methodologies and skills of the craftsmen (Dodds, 1992). Thus, it can be said that each item also represents local production characteristics. Thus, it might be concluded that the principles of usage and application remain almost similar.

Another example incorporating IGP together with Arabic calligraphy can be seen in Figure 4.11. In addition, calligraphic modules are placed in the middle of the star patterns. Such applications can be seen in various architectural applications, but as mentioned earlier, the significance of this particular example lies in its similarity of visual and compositional hierarchy to former examples. Once again, the scale of application is different, yet visual and cosmological relations remain present.

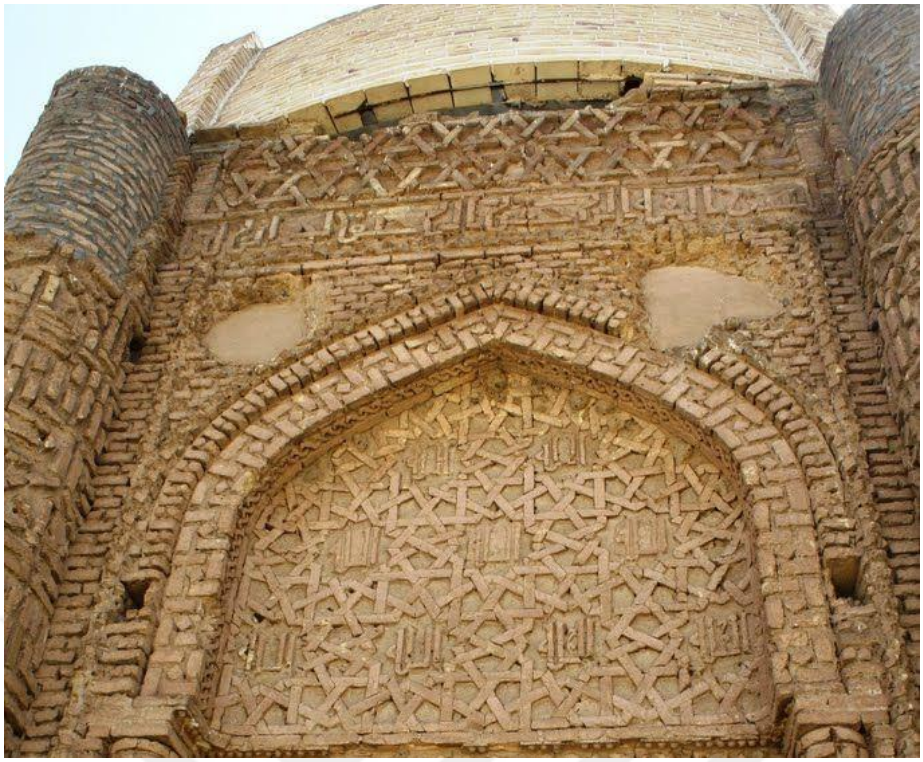

Figure 4.11: "A Seljuk example of a threefold pattern with 12-pointed stars created from the system of regular polygons at the eastern tomb tower at Kharraqan, Iran" (Bonner, 2017, p. 33)

According to Sharifah S. S. M. et al. (2013), geometrical proportions seen in architectural artifacts can be traced even in traditional Islamic carpets, especially of Persian-Islamic origin. In addition, Sharifah S. S. M. et al. (2013) present a visual analysis regarding similarities between Persian architecture and carpets, by stating that such similarities in application are present both for vegetative or "arabesque" patterns and geometric patterns.

In the following chapter contemporary applications of IGP will be discussed in detail. Firstly, a general theoretical background will be provided from the perspective of product design. Also, a brief explanation of terms and representational contexts will be provided.

5. REPRESENTATIONAL CONTEXTS: SPATIAL, TEMPORAL, TECHNOLOGICAL, FUNCTIONAL

5.1 Definitions of Representational Contexts

In the previous chapters, traditional applications of IGP were presented and analyzed accordingly, in regard to the shifts in the modes of application, material, and usage, regardless of the scale of the artifacts. Additionally, in some applications, integration of IGP together with Quranic verses and cosmological elements were regarded as the direct indications of the representational context of Unity and Islamic principles of revelation. When it comes to the contemporary applications of IGP, different representational contexts emerge. In the modern context, artifacts emphasize different values under the influence of changing consumption culture and production methodologies. As a result, a general overview on the contemporary approach towards both the user and product is needed. Baudrillard (1998) states that in the modern society we are more and more surrounded with triggering motivations that lead to consumption. Thus, in the modern context, different factors and parameters lead to relational discussions between the user and product, thus, mass production and mass consumption. Terms such as 'consumer society' and 'use-value' are explained by Baudrillard (1998) as a part of discussion related to the present settings of the modern industry. For example, he states that in the modern sense, culture itself becomes an "object of consumption" Baudrillard (1998, p. 108). As mentioned earlier, traditional applications of IGP can be regarded as entities of Islamic art, thus, manifestations of a cultural heritage. As a result, in the modern context, contemporary applications of IGP can be regarded as the "cultural objects of consumption".

In this chapter, contemporary applications of IGP are discussed according to the terms and parameters briefly mentioned above. At this point it is also important to define and discuss the differences between the two practices: traditional applications of IGP and contemporary applications of IGP.

With the emergence of new production methodologies, a separation between "craft" and "design" became evident (Bayazıt, 1994). To define "craft" Bayazıt (1994) states that it is a work requiring experience and craftsmanship for meeting the materialistic

needs of human beings. Crafted artifacts generally have a quality of being anonymous, just as folk songs, or folk dances. In some cases, anonymity can even be a criterion for a craft to be defined as a craft (Bayazıt, 1994). Design, on the other hand, is defined by Bağlı (2001) as the act of designing or a form being visualized in mind. Thus, it can be said that crafts refer to the modes of making, and design refers to the acts of mental envisioning. Thus, in the contemporary context, design becomes a term for the process of producing consumer objects in masses whereas craft is associated with traditional production techniques together with the notion of scarcity, or producing in limited availability (Bağlı, 2001). Another important point is that in the modern context, the notion of craft can be said to be resulted from the presence of design. Yet, in previous chapters, it was mentioned that traditional craftsmen were involved in metaphysical and religious practices as well, and it shaped their overall workflow. In addition, the fact that both literary and visual sources were utilized in form of the written manuscripts, can be regarded as an indication of a creative workflow similar to those practiced in contemporary product design.

Krippendorff (1989) makes a statement regarding the following definition "design is making sense (of things)", by saying that "making sense always entails a bit of a paradox between the aim of making something new and different from what was there before, and the desire to have it make *sense*, to be recognizable and understandable." (p. 5). To expound his position, Krippendorff (1989) makes the following explanation:

> *"The former calls for innovation, while the latter calls for the reproduction of historical continuities. In the past, sense was provided by alchemy, mythology, and theology. Now we speak less globally of a symbolic ordering that is constitutive of cognition, culture, and reality. Somehow, the word design has not remained in this creative state of paradox, but has shifted to one side. Its current meaning amplifies the aspect of making or, more specifically, of applying a technical-functional rationality to the material world at the expense of the sense that was to be achieved thereby. Perhaps, the pendulum has swung too far. Perhaps, technology has moved too fast for culture to keep up with it. Whatever the explanation, the current concern with product semantics is nothing other than a reaction to the missing sense modern industrial products make or a deliberate effort to recapture this lost territory for design."* (Krippendorff, 1989, pp. 9-10)

In the following discussions regarding contemporary applications of IGP, terms such as "reproduction of historical continuities" and "innovation" are used in this very sense, as defined by Krippendorff (1989). According to Bağlı (2001), the fact that modern design emphasizes innovation and contemporaneousness, resulted in the objects of crafts bearing the notions of past and antiquity.

Some of the traditional artifacts incorporating IGP are still being produced today with similar materials, and production methodologies. But mostly, change in production and consumption industry emerged innovative approaches towards creating products with methods such as computer aided manufacturing and 3D printing.

Mass production changed the whole industry together with the ways users interact with products. It also brought other notions and discussions regarding the objects we use today. According to Barthes (1993), an object can be defined as something that is constrained to the rules of production and having fitted into formed dimensions and qualifications. In the modern context, an object can be defined as anything that makes any use of something. With mass production, each object is produced in huge quantities. Thus, the general approach of mass production is more focused on the notion of "communality" rather than "individuality", resulting in the fact that each object can be defined as an item of consumption (Barthes, 1993). Yet, Barthes (1993) states that each object carries a meaning. In fact, an object is both a functional item and a transmitter of meanings. An object is always a manifestation of the following two planes: a deep, symbolical plane and classification plane. He defines the symbolical plane by stating that an object is a signifier of a signified. In this case, the quality of the signified is related to the viewer (Barthes et al., 2009). Thus, it is highly related to the knowledge, and cultural foundation of the viewer, or as Barthes, (1993) defines it, the "reader". His approach towards meaning shows how it can be formulated in means of semiological research, by stating that from all different defining parameters of an object the researcher might be concerned with the meaning only. To expound his statement, Barthes (1977) gives an example by claiming that in case of fashion, one would not be concerned with the "economic and sociological implications" as a part of semiological research, but rather "which level of the semantic system of fashion economics and sociology acquire semiological relevance: at the level of the vestmentary sign, for instance, or at that of the associative constraints (taboos), or at that of the discourse of connotation." (p. 96). This statement is the main point of semiotic analysis conducted in this study, as it is concerned with the representational contexts of both traditional and contemporary artifacts incorporating IGP. In this case, objects incorporating IGP can be regarded as objects bearing meanings in semiological sense. According to Bağlı (2001), as an object becomes the bearer of cultural values, it transforms into a representation itself. She states that at this point artifacts act as the signifiers, and temporal, spatial, technological and functional

representational contexts are the signified (Bağlı, 2001). Accordingly, if IGP are to be considered as elements of cultural heritage, it can be said that in the modern context, an artifact incorporating IGP becomes an object of representation. In this case, a traditional artifact ceases to function as it was originally intended, and starts to function as a signifier of the "time" (Baudrillard, 1988, p. 74). Examples of traditional applications of IGP presented in the previous chapters can be regarded as the signifiers of "the time" as well, as today they are being exhibited in a completely different environment: museums. Thus, the context in which traditional artifacts are discussed today might have a huge difference from the context in which they were originally created, as whatever is placed in the museums at the present might have been used within a completely different context in the past. Also, the notion of "crafts" becomes more evident in the modern sense, as each traditional object signifies traditional production techniques at the same time. Thus, production methodology becomes a self-evident conception in the modern context as it acts as a distinctive feature (Bağlı, 2001).

Firstly, as a part of the semiotic analysis method, each representational context will be expounded and presented in detail as provided by Bağlı (2001). Then, contemporary product designs incorporating IGP will be analyzed through the semiotic analysis method. Each example will be discussed within the scope of product design, by taking into account the previously provided theoretical background. Each example is gathered from various sources such as personal visual archives, online catalogues, and social media platforms. Additionally, each example is purposefully selected from an inventory of contemporary applications of IGP to clarify and exemplify the main discourse.

Conclusively, each example is discussed in terms of representational contexts firstly presented by Bağlı (2001). In addition, each example is discussed in regard to the representational context of Islamic principles of revelation.

5.1.1 Temporal representational context

Traditional artifacts incorporating IGP were produced according to the technical requirements and availabilities of traditional production methods. Today, some of the methods are still practiced, through which the notion of the past is represented. Contemporary artifacts embodying notions of antiquity and crafts are the representations of the temporal context. At this point, it is not important whether the

artifact is mass produced or hand crafted, rather the deliberate notion of the past is what makes an artifact manifest this particular representational context (Bağlı, 2001). Different applications of IGP in the modern context stand out as forms that reveal the emphasis of the past.

5.1.2 Spatial representational context

The place where an artifact is produced plays an essential role especially if the item is crafted by a craftsman. In general, crafted artifacts can be seen as the representations of a particular place, in contrast to the mass produced items that can be reached globally. Craft emphasizes local attributes and practical techniques, thus has a stronger value when it comes to representing locality. Touristic objects can be seen as cultural indications of a particular geographical location as well. They can be given as examples for the artifacts manifesting spatial representational context, thus, products act as representations of a particular location.

The fact that touristic objects act as proofs of translocation and travelling, gives them a stronger position when compared to mass produced objects. (Bağlı, 2001).

Artifacts incorporating IGP manifest spatial representational context that represents cultural values and visual attributes of a particular geographical location.

5.1.3 Technological representational context

Technological representational context is related to the production methodologies. Today, innovative and emerging production methods such as 3D printing and computer aided manufacturing change the industry and the way products are designed and produced. In case of craft, objects mostly manifest technological representational context by the natural use of the material. In case of mass produced design objects on the other hand, great emphasis is placed on the ideation phase. Technological representational context depends on the manner of using a material and its choice to a great extent. Thus, materials preserving their natural attributes and substantial references are representational components of the artifact that also represent the concept of craft. Aside from choice, use of material and the process of transforming it into a functional object is also an important feature of craft. For example, in the case of a weaved basket, production method can be traced in the outcome, which is accomplished by the practice of weaving a raw material. In craft, production traces on the artifact can be seen as references to the artisan’s workflow (Bağlı, 2001).

When it comes to mass produced designed objects, emphasis on the ideation process together with the invisible traces of production emerge a new discussion in the context of technological representation. In the case of IGP, even if a contemporary design incorporates patterns and embody traditional visual features of a crafted object, change in production methodologies manifest change in technology.

5.1.4 Functional representational context

This section expounds the usage of IGP mostly in its functional sense. While function is an essential component of design, crafted objects are generally regarded as more decorational and figurative. An example for the usage of IGP in functional representational context can be seen in both traditional and contemporary applications, as function can be regarded as a definitive parameter for an object (Barthes et al., 2009). This representational context can be seen especially in the innovative practical applications of IGP, as patterns have distinctive parametric properties.

In the following chapters of the study different contemporary applications of IGP will be discussed and analyzed through the following parameters: theoretical background provided at the beginning of the study, comparison to traditional modes of similar applications, and most importantly, representational contexts expounded in the sections.

5.2 Contemporary Applications of IGP in Product Design

In this final chapter of the study, it is aimed to present and explore all possible relations between the theoretical background provided at the very beginning, Islamic principles of revelation and cosmology, together with the representational contexts, through semiotical analysis. As mentioned earlier, in contemporary applications of IGP, principles of design are revealed through the incorporation of the "technical-functional rationality" (Krippendorff, 1989, p. 9) together with the notion of "traditional" applications of IGP. Thus, notions of temporality, spatiality, functionality, and technology are revealed even more. Several notions were already discussed through the use of IGP in traditional applications, such as functionality, and unity. When it comes to the contemporary applications of IGP, on the other hand, it can be said that all representational contexts previously mentioned are revealed in one way or another. Discussions include previously defined and expounded representational contexts through the examples of contemporary applications of IGP.

Each evaluation is based on the temporal, spatial, technological, and functional representational contexts, as stated by Bağlı (2001). In addition, each example is evaluated within the context of Islamic principles of revelation, and the notion of unity. Conclusively, each example is selected to reveal possible relations among the mentioned elements of discussion.

Contemporary applications of IGP can be encountered in various scales, practices, and fields. Emergence of new production technologies enabled designers to use innovative tools to design and produce desired outcomes. In addition, inherently analytical and structural nature of IGP made it easier to be used in contemporary design and production practices, which will be further expounded in detail in this chapter.

Some contemporary applications of IGP can be regarded as two-dimensional (or graphical) applications having visual and structural similarities with traditional applications to a great extent. These examples can be regarded as representations of the temporal context, as such similarities refer to the notion of "time", thus, traditional applications of IGP. An example for such an application can be seen in Figure 5. 1. In this particular example, it can be said that the mode of application refers to the use of IGP inside the domes of the mosques, seen in Figure 5. 2.

Figure 5. 1 : Moroccan sink by Kohler (Pijak, 2014).

Figure 5. 2 : A dome at a Mosque, Iran. (Url-2)

In Figure 5. 1, one can see the integrated use of patterns both arabesque and geometric. The arabesque pattern, however, is placed in a manner almost similar to the structural deformation seen in the dome of the mosque. In a way, it can be said that there is a certain product metaphor, regardless of the functionality. “In a product metaphor, the target is designed in such a way that it evokes in users some perception or experience of the source.” (Cila, 2013, p. 90). In addition, it can be said that the both applications are “structurally consistent: that is, that observe parallel connectivity and one-to-one correspondence.” (Gentner & Wolff, 2000, p. 298). In fact, it is the definition of “structure-mapping”, a component of linguistic metaphorical discourse (Gentner & Wolff, 2000, p. 298). In case of the example in Figure 5. 1, the structural consistency lies in the dome-like shape of the sink. Another correspondence can be seen in the use of the pattern, as it narrows down to the center. Yet, one might argue that the two have absolutely no relation in means of functionality, in fact, perhaps the latter can be regarded as controversial or irrelevant, which is another discussion. In means of functionality, it can only be said that IGP in this particular application are not taking any part in the functionality of the object. Thus, it can be said that this particular application of IGP manifests temporal, and perhaps, technological representational contexts, as there is no trace of traditional production methodologies seen in such applications of IGP.

A similar application on a similar product can be seen in Figure 5. 3. In this example, IGP is applied on the base of a sink, but this time it is on a planar surface. The shadow of the pattern can be seen on the secondary surface beneath the sink.

Figure 5. 3 : Motif Vanity by OMVIVO (Url-3).

A similar practice of generating shadows through the patterns is encountered in traditional architectural applications of IGP. Such an application is defined as “Jali”, and can be described as the use of decorational elements as a part of the architectural composition (Batool, 2014). Conclusively, application shown in Figure 5. 3 underlines the dynamic interaction of light and water by adding a new kind of functionality. Thus, the effect of transparency seen in traditional architectural applications, is achieved through the use of a geometric pattern generating a similar effect in the modern context. At this point, it is important to mention the term “mapping”. Expounded by Cila (2013), “mapping” is defined as “the physical application of the source on the target only.” (Cila, 2013, p. 12). In this case, it can be said that “mapping” is achieved through the manner of application.

Use of IGP in a similar way can be related to the notion of functionality traced in the traditional application as well. Yet, the overall functionality of both applications entirely differ from one another, as the latter is used as a way of protection from the excessive daylight, whereas the former incorporates IGP mostly for the aesthetic and visual purposes. Also, in the contemporary application, transparency is present as it is, through the use of an inherently transparent material. It can be said that technological, and temporal representational contexts can be traced in contemporary application of IGP shown in Figure 5. 3.

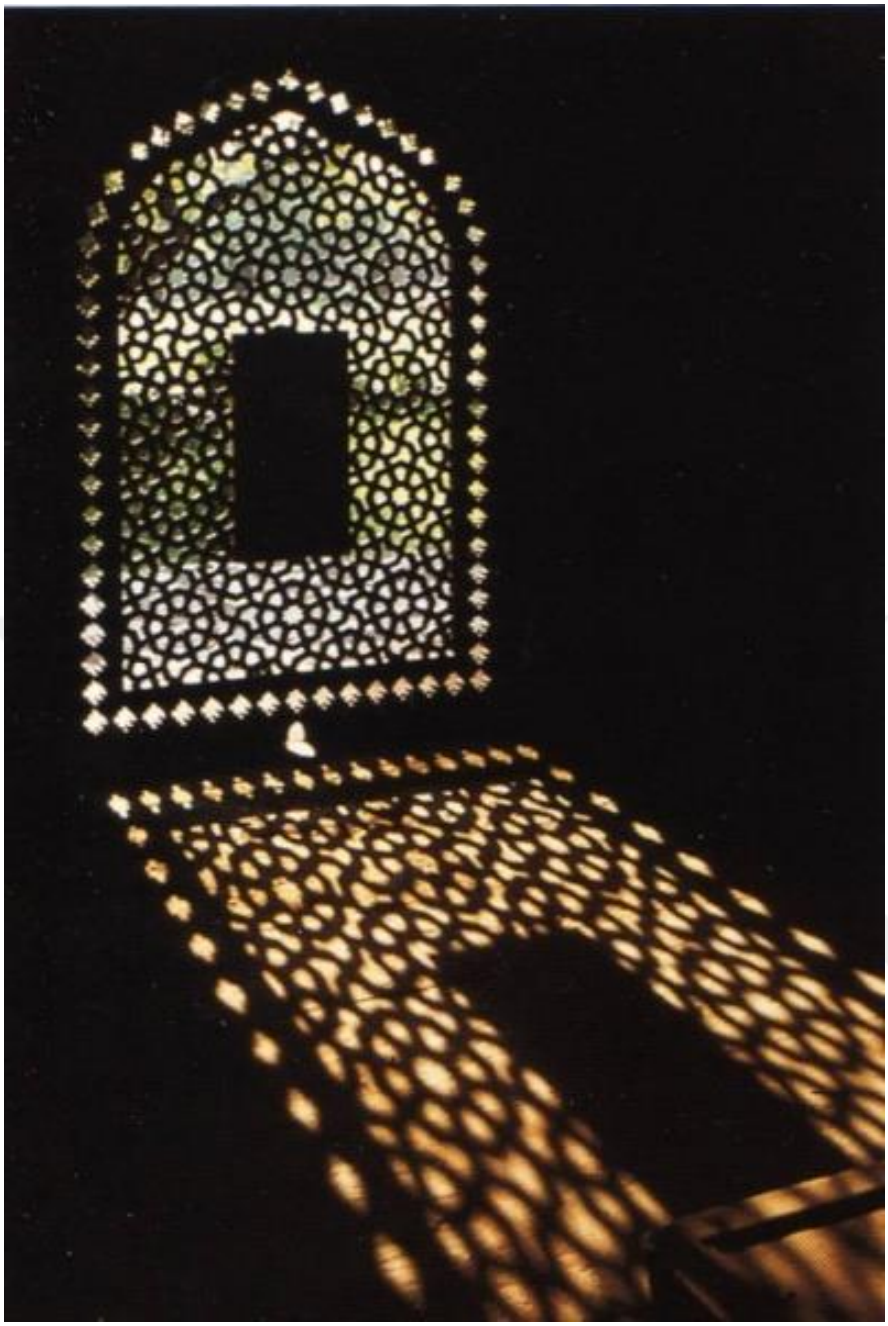

Figure 5. 4 : A Jali example (Url-4)

Another application of IGP in graphical means can be seen in Figure 5. 5. In general, graphical applications are far from manifesting functional representational context. In the example shown in Figure 5. 5, a geometric pattern can be seen used on the wayfinding panels. It is designed for Museum of Turkish and Islamic Arts, thus manifesting the notion of locality. It can be said that this particular application manifests spatial representational context. On the other hand, one might have discerned the functional representational context, only if singular modules of IGP were used as a part of the indicatory signs. In the present case, however, singular modules are used to add a notion of "belonging", as it is designed for the Museum of Turkish

and Islamic Arts. At this point, the singular module of IGP acts as a signifier of the general concept of Islamic tradition, or perhaps Islamic creative practices in general. Yet, use of IGP on a wayfinding panel referring to a WC can be regarded as a purely contemporary application, taking into account all the cosmological principles and relations of IGP discussed in the previous chapters.

Figure 5. 5 : Way Finding design, (Düzgün, 2018).

As contemporary production methodologies offer more and more feasible ways of design and production, it can be said that contemporary applications of IGP are becoming present on products of considerably wider scope of range and functionality. Production techniques such as digital and 3D printing enable many opportunities that were not available even shortly before.

The Figure 5. 6 is an example of a tableware incorporating IGP. In Figure 5. 6, IGP are digitally printed on the surface of the coffee cups and lower plates. In this case, IGP are applied on a product having traditional correspondences previously mentioned and discussed in the earlier chapters of the study. Thus, it can be said that this particular application manifests temporal, technological, and the primary representational context, which is the notion of unity.

Figure 5. 6 : IGP as two dimensional graphical application, in a Paşabahçe store in Istanbul.

A similar application can be seen in Figure 5. 7. It can be seen that IGP are incorporated graphically. Such applications can be regarded as the "reproductions of historical continuities", as Krippendorff (1989) defines it. The reason for such a resolution lies in the manner of application of IGP, as it is simply applied on a planar surface. Once again, produced with the help of digital printing techniques, resulting in the manifestation of technological representational context.

Applications of IGP of the kind shown in Figure 5. 7 can be encountered in various media and locations. For example, this example was captured in Tchibo. As it is a store where many different products are sold, one may infer that such encounter with the product is entirely arbitrary. Conclusively, as traditional applications of IGP can be traced mostly within the borders of Islamic art and tradition, when it comes to the contemporary applications of IGP, one might infer that IGP can be encountered in contexts regardless of the environment.

Figure 5. 7 : A triple bag set for personal care, Tchibo.

On the other hand, it is also important to mention that the locality of the product also plays an essential role, especially if it signifies a particular experience in that given location. Some examples for such applications can be defined as touristic.

According to Bağlı (2001) In Arab and Middle East countries, including Turkey, similar attractions and products are placed on the market. The reason for this is that the notions carried on them become more prominent than the products offered in the market. Thus, in contemporary applications, products incorporating IGP become the representations of a particular notion, or cultural context. at this point a notion previously mentioned by Baudrillard (1998), regarding the fact that culture itself becomes an object of consumption. An example for such a notion can be seen in Figure 5.7. It is a tote bag of a friend, bought in Konya, Turkey. In fact, once asked, the owner stated that the reason she bought and used it was only because it refers to a particular location and experience. Conclusively, it refers to a particular location. Thus, spatial representational context is revealed. Once again product is produced by digital printing techniques.

Another notion emphasized in this particular example is the highly religious figure, Mevlana, together with the whirling dervishes. The word “Mevlana” is also written on the upper left side of the tote bag. Thus, IGP are used as signifiers of a particular location and cultural inheritance.

Figure 5. 8 : A bag incorporating IGP, from Konya, Turkey.

a

Figure 5. 9 : A bag incorporating IGP, bought in Spain, used in Istanbul.

Another similar product shown in Figure 5. 9, bearing traces of the spatial representational context. The word “Granada” is integrated with IGP in order to emphasize locality of the product. Once again, pattern can be seen digitally printed on the product, through which technological representational context is revealed.

An important point to mention is that both products bear similar visual properties, although one is bought from Turkey, and another from Spain. Such similarity verifies the proposition made by Bağlı (2001), as previously mentioned.

Graphical applications of IGP on various materials and scales also manifest spatial representational context, by signifying the notions of locality. Some public spaces in Istanbul are adorned with IGP both in outdoor and indoor applications. In such cases, most of the times, IGP are incorporated similarly to traditional applications. Such applications can be mentioned as the “reproductions of historical continuities”, as defined by Krippendorff (1989).

Figure 5. 10 : An example of IGP in public space, Maslak metro station, Istanbul.

An example for such application can be seen in Figure 5. 10. It can be said that contemporary applications of IGP in public spaces signify a particular locality, an approach mostly adopted by the municipalities in Turkey. From this point of view, in some cases IGP manifest spatial representational context by signifying the notions of Islamic cultural heritage and traditional applications. Thus, different applications of IGP can be encountered while walking around the city, both traditional and contemporary, but only a few are presented in this study.

Another contemporary application of IGP in public space can be seen in Figure 5. 11. According to Fiske (2010), “When signs make myths and values public, they enable them to perform their function of cultural identification: that is, they enable members of a culture to identify their membership of that culture through their acceptance of common, shared myths and values.” (p. 163). It can be said that patterns are used as decorational elements and signify cultural codes. This time, IGP are applied on a separate material, integrated on another plane, most probably produced through the CNC cutting techniques. Such a production technique enables IGP to be used on various surfaces. In this case, as it is applied on an amorphous planar surface, it can be said that once again, geometrical proportions of the application are quite arbitrary. Also, it can be seen that the pattern is used together with the emblem of the municipality, which emphasizes the notion of locality, resulting in the manifestation of the spatial representational context. Once again, technological representational context is observed as production methodologies differ.

Figure 5. 11 : IGP applied on a wall by the municipality, Istanbul.

Figure 5. 12 : A screen, of "Jali" as a divider for WC, Turkey.

In some cases, applications of IGP can be seen in a perfectly consistent manner in relation to the function of the product. Such example was formerly presented, in the case of a water filtering object. In fact, it can be said that patterns even amplify the effect by signifying the notions of Islamic religion. Nevertheless, Figure 5. 12 refers to an opposite situation. In this case, IGP are applied on a planar divider that is used as an entrance to a WC. Although it can be seen that visual properties are quite similar with the application shown in Figure 5. 11, the manner of usage composes a contradictory situation. One of the reasons of contradiction arises from the function of the object on which IGP are incorporated. As previously expounded, entrances have significantly important meanings in different cultural contexts. Thus, once incorporated around an entrance of a mosque, IGP signifies principles of Islamic revelation. In contrast, in Figure 5. 12 IGP are used right at the entrance of a WC, resulting in contradictions regarding the signified system of meanings of IGP.

Another detail to point out for the future considerations is the use of the gender signs, shown in Figure 5. 13.

In some contemporary applications, IGP are accompanied with graphical elements signifying notions other than that of Islamic. In such applications it is discussed whether the overall composition is consistent with the Islamic principles of revelation or not.

Figure 5. 13 : Contemporary application of IGP on a masjid, Istanbul.

In Figure 5. 13, IGP are precisely integrated on a religious building, through the use of contemporary production methodologies such as CNC cutting. Yet, visual properties of the masjid emphasize a mixture of both traditional and contemporary typologies. Additionally, as all graphical elements, including the IGP, are used altogether in an arbitrary manner compared to the compositions encountered in traditional applications, it can be said that considerations regarding the overall geometrical proportionality is nonexistent. Thus, differences in the modes of application can be discerned, once compared to the traditional applications of IGP of such utilization.

Another riveting detail is the gender signs. Such signs are generally used to signify WC and are placed to guide the user. Discussion is not concerned with architectural properties and is limited to the use of IGP with accompanying graphical elements, yet from a semiotic point of view, use of a “mescid” icon together with a literary explanation is another design problem, as the icon itself infers to a certain typology that is much different from what we actually see.

Conclusively, incorporating IGP as traditional elements might result in controversial outcomes, if other compositional elements signify meanings other than that of religious, metaphysical, or cosmological. Thus, representational context of unity is

partially manifested through the function of the building, as it is a masjid, and it would still represent the notion of unity, even without any use of IGP. Thus, in this case, IGP act as auxiliary decorational elements. When it comes to spatial representational context, it can be said that no such signifiers are present, as such applications of IGP are not limited to a certain location.

Figure 5. 14 : IGP applied on a trash bin, Istanbul.

Another controversial application of IGP can be seen in Figure 5. 14. The same municipality emblem can be seen on the right side of the bin, which connotes the notion of "locality". Additionally, once again, this type of application overlaps the signified system of meanings of IGP, as patterns are placed on an object having negative associations both physiologically, and symbolically, which leads to a contradiction on symbolical, metaphysical, and semiotical levels.

It can be said that the last four examples incorporate IGP in a similar manner, as each design is achieved through the use of two layers, one of which acts as a background of the other. This similarity in means of design and production provides a fine reference plane for comparison, as in all of the four applications fundamental design problems are similar, regardless of the material choice, scale of application, and functionality. Thus, it can be said that in such cases, IGP mostly act as decorational elements signifying technological and spatial representational contexts, rather than acting as

representations of Islamic cosmology and principles. In fact, in some cases, use of IGP in controversial contexts such as WC dividers, may result in contradicting outcomes. Contemporary applications having traditional, visual, contextual and technical properties can be regarded as more direct examples of "reproductions of historical continuities". Such examples can be encountered in highly touristic locations, as they bear the notion of "time" (Bağlı, 2001). According to Bağlı (2001), supply of such reproductions of the past result in change of the system of meanings that products originally connote to. Figure 5. 15 can be assessed as an example for such a shift in meaning, as it is encountered in a highly touristic location in Istanbul; Kapalı Çarşı. Also, traces of production refer to a certain intention of acquiring a traditional look, which refers to technological representational context. In addition, temporal representational context is revealed, as in a way, such products can be defined as the "conversions of the past into goods" Bağlı (2001). Such products are highly ubiquitous, thus, only two examples are included, seen in Figure 5. 15 and Figure 5. 16. Both of the products have similarities in the manner of use of the materials, visual attributes and functionality, compared to traditional correspondences. In some cases, such products are produced in similar production techniques, and in small quantities, to achieve the required outcome. Such products emphasize the notions of "scarcity", as previously mentioned. It can be said that both products also manifest the representational context of unity, as both can be regarded as reproductions of traditional applications of IGP.

Figure 5. 15 : A backgammon gift set, Grand Bazaar, Istanbul.

Figure 5. 16 : A side table sold in a store in Eminönü, Istanbul.

As change in production methodologies leaded to new possibilities and opportunities, various applications of IGP emerged in mixed production methodologies. New technologies shape production methods that lead to greater possibilities and innovative applications, as in the case of "nurbs surface articulations emerging with introduction of CNC milling" (Schumacher, 2009, p. 33). In such cases, IGP are incorporated in a traditional manner, yet with relatively, or partially contemporary techniques. Use of IGP on a side table can be regarded as a common practice and is encountered both in traditional and contemporary applications. Designs of Nada Debs can be given as examples for such applications. Nada Debs is a designer from Lebanon, incorporating IGP in various products and applications with contemporary techniques. She mostly incorporates local artisanship with contemporary materials and production techniques, which result in hybrid creations embodying artisanship and design. Thus, in general, her designs can be regarded as contemporary product designs having Islamic traditional roots. Figure 5. 17 is a side table designed by Nada Debs, using both traditional and contemporary production techniques. Compared to Figure 5. 16, differences in production techniques, material choice, and mode of application can be

noted. Yet, both products have same functionality. At this point, the statement by Krippendorff (1989) can be mentioned, as his partition of the "innovative" from the "reproduction of the historical continuities" can be exemplified through the last two examples. Accordingly, Figure 5. 16 can be regarded as the latter, while Figure 5. 17 is the former.

Figure 5. 17 : Nada Debs, "C Resin Side Table", mondo collection.

It can be said that Nada Debs widens possibilities of contemporary usages of IGP while keeping traditional practices intact. Conclusively, it represents technological representational context, as one can see how changes in production techniques resulted in relatively contemporary outcomes. Also, her general design workflow is coherent with traditional usages of IGP, thus her designs have similar representational properties as of a traditional artifact, which embodies IGP as an element of ornamentation. Thus, representational context of the unity is also in subject. But the notion of contemporariness is achieved through the use of a contemporary material: resin. Yet, it signifies traditional modes of application through the use of IGP, which can be produced in brass, or silver. Additionally, it can be said that her designs manifest spatial representational context as well, since her designs take place in various exhibitions and parts of the world, and are mainly produced in Lebanon.

Another contemporary application on a product of a similar functionality can be seen in Figure 5. 18. Once again, the notion of contemporariness is achieved by the horizontal plane, produced from recycled plastics. It is entirely produced by contemporary production techniques, manifesting technological representational context. Additionally, it can be said that product manifests the representational context of unity through the use of a single module of IGP. In fact, without the pattern, product would be simply regarded as a "product design". Perhaps same statement is valid also for the Figure 5. 17.

Figure 5. 18 : "daevas adorns recycled coffee tables with persian + islamic patterns", (Url-5)

Another such example can be seen in Figure 5. 19. Incorporated on a phone case, patterns are produced with contemporary production methodologies for contemporary usage scenarios. In fact, compared to the previous example, it can be seen that IGP are incorporated in a similar manner, as in both examples patterns are embossed on the surface. Thus, it can be concluded that in the last three examples (Figure 5. 17, Figure 5. 18, and Figure 5. 19) IGP are incorporated on a relatively two-dimensional level.

Figure 5. 19 : A geometric pattern on a phone case, (Url-6).

In the following examples, IGP are incorporated on a relatively amplified three dimensional level. As seen in Figure 5. 20, a single module of IGP is used as a part of the product. In fact, the three dimensional outcome is achieved by extrusion. Product is produced fromsame recycled plastic material and is 3D printed. Function of the product is not emphasized as it is designed to be a toy.

Figure 5. 20 : "Zelli Man Mini", by Younes Duret, (Url-7).

Once again, even if the pattern used on the product has exactly the same structure with those of traditional patterns, change in production methodology and material choice can be assumed to be the defining parameters for a product to be discussed within different representational contexts. Change in production methodology and material choice can both be regarded as indications of the technological representational context. Function of the product, however, is purely contemporary, as using figurative elements are not allowed according to the principles of Islamic revelation (Burckhardt, 2009).

Functional representational context is revealed at its most when IGP are used as entities to perform a certain function. For example, in Figure 5. 21, empty gaps between the rays of IGP are designed to be used for functional purposes.

Figure 5. 21 : "Star Shelf" by Nada Debs (Url-8).

It can be said that the bookshelf manifests both functional and technological representational contexts. On the other hand, the bookcase embodies similarities with traditional uses of IGP, thus, being coherent with the theoretical principles explained at the beginning of the study. In a way, it refers to almost all mentioned representational contexts, as it has references from and notions of locality, production methodology, temporality, and functionality. Also, the bookcase tends to form a wider pattern once placed side by side as shown in the figure. Conclusively, in this example, IGP are used to emphasize the primary function of the product.

A similar application can be seen in Figure 5. 22. It incorporates primary features of both traditional applications of IGP and innovative explorations of IGP in practice. This time, pattern is "transposed" into the third dimension, rather than extruded. In fact, in regard to such "transposition", it can be said that product bears similarities with muqarnas structures previously expounded in detail. In addition, both applications have similar structural properties, considerations of geometrical proportionalities, and

even functionality, as both can be regarded as a means to distribute the light. Additionally, it effectively incorporates the representational context of unity, by signifying the connotative system of meanings, even purely on a functional level. Another important point is that this particular application of IGP is innovative in means of material usage and production methodology.

Figure 5. 22 : Mandala No.1, by Willowlamp (Url-9).

Also, the light sources are placed directly within the gaps formed by the rays of the pattern, which corresponds to the functional representational context. Conclusively, technological, and functional representational contexts are revealed.

An important point to be noted in the case of Figure 5. 22 is the manner of use of the pattern in such a coherent relation to its functionality, and implicitly with the cosmological and metaphysical principles of Islamic revelation.

To further emphasize, the relation between IGP and functionality of the product can be analyzed in Figure 5. 23. Once again, a single module of IGP is incorporated to reveal the functional representational context. The geometric module can be defined as a "12 pointed star", in case of which each point corresponds to an hour. This way, it emphasizes the functional representational context, both in graphical and three-dimensional sense. Also, use of a contemporary material, which is concrete, can be regarded as an indication of the technological representational context.

In such example, the manner of application of IGP is deeply integrated with the functionality of the product, thus resulting in a contemporary, and "innovative" application in the sense of the previously mentioned definition by Krippendorff (1989).

Figure 5. 23 : A clock inspired by Islamic patterns, designed by CitieSocial (Url-10).

Such “innovative” applications can be encountered in various products. A coffee cup designed by Selben Studio incorporates a single module so that the cup precisely fits its nest. It should be noted that such functionality is achieved through a similar act of “transposition” discussed in the case of Figure 5. 22.

Figure 5. 24 : Otto coffee cup design by Selben Studio.

Perfectly geometrical properties of IGP enable designers to utilize patterns in many ways, with the help of computer aided design and production methodologies. Such methods can be utilized to develop mathematically precise outcomes through the use of “parameters”. Parametric design is a method mostly used in computer aided design practices through the use of algorithms (Woodbury, 2010). In addition, it is among

innovative applications of IGP in various fields, including product design and architecture. An example for such an application on a textile can be seen in Figure 5. 25.

Figure 5. 25 : Design by threeASFOUR, ready to wear Spring/Summer (Url-11).

It is designed as a part of the Haute Couture collection by threeASFOUR. It can be said that in this particular example, inherently parametric properties of IGP are utilized and revealed. In traditional applications, parametric properties can be encountered in the domes of the mosques. Yet, in such cases IGP are mostly incorporated in relation to the form of the architectural element (Figure 5. 2). In Figure 5. 25, however, parametric properties are utilized regardless of the overall shape of the product. In fact, it can be said that such utilization is still present on a graphical level. On the other

hand, it constitutes a certain differentiation in the manner of application, compared to the previous examples formerly presented. Conclusively, it is an important example in means of innovative utilization, as patterns are not directly applied on a surface. Rather, such contemporary application can be regarded as another "innovative" outcome incorporating contemporary design and production techniques, by exploring new opportunities and abilities of IGP.

Recent academic studies on IGP explore new fields of application and utilization to benefit from the perfectly parametric properties of IGP. According to Karanouh and Kerber (2015), "Digital design tools such as algorithmic software and parametric models have matured past the point of just creating sculptural geometry." (p. 221).

Parametric properties of IGP enable new ways of implementation in material research as well. Schumacher (2009) discusses the term "parametric patterns" in his article by presenting applications of geometric patterns in architecture. In fact, he brings the term "parametricism" as a definition for a certain style, mostly found in the works of Zaha Hadid (Schumacher, 2009). Nevertheless, this notion can be found in product design as well.

Structural properties of IGP are further explored and presented in a scientific academic work by Rafsanjani and Pasini (2016). Rafsanjani and Pasini (2016) and Yi et al. (2018) mention "auxetic structures" (p. 64) that can be defined as a "structure that can be expanded and contracted with a simple force" (Yi et al., 2018, p. 64). Accordingly, in this study, IGP are discussed as "auxetic mechanical metamaterials" (Rafsanjani & Pasini, 2016, p. 292). Thus, IGP are implemented and tested as expandable materials during the "loading (tension) and unloading (compression)" (Rafsanjani & Pasini, 2016, p. 293).

In the following discussion, examples of both parametric and auxetic structures will be provided within the scope of product design. IGP revealing auxetic and parametrical properties will be exemplified and discussed in detail. In general, the primary concern is to expound possible shifts and differences, as in some cases, similar patterns are used both as auxetic structures and ornamentations on products. An example for such application can be seen in Figure 5. 26. It is excerpted from a video showing how IGP are transformed from two-dimensional ornamentations into three-dimensional auxetic materials. Several types of IGP are included in the video, yet only one is included for a consistent comparison, the same material can be seen in Figure 5. 27.

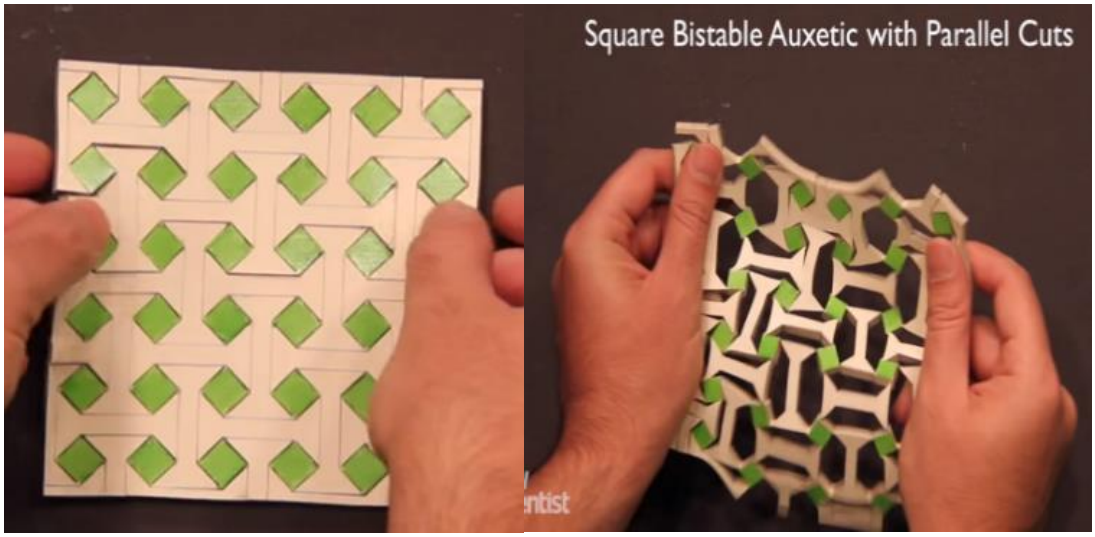

Figure 5. 26 : IGP as auxetic, expandable material (Url-12).

This exploration reveals various possibilities and adaptable practices of IGP. In Figure 5. 27, however, it can be seen that same pattern is used as a decorational element on a highly religious product. In this case, differences in functional representational context can be discerned, as in Figure 5. 26 the pattern itself acts as a functional object, whereas in Figure 5. 27 it is used as an "auxiliary" element to signify the notions of Islamic revelation. Moreover, in Figure 5. 26 functional representational context is highly amplified as IGP becomes a functional product itself.

Figure 5. 27 : "Rahle" (reading desk) designed by Raşit Karaaslan, produced by Mobi (Url-13).

The “rahle” incorporates IGP in a similar manner to that of Jali screens. Product embodies characteristics of a traditional “rahle” in means of material use and ornamentation. Also, it can be said that product embodies various notions in representational sense. First of all, as it is a highly religious product, in overall, it can be regarded as a representation of Islamic cultural heritage, art, and revelation. Thus, use of IGP on such a product amplifies its standing point in the context of temporal representation. Visual and structural properties of the pattern have commonalities with traditional applications of IGP.

Conclusively, same pattern can be seen in two completely different modes of application. One in the form of a functional material bearing scalable opportunities, and the other in the form of a “reproduction of historical continuities”.

Utilization of IGP based on auxetic and parametric properties are more and more encountered in contemporary applications, particularly in academic studies. In such applications, IGP manifest functional and technological representational contexts, as in some cases they are used for the structural abilities that are aimed to enhance the overall efficiency of a product. They are also used as dynamic elements in architecture, such as “screens, façade elements and shading systems” (Stavric & Wiltsche, 2019, p. 89). Stavric and Wiltsche (2019) exemplify auxetic structures through a visual shown in Figure 5. 28. This example is to show expandable properties of a particular Islamic geometric pattern. It can be seen that certain relations between the modules of the pattern result in dynamic abilities that enable flexible expansion.

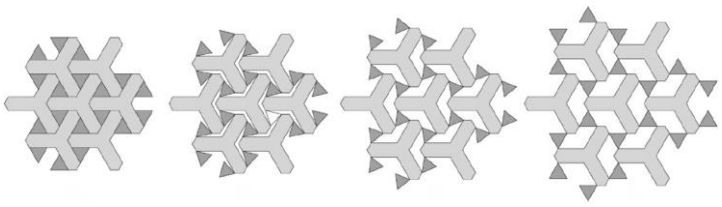

Figure 5. 28 : Auxetic IGP, (Stavric & Wiltsche, 2019, p. 86).

Same IGP can be seen in Figure 5. 29, in the form of a physical material, transforming into different shapes and sizes.

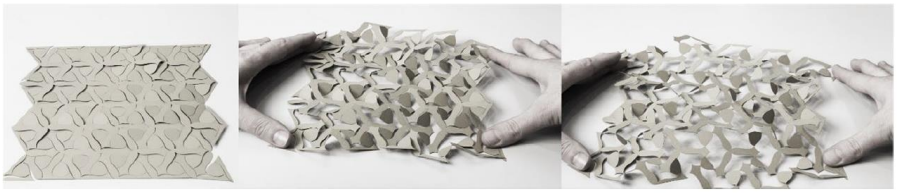

Figure 5. 29 : Auxetic IGP from paper (Stavric & Wiltsche, 2019, p. 86).

Similar pattern is encountered in various traditional applications, one of which can be seen below, in Figure 5. 30.

Figure 5. 30 : A pattern from Karaghan tower in Iran (Rafsanjani, A., & Pasini, D., 2016, p. 292).

Moreover, as mentioned earlier, in some cases, auxetic materials are used to enhance or provide a particular function. As seen in Figure 5. 31, product can be seen incorporating a similar pattern to provide different modes of lighting, which is a strong exposition of functional representational context.

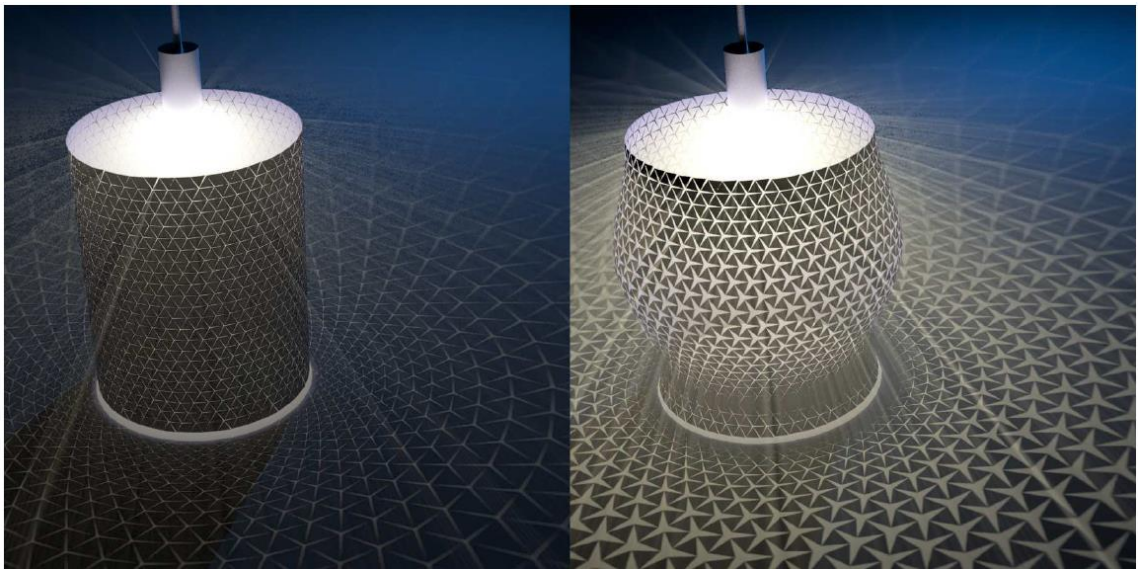

Figure 5. 31 : "Our auxetic design tools can also be used to explore lighting design—here an "open" and "closed" configuration of the same linkage provide mechanical dimming", (Konaković et al., 2016, p. 9).

Same pattern can also be seen on a completely different product as in Figure 5. 34. Innovative tire design incorporates a geometric pattern bearing algorithmic properties, this time in a different manner. Once again, notions of "adaptability" can be traced, as certain modules of the pattern are able to embark.

Moreover, it can be seen that in such examples functional representational context of the IGP is escalated, and that IGP has almost no relation to the connotative system of meanings, as the primary concern in such applications is to achieve the required outcome of "adaptability" and "functionality".

Figure 5. 32 : Innovative tire design by Hexonic (Url-14).

It can be said that the use of different modes of production enabled products that can change in shape, visual properties, and even functionality. Thus, another important feature of IGP is revealed: "adaptability".

A different use of auxetic materials generated on the basis of IGP can be seen in daylight system controls, shown in Figure 5. 33. It can be seen that the generated design has distinctive parametric and dynamic properties enabling enhanced functionality.

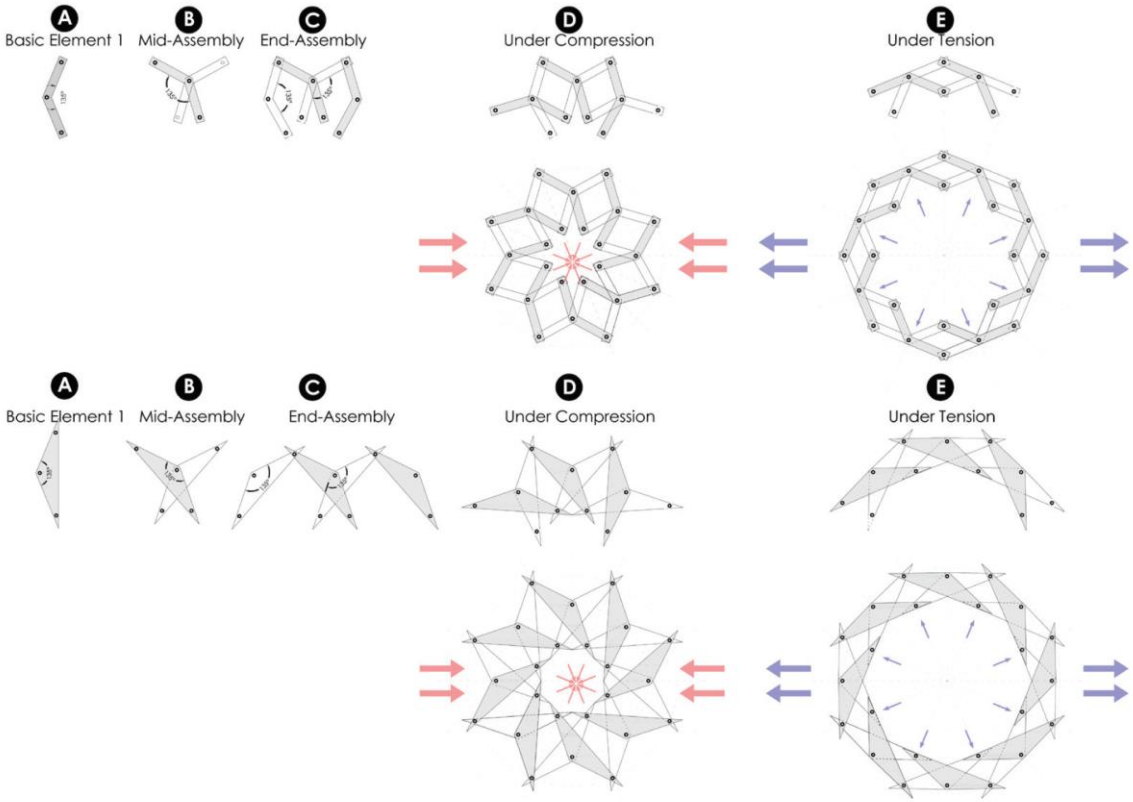

Figure 5. 33 : "Process of developing auxetic geometry", (Yi et al., 2018, p. 66)

A similar application of a likely principle can be found on Al Bahar towers, shown in Figure 5. 34. It can be seen how a geometric pattern is transformed into a functional product through parametric properties.

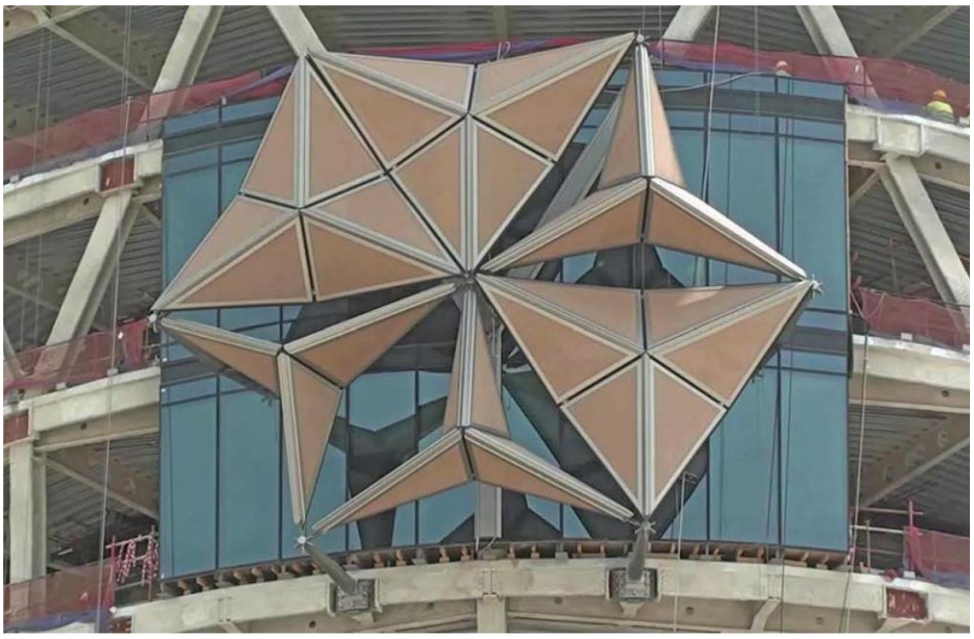

Figure 5. 34 : "An assembled part of the building's facade demonstrates the realisation of the CODE principles.", (Karanouh & Kerber, 2015, p. 197)

Figure 5. 35 : "The Mashrabiya of the Al-Bahr Towers as seen from the outside", (Karanouh & Kerber, 2015, p. 217)

Although examples provided above can be assumed to be examples of architectural applications, in this study this particular example is regarded within the scope of product design. It can be regarded as an outcome of both parametric and auxetic design properties of IGP.

Once integrated with contemporary production techniques, even more possibilities are being explored. As new production methodologies such as 3D printing and laser cutting are being used more and more, complex outcomes having distinct geometrical properties are being produced. As an example, CNC cutting and 3D printing practices were utilized to achieve the result seen in Figure 5. 36.

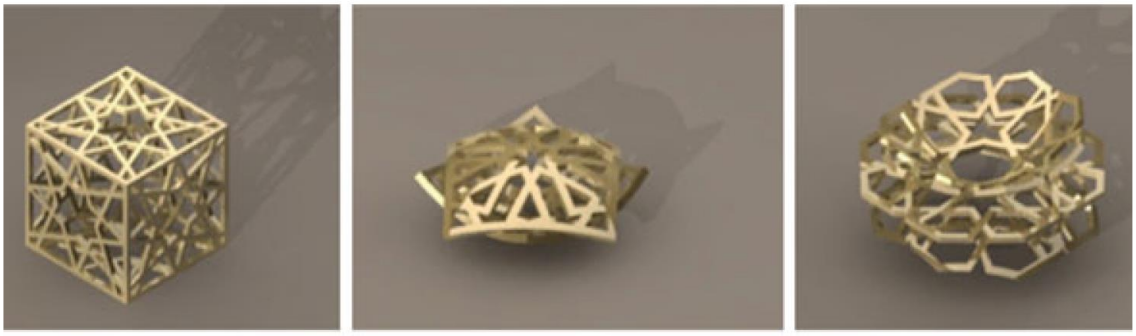

Figure 5. 36 : Jewelry design inspired by the IGP, (Rahim et al., 2016, p. 235)

In such example, one can see the parametric properties of IGP utilized with the help of computer aided design software that enable intricate and complex applications of IGP. It can be said that these applications are not otherwise possible to be produced, if not for the 3D printing methodologies.

Another academic research on parametric applications of IGP is conducted by Kaplan (2017). His work mainly includes "interwoven surface from a patch of regular polygons connected edge-to-edge, together with suitably chosen motifs inscribed in every polygon" (Kaplan, 2017, p. 71)

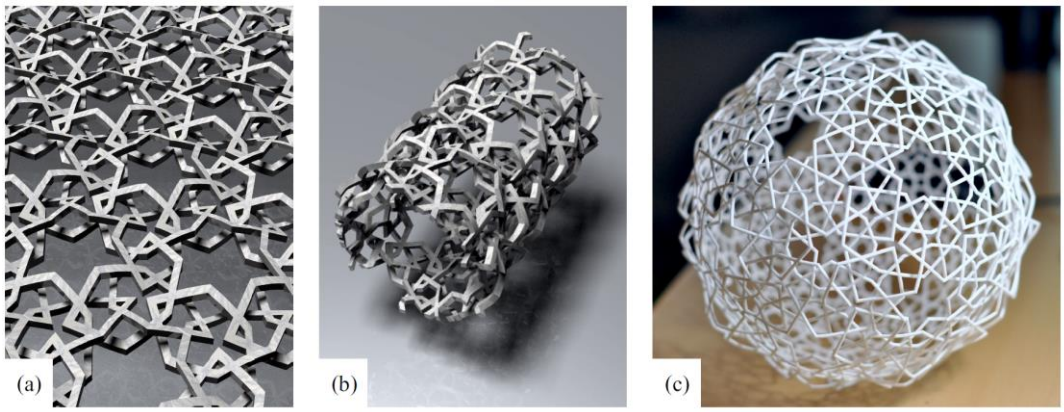

Figure 12 : *(a) A bulged interwoven pattern in the plane. (b) The same pattern wrapped into a cylinder. (c) A 3D printed spherical interwoven star pattern based on a truncated icosahedron.*

Figure 5. 37 : Interwoven IGP by Kaplan (2017, p. 78).

Kaplan (2017) intends to generate self-intersecting layers as "'inner' and 'outer' rather than 'upper' and 'lower'" (p. 75). This work incorporates different representational contexts as it uses contemporary production techniques such as 3D printing, and is not mass produced. It can be argued that 3D printing facilitated innovative production methodologies that enabled producing products in small quantities, even for personal purposes. Thus, outcomes are relatively closer to the crafts. In addition, it can be seen that outcomes of IGP in forms of 3D printed products result in shifts of material use. In this case, IGP act as a "material" that can be formed into a shape.

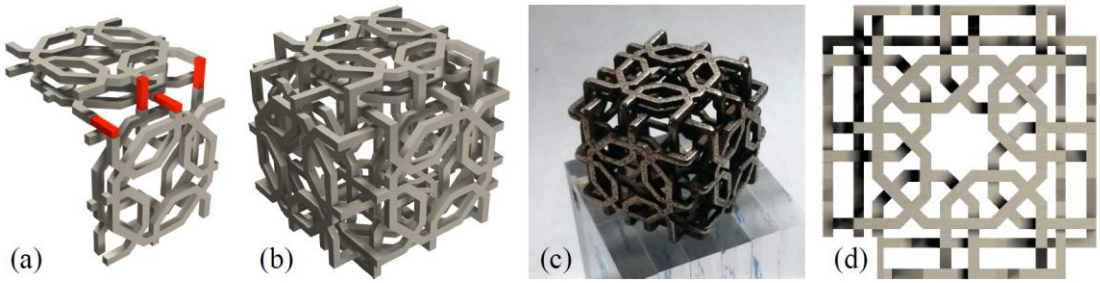

Figure 5. 38 : Structure of a cubical composition (Kaplan, 2017, p. 76)

Through the examples presented above, it can be seen that different production methodologies facilitate production of complex parametric structures that widen potential usages of IGP.

Throughout the study, it was aimed to present discussions of IGP in theoretical, practical and semiotical aspects. The next part presents cumulative outcomes as the last part of the study.

6. CONCLUSION AND RECOMMENDATIONS

Throughout the study, IGP were discussed in terms of theoretical, practical, cosmological, semiotical, mathematical, geometrical, and theological variables. Firstly, a background information was provided to define the IGP. Theoretical background is established on the basis of the works of the perennial philosophers. Relations of IGP with other fields such as cosmology and geometry were expounded in detail. Traditional applications of IGP were included to discuss each example in terms of the provided theoretical background. Representational context of the principles of Islamic revelation was defined in detail and discussed through visual examples of traditional applications of IGP. In general, it can be said that examples were gathered to clarify the overall discourse.

Later on, representational contexts were expounded in detail. Each context was discussed in terms of the contemporary applications of IGP. Once again, examples are gathered and presented in relation to the overall discussion in the study. IGP were analyzed in terms of semiotic analysis.

Perhaps, a lot more remains to be discussed, as each discussion could easily evolve into another, extending and revealing unprecedented connections. In fact, during the research process, one of the drawbacks was the inadequacy of such connections in design literature. As mentioned earlier, unfortunately almost no studies were found within the product design literature, analyzing such cultural heritage. It can be said that most of the noted works within product design literature in Turkey discuss “product design” within the context of “modernity”, by expressing the facts and ideas on how late industrialization period affected the overall progress in many aspects. Yet, during the research phase, it was truly challenging to find local sources on how it actually was before the objects started to be called as “product designs”, as the knowledge of the “traditional creative modes of thinking and making” were mostly expounded within the context of “making”, thus disregarding the stage of “thinking”. This fact leaded to another challenge, as in order to gather information on the missing piece of “thinking” it was required to gather, analyze, and utilize information provided by the perennial philosophers, as they tend to explain the modes of “thinking” from a rather

metaphysical, cosmological, symbolical, and theological standing point. ofThe modes of "making", however, has already been analyzed, discussed, expounded, and utilized by many prominent authors. Thus, one of the aims of this study is to offer a possible framework in which such cultural elements can be discussed within the borders of product design, by taking into account the possible relations with cosmology, theology, and metaphysics.

Eventually, few conclusion remarks are gathered together in this section to summarize the overall outcome.

One of the interesting details regarding the traditional applications of IGP was encountered during the reading sessions on the manuscripts of the traditional craftsmen, as existence of such manuscripts can be regarded as an indication of a certain "design process" adopted by the craftsmen. Eventually, several additional questions emerged regarding the differences in the overall creative workflow of the traditional craftsmen and contemporary product designers. Such question, however, is another discussion that can be expounded in further studies.

When it comes to the contemporary modes of application, it can be said that use of IGP in mixed compositions signifying rather functional notions, result in controversial outcomes nullifying the connotative system of meanings of IGP. A more secure way of incorporating IGP can be seen in using them as "reproductions of historical continuities". In such case, however, IGP act as decorational elements signifying the notions of a particular cultural heritage, or tradition.

The future considerations for IGP can be regarded as compatible incorporations of traditional art and modern technology. Yet, it can be seen that in such applications, IGP are incorporated as means to achieve a certain functionality. Their inherently precise, analytical, and structural properties enable new opportunities in the explorations of new materials, objects, and applications, which can be further developed, discussed and utilized in the future studies.

To conclude, IGP are almost (perhaps even more than) nine century old creations of the past. Throughout the study, it was discussed that substantially, IGP are the outcomes of a particular heritage incorporating knowledge of theology, geometry, mathematics, geometry, astronomy, chemistry, together with the other scientific disciplines. Yet, it can be said that in most of the contemporary applications of IGP,

products still incorporate the very exact similar patterns (in some cases erroneously even), to signify a particular cultural heritage, or notions of a particular tradition, and in many cases, religion.

Conclusively, I hope this study conduces to more research on such discussions within the scope of product design. “if we are in touch with the language of the present time and ground ourselves in this strong old tradition, we can arrive at an expression that is not only contemporary but that could be meaningful and valid in the coming century.” (Chorbachi, 1989, p. 788).

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