EXPLORING GEOMETRY BASED VISUAL PERCEPTION IN DESIGN: ARCHITECTURE AND FASHION

Thesis submitted by

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"STATEMENT OF ORIGINALITY"

I, Smt Jayati Mukherjee, registered on 18.4.18, do hereby declare that this thesis entitled "**Exploring Geometry based Visual Perception in Design: Architecture and Fashion"** contains literature survey and original research work done by the undersigned candidate as part of Doctoral studies.

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I dedicate this research to my Ma, whom I lost lately, and who was so eager to see me complete my work - her untimely demise only giving me more impetus to finish it for her. I miss her beside me, but I am sure, she is happy today as I submit my work. And to my late Baba, who always supported my activities which shaped me into who I am now.

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This thesis was a quest to probe some unanswered questions that arose in my career pathway which veered across the domains of Architecture and Fashion, over years of deliberation with Geometry. I express sincere gratitude to my Supervisor, Dr. Mainak Ghosh, Professor, Department of Architecture, Jadavpur University, for helping me shape the hypothesis with directions, and patience in guiding me to conclude the research process, which was much waylaid owing to the pandemic period and my professional commitments at times.

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PREAMBLE

> "*What do Tom Ford, Raf Simons, Pierre Balmain, Pierre Cardin and Gianni Versace all have in common? Before kickstarting a flourishing career in fashion, each of these individuals enrolled to study architecture or industrial design*". [Bobila,2017]

> "*Architects Zaha Hadid and Frank Gehry who have spent some time off from designing buildings to work on jewelry, shoes, and bags*". [El-Gammal, 2018]

The various attributes of Architecture and Fashion are recognized to go a long way in establishing a relationship between these two important Design streams. What then links them and leads to cross-pollinating the two disciplines, which are diverse in their own way?

Architects like Zaha Hadid and Rem Koolhaas worked in tandem with fashion houses, to create bespoke range of products. Fashion designers are influenced by architecture and the styles of architects, but architects' alignment with scale, shape, and proportion has been shown to have just as much of an impact on their style as their work.

The Human body remains the common origin, while Fashion originates defined around personal space, while Architecture veers on the existence in large-scale spaces. Through creativity and the concern for the end user, within the context of time, space and region, fashion and architecture convey personal, social, and cultural identity. Being streams of Design, both are referred to as a problem-solving process, with solutions arising from its micro- environment with aesthetics in purpose. The design solution to the problem stems from the inherent notions and perceptions of the environment that generates the problem. Their relationship being symbiotic across eras, reflecting how clothing and buildings mirrors each other in form and appearance. [www.archasm.in., 2019]

In Fashion, it is a complex problem solving since the designed object must have aesthetics bearing integral relationship with the human body, and exploring elements of factors like silhouette, proportion, elements, colour, pattern, and construction. Architectural design works in situations composed of boundaries and volumes that explicitly or implicitly pose particular questions in the spatial context, the situations reflecting the economic, political, and social conditions. They share a common theory of Design as a base for the conceptualization. The interconnection became more intriguing with the help of the development of materials, newer technologies, and the broadening of the knowledge base. [Farahat, 2014]. Thus, despite dwelling on different materials and ways of construction, the glamour, elegance, and fluidity of Fashion harmonize with the rigid, stable, and structuralism of Architecture. Fashion and Architecture remain two separate fields affected and inspired by each other in diverse directions of form generation from concept. Architecture and fashion can be considered Art as well since it is design fulfilling functions. [Jonassen, 2000]

Architecture and Fashion share a common understanding of space, structure, and aesthetics. A common creative ground to start analysing the design realization, in terms of extremely appealing and beautiful structures and spaces. A space is experiential and it is experienced in the context of the human body only. As Vitruvius said, *"Our bodies and movements are in constant interaction with the environment; the world and the self-inform and redefine each other constantly".* [Malhotra & Poovaiah, 2015]

The above statements affirm the inter-relation of the human body and space and aesthetics, which manifests geometric structures and principles naturally embedded within the form to generate its visual imprint on observers.

- This research paper focuses on the Geometry intrinsic to the form development and its fulfilment of functional purpose, in terms of Architecture and Fashion, which overlap in their visual context but remain principally two different purposes of design.
- It delves into understanding the visual perception of a design, appreciated cognitively, to integrate and / or segregate the two design streams in discussion, identifying the explicit aesthetics based on its inherent geometric principles, which connect them, to build a cohesive visual experience.

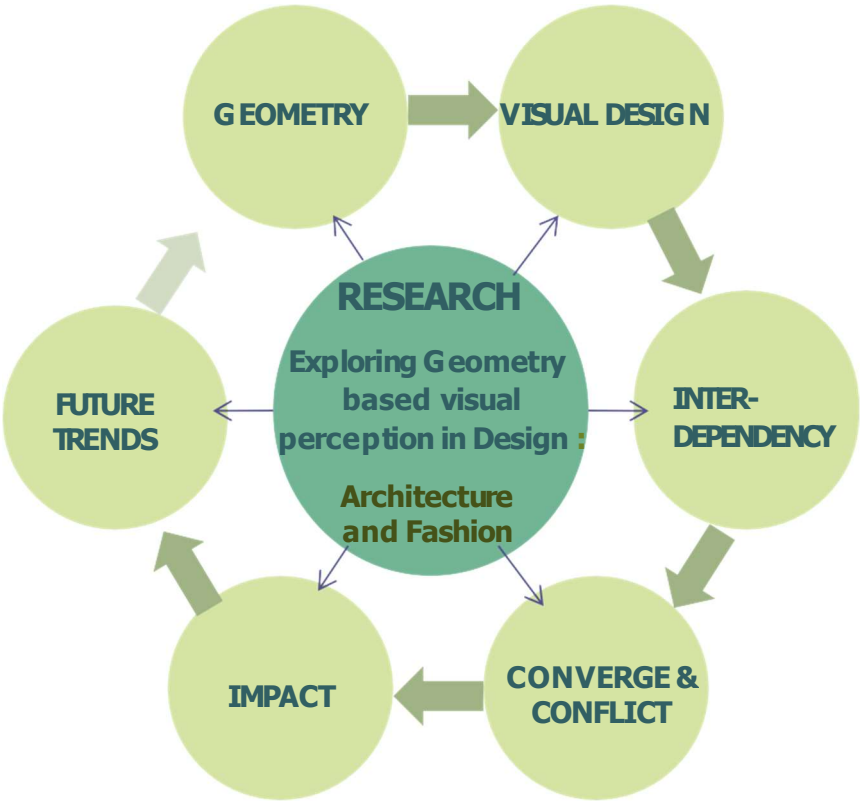


Fig. 1 – OBJECTIVE AND PROCESS OF RESEARCH: Exploring the hypothesis [pc: Author]

CHAPTER 1

INTRODUCTION

1.1 Background

This research hypothesizes that the visual perception of designed forms in Architecture and Fashion lies in their inherent Geometry.

Plato's vision of the physical world is that it must fundamentally embody beautiful concepts. [Wilczek, 2016] As Vitruvius said, "*The timeless notions of beauty can be learnt from Nature's Design,"* which is based on the laws of proportion and symmetry. Here the mathematics of proportion merges into the sensorial experience, implying a visual quality that will arouse an emotion— a psychological experience. The Venustas of Vitruvius was possibly more anthropomorphic. [Encyclopaedia Britannica]

Journey through various periods in history generates visual experiences and responses. This encompasses the cultures that grew in various geographical locations, hitherto unconnected then, but expressing similar evolving aesthetics by philosophy and elements. As W.J.T. Mitchell asserts, "*The received notion of visual experience cannot be grafted on to a received notion of culture."* It emerges automatically. While natural elements are not products of culture and are seen and interpreted meaningfully, the visual culture of communities embodies everyday objects and practices of a group of people or their entire way of life, with different social and cultural groups defining visual elements their way. But it is the visual culture that creates the perception of shapes and the emotions they generate. Social groups differentiate themselves through lines, shapes, and other elements, establishing their identity through their spaces and lifestyles, [Bernard, 1998] created by our sensory interpretations. '*Our perceptions of the world are all illusions,'* created by what we visually choose to identify. [Valberg, 2005]. Throughout history, designed spaces and objects consistently reflect the unique identity of each period. From the prehistoric periods to early settlements in Mesopotamia, Egypt, India, and China, through the Islamic world of Central Asia, into the medieval and Renaissance periods in Europe, or through the ethnic communities of Africa, this identity is remarkably distinct to each culture.

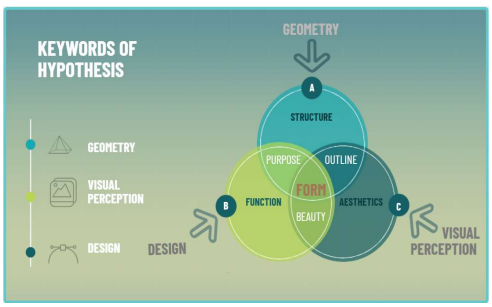
A created design embodies a mathematics that its inherent geometry alone can interpret. As all manmade forms, whether 2D or 3D, can only be expressed in terms of their geometry, that leads to the elements that create the form. This concept can be traced back to ancient times and the same period. According to Vitruvius, *"No building can be said to be well designed which wants symmetry and proportion."* [lexundria.com/vitr/3.1] In truth, they are as necessary to the beauty of a building as to that of a well-formed human figure, which nature has so fashioned [De Architectura, 1826], as he explored the body as a proportion to the structure. Examining the works of ancient scholars, he concluded that the body's proportion was a model of a perfect natural proportion. Thus, he initiated the concept of fitting the 'ideal' body into a circle and a square, generating the proportions of the Vitruvian Man.[Farahat, 2014] Understanding the beauty of the form intrigued Vitruvius - from the

harmonic ratios of Pythagorean music theory to the appreciation of beauty being connected to a higher cosmic order. As a result, his directions indicate the right to deviate from the proportions if adept at corrections in the visual aspects, or as the visual process of form generation. [Jonassen, 2000] Thus emerges the intrinsic value of proportion and mathematics in design.

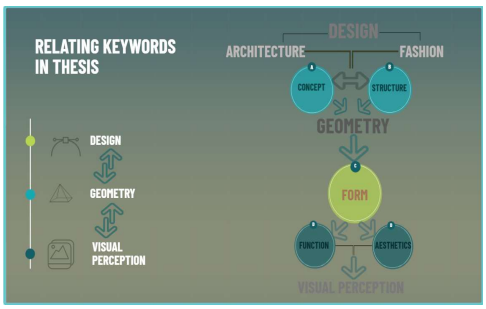
In later periods, the relevance of aesthetics was realized as the new way of appreciation; the visual merits of artifacts were to be understood in a rather subjective manner, and the influence of the fine arts as sensorial stimuli on perception surfaced. When one looks at a Design composed of complex elements in any field, it is seen as a whole before focusing on the parts or components, following closely the Gestalt theory, which plays an important role in determining perception of art and design. The perception of the form is generated by organizing the visual elements in holistic, parallel, and analogue ways. The visual form encompasses the aesthetic outer appearance and how they integrate or complement the functionality and technicality of construction. From concept to realization of the physical form, designed products refer to physical and spatial dimensions. [Ali, 2013]

Thus, a cognitive process supports a typical form and its aesthetics. In this way, the geometric elements and the deconstructed visual abstraction are perceived in forms along with the organic principles of growth, movement, etc. People tend to perceive geometry as the driving force behind various art movements and see it as a reason to explore future designs. Geometric compositions give rise to such abstractions and deconstructions. One can interpret creative thinking and the development of form through the proper application of geometric principles for element analysis and organization. These geometric principles of design have identified important directions for organizing and ordering the visual elements that arouse positive appreciation and emotional reactions in the viewer as perceived in the form. [Malhotra & Poovaiah, 2015].

This Research started on the premise of the Keywords and their basic relation to form generation. During the progress of initial studies, the direction of the hypothesis now modified into a correlation between the Keywords - where Geometry starts emerging as pivotal in emergence of form, serving the functional need and generating a physical form. This translation of interpretation of the keywords, is cited as below –



Modified correlation of keywords



Correlating Keywords: **Fig. 2a**– Broad interpretation on hypothesis **Fig. 2b** – Interrelation within thesis

The keywords are to be elaborated hence.

1.1.1 Geometry

Geometry in design is based on its elements and their properties. The mathematical relationship between the elements forms the structure of all objects and space around us, whether natural or man-made. This is essential to the way in which the human mind perceives the visual world in which we exist. While natural forms have geometric attribute intrinsic to its growth, man-made forms are created based on understanding of geometry, which is inherent to the human mind by virtue of evolution and the structured space human beings live in. All visual compositions are perceived subject to acceptance and interpretation of the inherent mathematical relationships of the elements within the visual frame. As a point travels from its position to a line, creates a shape and grows into a form, Geometric design unfolds itself from 2D to 3D. It is this specific mathematical sequence / arrangement which helps in imbibing the principles of Design, especially balance, in a composition. Geometry of Design is thus integral to its aesthetics.

> *'Conditions are not invariable: terms are not*
> *final. Thus, the wise man looks into space,*
> *and does not regard the small as too little,*
> *nor the great as too much: for he knows that*
> *there is no limit to dimension'*

- Chuang Tzu, [4th Cent. BC] [Zhuangzi, 1889]

As Keith Critchlow also says, in 'Order of Space' – *"One cannot imagine an object or being without space. Experience of space is a characteristic of the dimensions of human consciousness. Designers need to know the basic 'freedoms' of their constructions – space. Human existence is multi-dimensional."* [Critchlow, 2000]

In school we are trained to think that geometry starts from being flat to project into solid. In reality, a complex idea can be reached through multiple routes – starting from the nondescript 'point'. Question lies in - what physical form can be given most appropriately to the point for the exploration of ordered movements in space?

From mundane elements, it transcends to having symbolic value. Number, Music, Geometry and Cosmology remained as the four great Liberal arts of the ancient world - from tangible outlines to intangible measures. Human mind perceives the visual world based on the mathematical relation of the elements and the structure manifested through visual elements and structure [Zoelouiseridgway, 2017]. Geometry of form is manifested through visual elements and structure. In Natural forms, Geometric Attribute is intrinsic to growth. All of nature evolves out of simple geometric patterns incorporated within the molecular 'seed' structure. Man-made forms are created primarily based on geometry, which is inherent to the human mind by virtue of evolution and the structured space human beings live in. Geometry is all around us.

1.1.2 Visual Perception

Visual perception is a creation of the mind's eye, guided by layers of experience. The act of seeing is a dynamic and creative process. Our eyes determine what we look at and/or what we find important. This mechanism controls what to see and how to understand the world around, and explains why we struggle to focus on an element or object when we are stressed or fatigued. Visual perception enables us to recognize objects even under difficult conditions. Careful arrangement and manipulation of information in design guides the viewer to sequential observation, starting with the most important. [Santella, 2005] It explains why we struggle to focus on an element or object when we are stressed or fatigued. Visual perception enables us to recognize objects even under difficult conditions. Careful arrangement and manipulation of information in Design guides the viewer to sequential observation starting from the most important. [Zakia, 2007]

Our vision seeks patterned structures in our visual environment. The dynamism of changing images of our immediate visual world is perceived in 3D. Making inferences from the visual features extracted, perception towards identifying/creating excellent design generates out of this geometric sensibility naturally built in us. Human world is a combination of natural and man-made objects and the human body itself a complex geometric structure with inherent mathematical proportions. Naturally, the human mind seeks to perceive and attain geometric balance in the visual environment by identifying geometric elements and seeking balance in their arrangement. Geometry, thus, subconsciously plays a vital role in visual creations as well as the way they are perceived.

One constantly receives visual stimuli from the environment. Vision is the most dominant sense for them; it provides more information compared to other senses combined (Carmona, 2003). The process of forming meaningful experiences through registering visual sensory stimuli is known as 'visual perception'. It is the ability to perceive our surroundings through the light that enters our eyes. The visual perception of colours, patterns, and structures has been of particular interest.

> *'Human vision is an amazing ability; capable of interpreting our surroundings so as to interact safely and accurately with little conscious effort. However, we are well attuned to nature and natural environment, which has significant implications for design—perceived exclusively through vision'.* [Ghosh et al., 2015]

In order to determine what we can do to guarantee that our goods offer the greatest viewing experience possible, we must look into how we see the world and the reasons behind our perceptions.

Visual perception is thus the ability to see, organize, and interpret one's environment.

> "*In a study ….. It was predicted that peoples of different cultures would be differentially susceptible to geometric illusions because they have learned different, but ecologically valid, visual inference habits."* [Segall et al, 1967]

1.1.3 Design

For this thesis, 'Design' focusses on the domains considered for study—Architecture and Fashion and their interrelationship. As Walker said, the purpose of Design History is to explain design as a social and historical phenomenon. [Walker, 1989]

Prasad Boradkar suggested that -

"design's core mission is to fashion things so that we may have meaningful interactions with the world. Meanings are neither inherent properties of the things themselves, nor are they total fabrications of the human mind; they are suspended in the spaces between us and all that is around us. Meanings emerge and change continuously as people and things travel through their lives, constantly bumping into each other.". [Boradkar, 2014]

Hence, design remains a socio-cultural expression that travels through time in the lives and practices of human beings and settlements.

As with architecture, sculpture, and fashion, three-dimensional designs take up space that influences the design's overall shape. 3D format and space is the basis of Architecture. Just as the clothes present a face for a person, the building skin does the same to the street and the outside world; Like Frank Gehry's structures, the external treatment and visible form may conceal what it covers. Fashion designers translate a two-dimensional material (cloth) into a 3D form (body-shaped garment). When creating and building a garment that fits the human body, fashion designers must experiment with form and shape and think spatially like architects. At their core, they interact with form as a mirror of who they are, reaching their greatest potential when the body and form are in harmony. They must be sensitive to their surroundings and strike a balance between self-expression and practical needs. [Wordpress.com, 2011]

Thus, Design in terms of Architecture and Fashion is based on structure, shape, and prettifying up basic human necessities of clothes and shelter.

1.1.3a *Architecture*

Architecture is the physical manifestation of the form of the human space. It is the structured environment, mostly man-made, where human activities happen. It is this physical space that influences the emotional space by controlling actions initiated. Space aesthetics visually communicate emotions, while physical space dictates activities. Architecture expresses itself through geometric shapes, and imaginative space design knows no bounds. Conceptualization of form remains purely geometric irrespective of whether organic or man-made outlines. Experience and creativity guide the perception of architecture as a complex geometric structure in 3D space. It is a movement experienced through space and time, within structures and enclosures. The design of a structure emerges from the inherent geometric form of spatial enclosure. Space is experiential and encompasses our being. The

experience is based on our perception of the boundaries, as defined by the elements of the form. Architecture remains the path to enclosing the experience of space. [Ching, 1996] In history, we find future forms in Architecture generating out of past styles, with buildings expressed as evocative forms and surfaces, not as spatial environments. The visual impact is a kinetic experience of the observer who arrives at a single image as a product of various images and cognition of elements. 'Visible Form' becomes an analysis of the process of perception. Over timelines, Architecture and form interpretation draw together a mental image building out of a series of three-dimensional images absorbed as one experiential movement through the space, both inside and outside the built shell.

Architectural evolution over periods is an understanding of the relation between social processes and built spaces, connecting the aesthetics to the space, integral to the function of the space. [Frankl, 1973]

1.1.3b *Fashion*

Fashion is the physical expression of personal self. It is a reflection of societal and visual aesthetics. The human body is a geometric form with complex variations allowing creative exercises without limits. The dynamism of Fashion is more dramatic and intense, transcending and transforming the visual space of the human body. Intrinsic to the human body as space, fashion manifests itself through simple to elaborate designs, guided by personal choices. The body geometry controls the creative manifestation perceived through its geometric elements. Fashion expressed through geometric prototypes is inclusive of its basic purpose. Visual proportions guide the creativity through geometric elements. The design of this personal space of the human body influences the emotions and communicates to the societal aesthetics. It has been instrumental in dictating the aesthetics of the human world. It is perceived in the context of the socio-economic-political-regional character of our environment. Fashion has remained self-expression, whether for the basic need of a sheath or for adornment. [Rissman, 2015]

Designing the human body's personal space influences emotions and communicates with societal aesthetics. Fashion serves as a fundamental necessity, whether it's to fulfil a basic need for protection or to adorn oneself. Fashion encompasses different domains, which include garments, lifestyle products, and other products and accessories of daily use. [fibre2fashion, 2007]

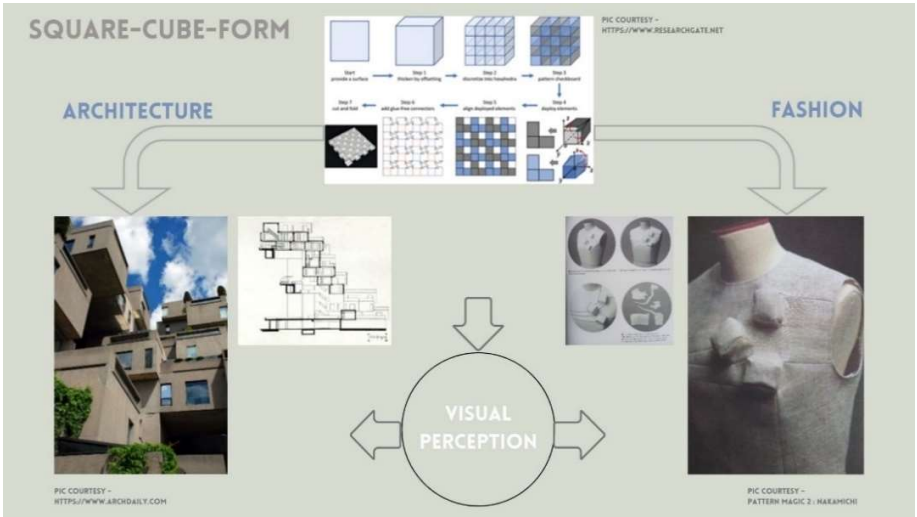
The above contextuality merges when Issey Miyake's words *"Design is not for philosophy, it's for life"* [https://thearchitectsdiary.com, 2023] echo in Balenciaga's views, *"The designer must be an architect with the patterns, a sculptor with the shapes, a painter with the colours, a musician for the harmony and a philosopher for the sense of measure*". [https://ark-architects.com, 2019]

1.1.4 Geometry, Visual Perception and Architecture & Fashion

Buildings and clothing both serve to shelter and protect the body while offering a way to express one's cultural and personal identity. In reality, fashion is transient, unlike architecture, which is perpetual. They are interlinked, producing designs through a combination of elements and techniques, similarities and connections binding the two domains together. Their design processes bear striking similarities, travelling from a two-dimensional medium, transforming into complex three-dimensional forms. Obvious parallels exist since, conceptually, both fashion and architecture dwell upon geometric forms and structures in the context of perceptions. Both forms of art, reflect the tastes of the people who inhabit those spaces, whether they be physical or personal. Architecture and fashion use their respective styles to represent character, attitude, and feelings and reflect the visual aesthetics of periods in timelines. As a visual language, both fields utilize innovation, experimentation, and fluency with the elements and principles of design—geometry and geometric forms being the end objective. Architecture creates the space for the activity, while fashion creates the aesthetics and dynamism for it.

The two seemingly disparate topics have obvious parallels to ideas of construction, production, and consumption. Fashion has always been criticized as an artificial and superficial construct of vanity; architecture has had some measure of respect both as a pursuit of beauty and an expression of our culture. Since both are in the sociocultural/economic and symbolic/artistic fields, the conditions of production and consumption are similar. The original product is unique in a way that is both varied and consistent.

The Keywords and their relation in Design development is summed up in the following illustration:



Interpreting Keywords of thesis in Design: **Fig. 3** – Perceiving evolution of Form through application of Geometry [pc: Author]

1.2 Objectives of the Research

Architecture and fashion have remained the two most prominent expressions of design in the evolution of civilizations, depicting the lifestyle and creating signature aesthetics, cross-influencing each other, and building visual identity with distinct features from communities to eras. The question arises as to why the similarity is so palpable and homogeneous, yet distinct from one period or settlement to another. In this context it is evident that these visual features are linked to a geometric principle of the emergence of form and its surfaces and features. The entire structure channelizes the perception of the visual form.

In this context, the research work would be an effort to identify the geometric structure across periods, cultures, lifestyles, and activities. It would attempt to explore the elements and principles thus identified vis-à-vis the way we see and comprehend the object of view. The research and subsequent directions would lead to the creation of guidelines that determine the shapes and how they look in these two areas of design. It would be possible to identify the intrinsic geometry that guides form generation and appreciation, executed by the subconscious human mind in creativity.

Such indicative guidelines will subsequently be able to set parameters for consideration in form generation based on the conscious application of geometric elements and principles in design.

1.2.1 Primary Objectives

The primary objectives are as follows:

1. *Study* ***TIMELINES*** — To study history and cultures to recognize the visual elements and parameters and identify what resonates across Architecture and Fashion of eras.

2. *Identify* ***ELEMENTS & PRINCIPLES*** — To study geometric elements and the application of principles of Design as found in nature and the man-made world around us, inherent to forms, which we perceive with our subconscious.

3. *Identify* ***COGNITIVE ASPECTS*** — To understand the visual perception which underlies the appreciation of the geometry of forms in design.

4. *Study* ***INTERDEPENDENCE*** — To study the comparative influence of parameters of Architecture and Fashion forms and how they remain interdependent, including similarities and dissimilarities.

5. *Establish* ***DIRECTIONS*** — Formulate guidelines for application on forms for visual perception in a determined direction.

1.2.2 Pathway

We will conduct the aforementioned analysis by examining the current foundations of visual understanding in designed forms. These would include:

- ***Identifying geometry*** in natural and man-made forms
- ***Identifying elements*** in Architecture and Fashion on features of visual identity in world cultures and lifestyles of communities that evolve a local and regional identity
- ***Identifying the adaptability*** of physical and human space with geometric elements
- ***Identifying the cohesion and disparity*** that distinguishes the interdependence of Architecture and Fashion as two dominant streams in Design with individual forms and expressions.
- ***Conducting surveys*** to understand/establish the perception towards designed forms
- ***Analysing and synthesizing*** the observations to identify the visual parameters
- ***Suggesting directions*** for the application of parameters in future designs

1.3 Methodology

Every research project begins with an underlying idea, a hypothesis, which again is the result of a question(s) raised in the beginning.

It is now important to decide on the inquiries for taking the research ahead, as follows:

- *Which is the best methodology that suits the area of investigation?*
- *What would be the problems and benefits of conducting research employing such methodologies?*
- *What are the parameters to be selected to ensure the best/appropriate results while employing these methodologies?*

Human cognition primarily perceives the hypothesis under consideration. for exploring the topic justify the exploration of the topic itself. A suitable approach to the research topic as above would be a thorough investigation on existing applications in practice over ages to identify the logic of the existence of the elements and principles, and studies and investigations would reveal the logic behind it. A qualitative analysis, comprising a relevant literature survey, would also point to the variables that exist and help probe deeper into the subject. In the absence of physical data available on the subject, the research relies largely on secondary research to begin with.

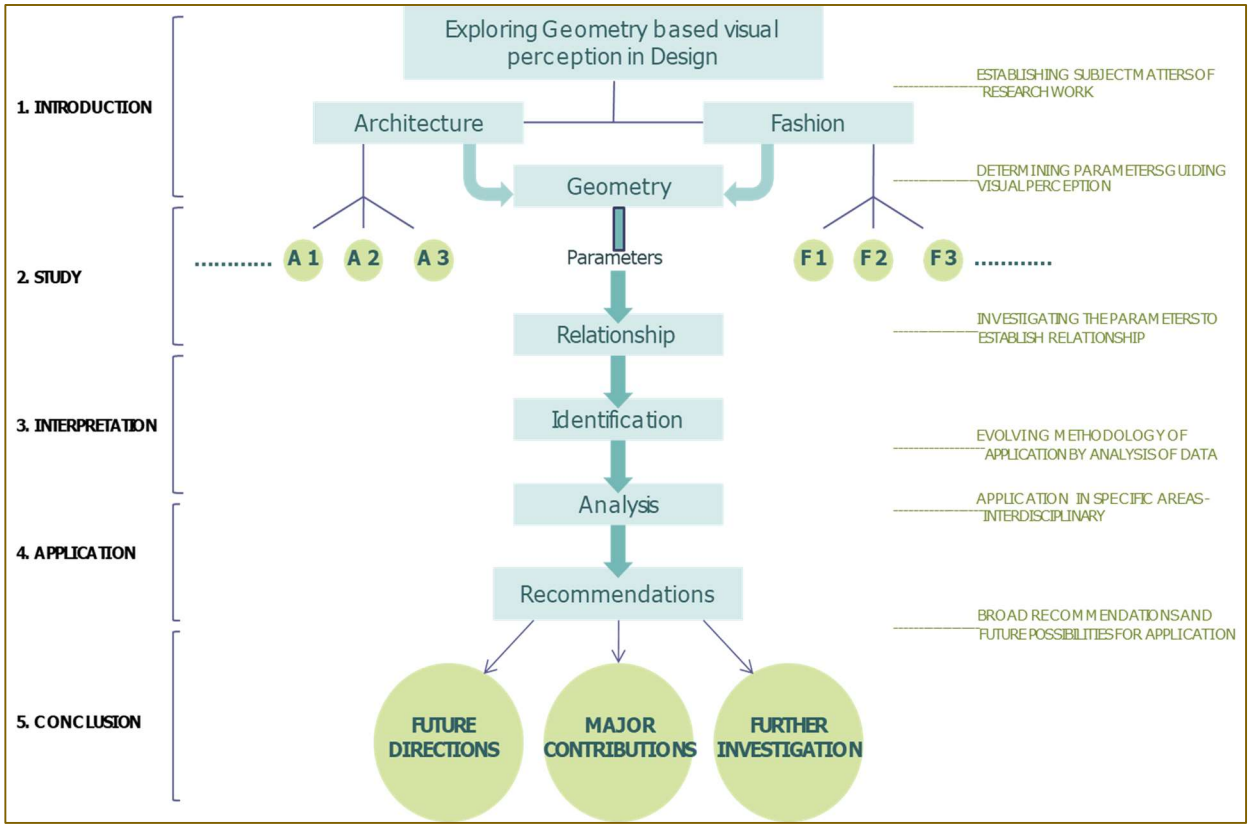
Selecting the sample to survey and study is crucial for validating parameters identified through secondary research. Sampling could be either random or systematic, depending on the needs of the study or the specific research objectives, and encompass fields of Architecture, fashion, and general perception as well. The process of returning to the research work is to be maintained, often, to lead to more parametric issues towards deeper understanding of objectives and hence lead to further research work on the subject. Quantification of data would lead to validating the qualitative principles.

1.3.1 Stages

The stages adopted as per methodology are as follows:

- ***Introducing the subject matter*** of research work through the establishment of its background, objectives, and methodology.
- ***Defining the prime aspects*** of the research work, namely, the geometry and Design domains, i.e., Architecture and Fashion.
- ***Identifying various parameters and sub-parameters*** related to these aspects, based on literature study.
- ***Analyzing design areas and visual elements*** to establish the link or highlight differences between the two streams, confirming whether this parametric interdependence works universally with geometric applications.
- ***Analysis and validation of parameters*** through primary research via surveys
- ***Formulating strategies and recommendations*** as an outcome of these studies for future applications.
- ***Concluding research pathway*** through the compilation of emerging issues, major contributions, and areas of further investigations.

A summary of the stages of the methodology is as illustrated below:



Stages of the Thesis: Fig. 4 – Methodology of Research [pc: Author]

1.3.2 Structure

The research is submitted in a report chaptered as below –

Chapter 1 –Introduction to the subject, briefly stating the background for the research; including setting the hypotheses/research problem and its justification.

Chapter 2 - Literature survey towards Secondary Research discussing Geometry, Visual Perception and Design – Architecture / Fashion, investigating prevalent theories and observations and their implementations in contextual areas. It includes presentation of summary of various experts and articles based on studies, as well as from allied researches on existing practices of application of Geometry, looking into the intrinsic aspects of the same.

Chapter 3 - identifying characteristics of var8ious study areas and deducing related parameters and sub-parameters, following the literature study.

Chapter 4 - Surveys towards Primary Research, following the related parameters and sub parameters in order to answer the research question, conducted on General human samples and specific to those with Architecture / Fashion background

Chapter 5 - Analysis of the study data, thereby formulating the relevant strategies and recommendations.

Chapter 6 - Presenting the theoretical conclusions, which includes outlining the implications of this research work in terms of issues, contributions and further investigations.

1.4 Limitations and scopes

Limitations

- Aspects of design w.r.t Architecture & Fashion only to be considered in the research
- Secondary investigations to be limited for establishing the parametric relationship
- Analysis of geometric structure restricted w.r.t. physical manifestation of Design
- Research understanding to remain contained within visual perception and elements
- Primary investigations to be considered for validation of findings, formulating strategies and recommendations

Scope

- Identifying visual elements that influence design
- Interdisciplinary approach to design may be developed
- Establishing Geometry and factors of perception as the underlying principle towards future design exercises in generating pre-determined visual response
- Determining directions for parallel studies within emerging factors for further research

CHAPTER 2

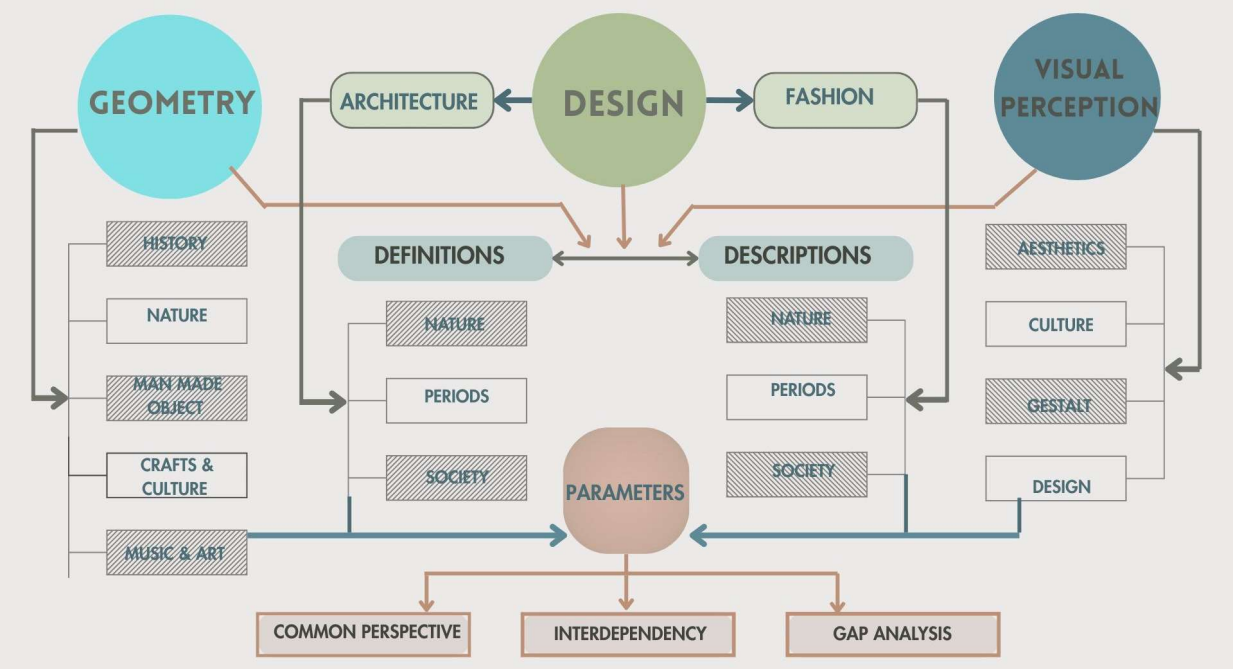
LITERATURE SURVEY

2.1 Framework of Literature Survey

The previous chapter introduces the structure of geometry in design and shows how the two major branches—architecture and fashion—perceive it visually. It also brings forward questions about the commonalities and differences between these two diverse streams. As the next step in the research methodology adopted, a literature survey encompassing the various broad domains to be studied is needed, seeking an answer to the questions arising on the interdisciplinary relation of the two streams considered. In the broader perspective, the perception of geometry can be interpreted in various ways. The main objectives of this research include a thorough and detailed exploration of the topics and subtopics of the subject matter. The goal of the literature review is to find the parameters and gaps in the study by identifying the geometric elements and rules that affect how people see certain design streams.

Over the ages, geometry has remained the underlying principle of the construction of Form. It has manifested itself through the visual elements and has emerged as the common thread of expression in design, whether architecture or Fashion. Geometric principles seem to be the connecting thread between the visualization of the 2D idea and the creation of the 3D form. They leave strong influences that make the forms of both design streams seem to be influencing or complementing each other through objects, cultures, and design languages. The literature survey would be related to the main points of this research, which are continuing the conversation about the topic and finding factors and parameters that will help figure out the reasons for the similarities.

The Literature Survey is to be conducted in the following manner :



Approach to Literature Survey: Fig. 5–Categories & stages of study [pc : Author]

2.2 Geometry

The geometry that is to be probed here is to be in the context of how it is present in Design, its evolution through the ages, cultures and time periods – its recurrence in nature, in music and art and crafts – its essence imbibed and resonating through objects and artefacts designed by Human mind. The mathematical technicality is not in the purview as the thesis aims to identify perceiving Geometry in Design through the human mind and passing it on further in design forms.

2.2.1 Definitions

Geometry considered in this thesis is w.r.t. design. Therefore, the focus is on analysing the attributes and properties of the visual aspect in objects and space. As Encyclopaedia Britannica explains, "..... *a combination of the Greek words 'geo' (Earth) and 'metron' (measure) for the measurement of the Earth*"—thus defining objects on earth.

Merriam-Webster dictionary defines geometry as:

"1a : *a branch of mathematics that deals with the measurement, properties, and relationships of points, lines, angles, surfaces, and solids; broadly: the study of properties of given elements that remain invariant under specified transformations….*
3*: an arrangement of objects or parts that suggests geometric figures"*

In The Oxford English Dictionary, geometry is defined as
"*the science of properties and relations of magnitudes such as points, lines, surfaces, or solids in space and the way the parts of a particular object fit together*"

As John Casey elaborates on Euclid's Elements [300 BCE]—

"Geometry *is the science of figured Space. Figured space is of one, two, or three dimensions, according as it consists of lines, surfaces, or solids. The boundaries of solids are surfaces; of surfaces, lines; and of lines, points. Thus, it is the province of geometry to investigate the properties of solids, of surfaces, and of the figures described on surfaces*" [Casey, 2007]

Frank Wilczek says—

"According to Galileo, nature is like a book that is the universe, which is written in the language of visual elements, of triangles, circles, and other geometric figures". [Wilczek, 2016]

Quoting Johannes Kepler—

'*At ubi materia, ibi Geometria.' Where there is matter, there is geometry.* [Kepler (1601), 2003], he believed *"Geometry existed before the Creation, is co-eternal with the mind of God* [Harmonice Mundi, 1619] ... *therefore I chance to think that all nature and the graceful sky are symbolized in the art of geometry*". [Dyson, 1964]

The above interpretations indicate that all forms in the physical world owe their existence to geometry in structure and elements, as well as the essence of creating the visual experience. Any form thus created, by nature or man, must embody and owe its visual experience to geometry.

2.2.2 Descriptions

"*Eventually it was realized that geometry need not be limited to the study of flat surfaces (plane geometry) and rigid three-dimensional objects (solid geometry) but that even the most abstract thoughts and images might be represented and developed in geometric terms.*" [Encyclopaedia Britannica]

The definitions clearly demonstrate how elements in the natural and human world perceive geometry. Other aspects of visual perception are determined and guided by inherent geometry, geometric principles, and logic. This demonstrates how geometry's mathematical regularity determines the beauty of the physical world, which is inherent in the micro units of its structure. We can now go into more detail about a general definition of geometry in the context of the specific areas where it is most useful. [Wilczek, 2016]

2.2.2a Geometry In History

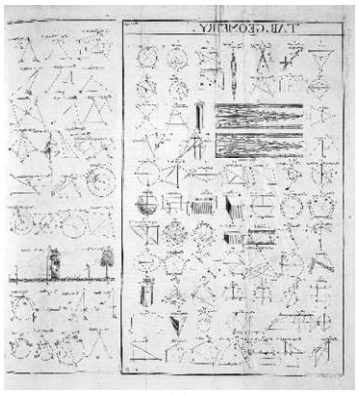
Ancient civilizations used the mathematical principles of geometry extensively. In 1930 Sigmund Freud wrote in 'Civilization and its Discontents'—*"Mathematics appears to be one of the oldest of human activities"* [Gorman, 2003]

It appeared in the cruciform tablets of Mesopotamians, on the papyri of the Egyptians, in texts from ancient China, in the religious doctrines of India and the subcontinent, and in the indigenous cultures of Central America. It demonstrates that mathematical expressions continue to be a common thread in all cultures and settlements across the world, establishing them as the absolute factor of mathematical creativity and expression. [Whewell, 1840] Human races have always been interested in lines and forms, while geometric expression happens through a language of points, lines, planes, curves, and surfaces. The last ice age gave rise to the remarkably sophisticated cave paintings from Lascaux, France. In the Stone Age that followed, these depict the activities such as hunting. Through lines and form. [Encycl. Brit.] The Indus Valley artifacts reflected geometric and stylized objects in their seals, ornaments, leisure, and gaming objects. The Egyptians adopted the geometry of vegetable origin, like reeds and palm branch ribs, into linear built elements. The Greeks, on the other hand, incorporated the interplay of light and shade through the use of colonnaded porticos. Greek buildings were intrinsically designed with golden sections and optical corrections for aesthetic appeal. [Fletcher, 1999]

Every civilization holds a special position for beauty and order, the latter imitated from nature in man-made works. Archimedes designed the machines used in the defence of the Syracusans against the Romans under Marcellus, and he contrived them as simple geometrical games, not as significant issues [Encyclopaedia Britannica]. According to Herodotus, King Sesostris imposed an annual levy

to raise money and divided the land among all Egyptians, giving each one a quadrant of equal size. In case of land loss due to flooding, overseers would measure the remaining land and adjust the tax accordingly. In this sense, geometry seems to have been created and then transmitted to Hellas. [Herodotus, c.109- https://www.azquotes.com].

Egypt, being a land of habitation traceable to prehistoric times and bearing the landmarks of megalithic structures, possibly remains the earliest example of geometric structures. About 3100 BCE, the earliest known clear-cut written documents from Egypt and Mesopotamia show that ancient peoples had already started to develop mathematical principles and methods for measuring storage containers, building structures, and surveying geographical regions. The Greeks began collecting and expanding this practical knowledge in the sixth century BCE, and they used it to generalize the abstract concept that is today known as geometry. The ancient Greeks achieved through their art and architecture what was consolidated in Euclid's Elements, a 2300-year-old book whose theorems and principles still hold good largely.



Understanding of Geometry in History: Fig. 6a – Table of Geometry: Cyclopaedia, 1728

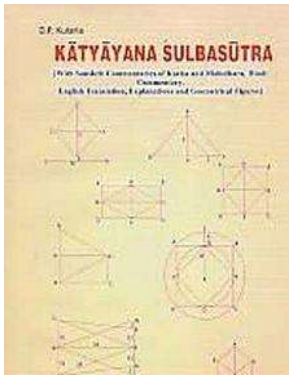
Fig. 6b – Woman teaching Geometry: Euclid's Elements, 1312

In pre-Greek Mediterranean societies, the three difficult geometrical problems of antiquity—to square a circle, trisect an angle, and double a cube—likely sprang from pragmatic concerns, from timekeeping, religious ritual, and construction, respectively. Furthermore, the idea of conic sections, the central topic of later Greek geometry, may have originated from its use in astronomy and optics and gained widespread significance as a result. When Pythagoras proposed his well-known theorem in the sixth century BC, his teachings demonstrated how mathematics and numbers underlie our comprehension of the world. Plato was equally ecstatic about interpreting the Universe through Geometry. Aristotle was a disciple of Plato. [Encycl. Brit,]. Plato proposed studying the universe in terms of five symmetrical forms, known as the Platonic solids. These objects of mathematical beauty serve as models for nature. [Wilczek, 2016]

In order to balance its earthly beginnings and its standing as the model of exact reasoning, ancient geometry came to be associated with the sublime. As elaborated in Encyclopaedia Britannica—The Pythagorean idea of right angles and triads is demonstrated by a few puzzles and their answers found

in Babylonian clay tablets dating back to 1700–1500 BCE. Egyptians used the rope as a tool to create the perfect right angle by using knots to bend, with a length of 3 equal spaced bent at intervals of 3-5-4 giving the perfect right angle, but there remains no record to illustrate it as the basis of Pythagoras' logic. This skill earned them the name 'rope pullers' in Greece. Similarly, to determine the precise location of the sacrifice altar, the ancient Indian Vedic texts contain parts known as *Sulvasutras*, or "rules of the rope." On the other hand, the cube and its double were found in Vedic scriptures in the form of the altar as a practice. The Greeks tackled this issue for religious and ceremonial purposes, and the oracle recommended its application for social purposes. [Seidenberg, 1961]

Thus, we see the blend of Vedic practice and Greek Myth. The treatises of the different cultures and religions show the common thread on Geometry. Some are illustrated below:



Ancient treatises on Geometry :
Fig 7a: Cover page of Sulbasutra by Katyayan

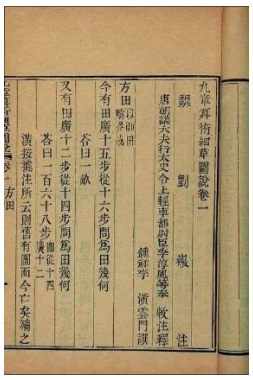


Fig. 7b: The Nine Chapters on the Mathematical Art

Fig. 7c: René Descartes' Discourse on Method

Fig 7d: Page from the Al-Jabr wa-al-Muqabilah

The aforementioned examples demonstrate how geometry was regarded as essential to education and design application, as evidenced by its thorough documentation in numerous treatises. They closely adhered to these design concepts while putting them into practice. According to Euclid, '*The simplest surfaces are planes, with lines and curves on them, generating planar geometry. While curved surfaces and solids lead to solid geometry*". (Casey, 1885)

Encyclopaedia Britannica writes—

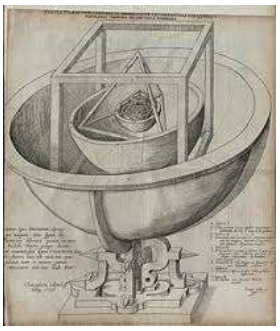
> "*Perhaps the origin, and certainly the exercise, of the peculiarly Greek method of mathematical proof should be sought in the same social setting that gave rise to the practice of philosophy—that is, the Greek polis. …… Greek society could support the transformation of geometry from a practical art to a deductive science.*"

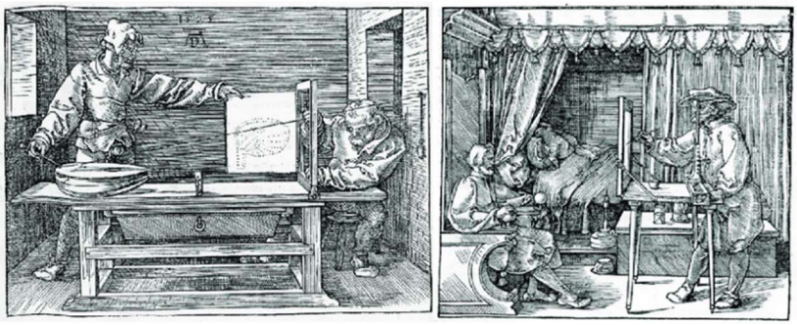
Ancient geometers understood angles and their trisections, squared the circle, and measured the space in terms of rectilinear areas to calculate solutions on curves with minimal errors. The Greeks' deductive use of geometry led them to conclude that the planets in the solar system move in elliptical paths. It began with Ptolemy's construction on circular pathways in Alexandria, Egypt, between 127 and 145 BCE. Thus, in line with Kepler's description of the world, we find the universe ultimately defined by spheres and Platonic solids. Based on the sun's route and location to illuminate areas, Greek stadiums were sized and positioned using the same geometry and astronomical calculations.

As Kepler himself said, Tertius Interveniens (1610),

> *"Thus God himself was too kind to remain idle and began to play the game of signatures, signing his likeness into the world; therefore, I have a chance to think that all nature and the graceful sky are symbolized in the art of geometry.* [Dyson, 1964]

In late antiquity, intricate designs derived from fundamental geometric shapes were already prevalent in the Byzantine and Sasanian empires. Nonetheless, Islamic painters developed a new ornamental style that prioritized harmony, reason, and order by incorporating essential components from the classical heritage. [MoMA, 2004] The experience of representing space through a sense of order and harmony in the interpretation of buildings and artworks was created during the Renaissance by the Florentine architect, artist, and engineer Filippo Brunelleschi, who developed his methodology of projective geometry in developing realistic perspective drawing. Brunelleschi and Leon Battista Alberti built on this to come up with a theory of linear perspective that explained the *'point at infinity,'* or the spot where the parallel lines of the visual frame seem to come together. Cartographers adopted global maps as a result of this knowledge and the stereographic projections that were previously employed. [Robb & Argan,1946]





Development of understanding on Geometry:
Fig 8a: Mysterium Cosmographicum by Johannes Kepler
Fig. 8b: Instruments for drawing perspectives Albrecht Dürer, 1525

This thesis does not cover later geometry advances as they are more related to mathematical models and less relevant to this study on visual design and perception. Later mathematicians, such as Carl Friedrich Gauss (1777–1855), concentrated on studying geometry on surfaces rather than forms, which allowed for the possibilities that arise from elements on two-dimensional surfaces, which are more noticeable to the human eye. [Wilczek, 2015]

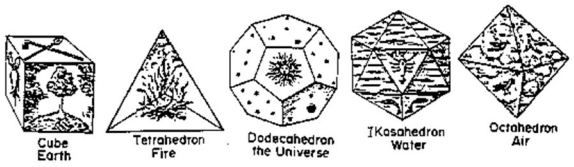
2.2.2b Geometry In Nature

Natural objects infinitely display geometry and its mathematical sequence in their form and component growth. This sequential growth follows a route through numerical logic. Pythagoras' famous theorem on right-angled triangles emulates the relationship between numbers with sizes and shapes. It reveals the latent unity between Mind and Matter in the triangle's shape, with Shape continuing to be a fundamental property of Matter and Number being the purest byproduct of

Mind. Simple and unexpected connections between numbers and musical harmony are established by the laws of stringed instruments. Therefore, we can deduce that most objects of aesthetic or harmonious arrangement are based on numbers.

As Wilczek says— *"It led Pythagoras to surmise that All Things Are Number"*

Using five symmetrical forms known as Platonic solids, Plato provided a geometric theory of atoms and the universe. His approach to things of mathematical beauty made them models for the natural world. In his projective geometry works, Brunelleschi concentrated on the real-world appearance of objects and concepts related to relativity, invariance, and symmetry—all of which have the potential to be aesthetically pleasing. The Platonic solids represent the elements of the earth. The smallest living things in the biosphere, like viruses, diatoms, and bacteria, show how the Tetrahedron (Fire), hexahedron (Earth), octahedron (Air), dodecahedron (Universe) and Icosahedron (Water) are reflected in their exoskeletons. [Dehovitz, 2016] As Plato said, some chemical reactions and the proportion of composite materials are based on the geometry of their atoms. To him, "Symmetry dictates structure". It is strange to discover rocks in the shape of the five solids from primitive settlements bearing the exact geometric structure. It establishes the conscious understanding of geometry in objects in life with concerted application of its basis in designs of the periods.



Platonic solids: **Fig 9a:** Platonic solids: w.r.t. elements: Hermonice Mundi, Kepler

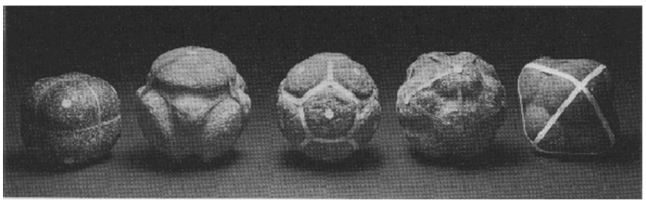


Fig. 9b: Neolithic stones, Scotland, 2000 BCE[georgehart.com]

On the other hand, Newton introduced the mathematical understanding of nature through the methods of analysis and synthesis, arising from the study of the smallest component, an atom. His Laws of Motion define the dynamics of objects while interpreting them as the laws of change, ushering a concept of beauty different from the static beauty interpreted by Plato or Pythagoras. Following the principles of symmetry and beauty in mathematics, Maxwell introduced the idea of space-filling fields in place of point-like particles, which Faraday had already introduced. His work on perception of colour explains our sensory experience or perceiving reality. In physics, the core theory—an accurate representation of physical reality—embodies beautiful ideas. The laws governing atoms and light are nearly identical to those governing musical instruments and sound. Simple building elements underpin a few exquisite designs in nature's flamboyant creation of the material universe. The Principles of Symmetry fulfil and transcend Pythagoras' Harmony and Plato's Conceptual purity.

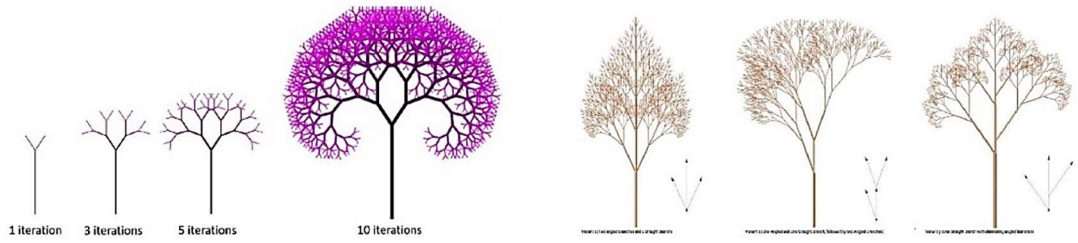
To appreciate Nature's Art, as Galileo wrote in his book The Assayer, 1623:

> *"Philosophy [Nature] is written in that great book which ever is before our eyes—I mean the universe—but we cannot understand it if we do not first learn the language and grasp the symbols in which it is written. The book is written in mathematical language, and the symbols are triangles, circles, and other geometrical figures, without whose help it is impossible to comprehend a single word of it : without which one wanders in vain through a dark labyrinth.*" [Oxford, 2024] .

Nature's Art, thus, arises from

- *Symmetry*—leading to harmony, balance, and proportion
- *Austerity*—creative abundance of effects from limited elements and resources.

We need to learn from Nature that the world embodies beautiful concepts. Geometry is no less beautiful, being more suited for our highly visual brains. Euclid's Elements explains geometry as a system of logic, concluding with the construction of only 5 Platonic solids. Although Plato's theory of the four elements and the universe represented by the solids may not find consonance in science in all aspects, it works on the intuition that the physical world embodies concepts of beauty based on mathematical regularity and perfect symmetry. The idea that structure can be derived from symmetry is now seen as the foundation of Nature and her physical elements, which seem to get their shapes from symmetry. Symmetry emerges as the default structure when information and resources are limited. Plato's use of the word 'Demiurge' denoting the Creator of the physical world as we see delves deep into the creative vision of ideas over the physical forms that we see, as if an artistic intelligence were moulding the forms from templates that are mathematical units. For example, an atom is constructed from a series of triangles. Or the growth of a tree from Fractals. This indicates that the physical world embodies beauty in its deepest structure—in its core elements that construct the forms, which are based on geometry. [Wilczek, 2015]

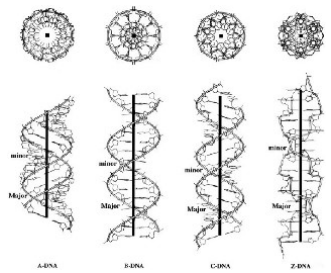


Growth of a tree from Fractal: **Fig. 10**—Emerging of different foliage [parametrichouse.com]

The repetitive geometry of the virus' structure thus fits the definition of a Platonic solid. In the movement of motion, Newton read the dynamic Beauty. In Kepler's model of the universe, beauty emerges in perfect symmetry through the use of Platonic solids that fit perfectly within the sphere, whether superscribed or inscribed. The same concept of beauty through symmetry is inherent in Maxwell's equations, which owe beauty to shapes, space, and symmetry. In nature, reality and mathematics seemingly complement each other.[Wilczek, 2015]

In nature, geometry is intrinsic to the growth of form: the geometric attributes within each manifested form or pattern. The principles are demonstrated through the branching of trees, snowflakes, stripes on zebras or tigers, and nautilus shell – i) Spirals, ii) Fractals, iii) Tessellations. These generate patterns based on symmetry, directions, measures, balances, and frames. [Stevens, 1974]

The shapes that are made by the Golden Ratio and the Fibonacci numbers can now be seen in spirals, phyllotaxy, and the proportions of organic forms. The Sacred Geometry is considered absolute across cultures and is behind the generation of the Flower of Life with its derivation of the Seed of Life. These patterns persist in the natural growth of organic objects and influence man-made designs through repetition or succession. [Melchizedek, 1999]. The human mind interprets geometrical shapes—hexagons in beehives, hyperbolas in rainbows, tessellations on snake skin, circles in water, human footprints, pentagons in starfish, or the Fibonacci series in pineapples. The symmetry, whether reflectional, rotational, or translational, is too obvious for the mind to interpret. [Lal, 2015]



Patterns in Nature:
Fig. 11a: DNA structure and design

Fig. 11b: Fractal in snowflake
[Telluride News, 2013]

Fig. 11c: Flower of life in nature
[Aydan Aghabayli, 2016]

Nature chooses the shapes of things to help them grow in ways that make the best use of the resources they have – e.g. the spiral of phyllotaxy helps plants get sunlight and water. The appreciation of this geometry ingrained in natural bodies is interpreted through shapes—circles, squares, and equilateral triangles. The reason we see a sunflower or a pineapple with its sequential growth in Fibonacci numbers. Two sequential units strive to achieve the golden ratio. Quoting D'Arcy Thompson—*"..no organic forms exist save such as are in conformity with mathematical laws*." thus indicating the mathematical interrelation of components in natural forms based on geometry. [Thompson, 1917]

Fractals show how symmetry in nature comes from the basic elements of lines, planes, and spaces, which Euclid named, and how they are spread out evenly to create the principle of invariance. The apparent irregularity or fragmentation of natural bodies and phenomena consists of various scales of measure but does not affect the said invariance. However, the scales are infinite to describe the clouds, mountains, coastline, or trees with a higher degree of complexity. [Wilczek, 2015] On the other hand, one finds that the Pythagoreans' observations on the Golden Section resonated throughout the Greek culture. The presence of this ratio intrinsically in organisms as much as the human body fascinated

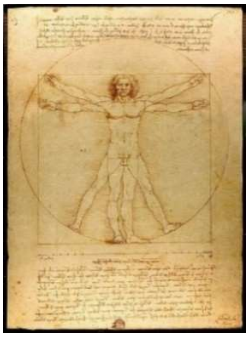
mathematicians of the European Renaissance, as also emerging in their arts. The same is also corroborated by the Fibonacci numbers identified in the Middle Ages [Seidenberg, 1962]. *"…much, if not all, of natural structure is fractal. Natural forms exhibit complex geometrical structure on a hierarchy of scales, from the large to the small, going down to the microscopic scale"* [Salingaros, 2012]

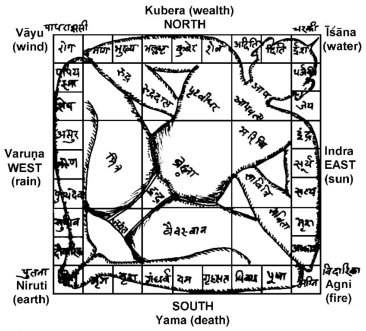
2.2.2c Geometry in Man made objects

Design by the human mind, thus, is expected to embed this harmony and symmetry with the hands that create. The British Library writes –

> *"Vitruvius thought that a timeless notion of beauty could be learnt from the'truth of nature', that nature's designs were based on universal laws of proportion and symmetry. He believed that the body's proportions could be used as a model of natural proportional perfection. He wrote of the way ancient scholars examined many examples of'well shaped men' and discovered that these bodies shared certain proportions. He showed that the'ideal' human body fitted precisely into both a circle and a square, and he thus illustrated the link that he believed existed between perfect geometric forms and the perfect body. In this way, the body was seen as a living rulebook, containing the fixed and faultless laws set down by nature."* [www.bl.uk, 2017]

In a similar way, in Vedic philosophy and building designs, there is absolute acceptance of the square in a grid, a perfect mandala, as symbolic of the universal system, with the Vastu Purusha superimposed, connecting the human to the world. Circles and Octagons also have a similar significance [Kramrisch, 1976] The concept of the human body within a square and a circle resonates from the Vitruvian man to the Vastu Purusha of Vedic geometry, illustrating the absoluteness of the concept transcending borders of civilizations.





Human figure & Geometry: **Fig. 12a:** Vitruvian Man [Da Vinci, 1490] **Fig. 12b:** Vastu Purusha Mandala [Rana, 1993]

As Ching says-

> "*Form and space comprise a design vocabulary, both elemental and timeless, both being interrelated and organized in shaping the human environment. A design is a wilful act, a purposeful endeavour. However, the ordering of forms and spaces elicit responses, communicate meanings."* [Ching, 1979]

Understanding the spatial order follows the evolution of the human mind. This Order as pattern seems universal, irrespective of the interpretation of the space. The tangible and the intangible together creates the objects in space. Following Einstein's theory, the geometric property of space is directly in relation to the distribution of matter, enabling the existing universe defined through

position, size, shape and relative motions. Early Buddhist philosophy speaks of imagining object only within a space, the infinite human consciousness determining the infinity of space. From the basic flat plane, the geometry transcends into the spherical form of the universe. [Critchlow, 1969].

According to S. Balaram, "*The design activity of any location can be appreciated only within its contextuality"* [Balaram, 1998] This is manifested in the ethnic traditional arts practised with creating for functional needs and communicating purpose along with the aesthetic intent. Visual culture of communities are those objects produced for use with the intention of being beautiful. Art and design stir emotions. [Balaram,1998] As Louis Sullivan coined 'Form Follows Function', earlier it was thought that appearance was subordinated to the fulfilment of purpose of the object. However, lately, form also dominated over function following visual aspect of the object. [Bernard,1998]. The visual art forms of a community or culture manifests itself in its settlements and lifestyle.

Le Corbusier says –*"Geometry is the language of man …he has discovered rhythms, rhythms apparent to the eye ….and these rhythms are at the very root of human activities. They resound in man by an organic inevitability, the same fine inevitability which causes the tracing out of the Golden Section by children, old men, savages and the learned"* [Corbusier, 1923]

Divine Proportions of the Golden Section play a significant role in man-made designs. The understanding of the human proportion continues into modern Architecture with the adoption of the figure in the Modulor scale of Le Corbusier. [Frings, 2002] The application of Golden section in Fashion is seen in the patterns of dress making, with the Fibonacci sequence conforming to Golden sections etc. applicable to the proportion of a woman's body. [Kazlacheva, 2017]. This is illustrated below in the application of Mondrian Art in Architecture and Fashion.

Golden Section & Design:

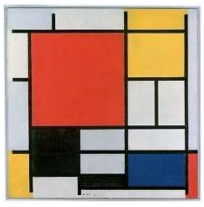


Fig. 13a: Mondrian: Composition [1921]

Fig. 13b: F.L. Wright Window [1912]

Fig. 12c: Mondrian Dress YSL [1960]

2.2.2d Geometry in Crafts and Culture –

Traditional crafts are a way of life across cultures, practiced to produce artifacts for daily use yet with conscious aesthetic intervention for visual delight. The geometry intrinsic to the patterns and orders of these products creates identity for the craft and pride for the community. Crafts may be defined by their forms, in a region or location. Ethnicity signifies the cultural aspects that are identified within each traditional community. The symbolic values and socio-cultural-economic-political values legitimize its identity, creating its '*own design'* and having distinct symbolic value. This cultural identification leads to recognition of the craftwork inherent to a community. [Vega Torres, 2016]

According to the UNESCO Convention 2003,

> *"Traditional craftsmanship is considered the tangible manifestation of the intangible cultural heritage of a nation or settlement. It manifests itself through shelter, clothing, and other artifacts and objects needed for daily activities, decorative art, ritualistic products, etc. The symbols and elements reflect the cultural practices, skills, and techniques unique to the craft."* [UNESCO, 2003]

All the folk-art forms are ethnic in nature, identifiable within their geographical regions, depicting the myths and cultural experiences of the particular region. Folk art forms do more than just define a culture. They also help people work together to solve social issues and challenges by expressing feelings through expressions that come from blending elements from different social classes and barriers.

Although it is to be spoken in the context of Indian crafts in the following discourse, this remains the essence of all folk arts and crafts across cultures. This is why we can distinguish the Madhubani painting motifs of Bihar from the Kalamkari designs of Andhra Pradesh. The understanding of geometric form and use of surfaces carries a distinct similarity across cultures and the ethnomathematics in making woven bamboo handicrafts of using community in Banyuwangi, Gintangan village using Geometry. [Yudianto et al, 2020] The forms of Matryoshka wooden dolls from Russia bear a resemblance to the Channapatna toys from Karnataka, India. Craft identity and symbolism emanate through elements.

Similarity across crafts: **Fig. 14a:** Matryoshka nesting dolls, Russia

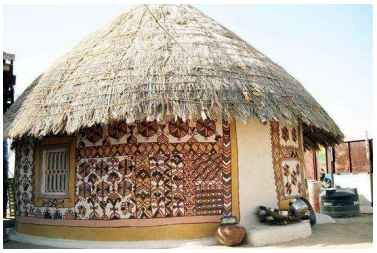
Fig. 14b: Channapatna toys, India

As the WIPO report states—

> '*A design (w.r.t crafts) refers to the aesthetic aspect or outward appearance of a product, such as its shape, patterns, lines, or colours, and may be embodied in a wide range of handicraft products.' It is these that create the identity required for registration under patent rights.*" [WIPO, 2016]

In this context, the study of geometry in crafts emerges in the form of ethnomathematics, which is the application of mathematics in cultural life, or the way cultures mathematize. The geophysical conditions of a location partially determine the characteristics of a region's cultural products, which include space and lifestyle products. Landscape, climate, and materials control use of space, built forms, clothing, and other accessories. [WIPO, 2016]

Folk and traditional houses remain the simplest and most evident examples of indigenous understanding and application of Geometry. It reflects the transition from nomadic to domestic life; the use of building materials for structural purposes is reflected in the resultant built form. Materials dictated the space and its form, from the menhir alignments and circles carved and arranged to reflect ritualistic beliefs to the shape of the igloos. Spirals, circles, and other curved shapes contrast with the straight lines of buildings used for rituals and beliefs, highlighting the significance of shapes. Regular low-height structures, along with megalithic spaces and elements of religious structures, establish a sense of scale and serve to impress. The form of enclosures, such as mounds for burial or courtyards with shadows based on solar orientation, was consciously used for natural processes as well as protection from climatic conditions. [Palmer, 2008] The geometric patterns on the Kutchh huts located on the western coast of Gujrat, India, and the huts in Ndbele, Burkina Faso, Africa, demonstrate this concept.



Geometric shapes in cultures: **Fig 15a:** Ndebele hut, Africa **Fig. 15b:** Bhunga hut, Kuchh, Gujrat

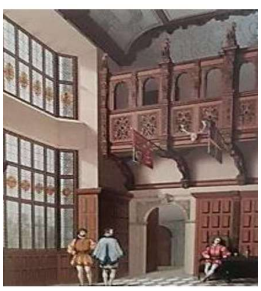
Alongside, the clothing and lifestyle products matched in form, purpose, and utility. Clothing came as a necessity to protect. However, people created the form's aesthetics with the intention of impressing others. Since the simple loincloth in ethnic societies and primitive races, where nudity was natural, human evolution has shown opulence and flamboyance when Renaissance French fashion is studied. The form and aesthetics of clothing and accessories complemented the spaces. The simple clothes of the first settlements or the linearity of Egyptian skirts and crowns matched the surface elements of the built spaces. [Racinet, 1888]

It is fascinating to observe how remarkably different styles emerge in different locations, though the influence and design of the spaces belong to the same historic periods. Illustrated below a comparison of period interiors:

THE GREAT DECORATIVE MOVEMENTS

DESCRIPTIVE SUMMARY

RENAISSANCE	BAROQUE	ROCOCO
Large (monumental).	Large.	Small.
Symmetrical.	Symmetrical.	Asymmetrical.
Straight lines.	Straight and curved lines.	Only curved lines.
Straight or turned legs, low heavy stretchers.	Cabriole legs. Ball and claw feet.	Cabriole legs. No stretchers. No angles.
Architectural motifs, acanthus, humans, animals.	Classic motifs, shells, lions, acanthus, etc.	Nature motifs, rock and shell, ribbons, Chinese.
Turning, carving, painting.	Carving, veneer, lacquer, ormulu.	Gilding, lacquer, caning, marquetry, ormulu.
Oak, walnut.	Walnut, mahogany, ebony, marble tops.	Walnut, mahogany, fruitwood, rosewood.
Velvets, brocades, damasks, cloth of gold. Tapestries.	Damasks, brocatelles, velvets, needlepoint, leather, Gobelin tapestries. Oriental and French rugs.	Damasks, brocades, satins, taffetas, moirés, Toiles de Jouy. French rugs.
Crimson, gold, green, blue.	Red, yellow, blue, green.	Soft, light colors.
Chests, cabinets, refectory tables, beds, chairs, stools.	Cabinets, tables, chairs, four-poster beds, clocks.	Commodes, desks, tables, consoles, beds, sofas, chairs.
Formal dignity, sincerity, strength, repose,	Massive grandeur, elegance, elaboration, variety.	Luxurious ease, intimacy, femininity, gaiety.



Comparative study: **Fig. 16a:** Comparison of Renaissance elements **Fig. 16b:** French Interior – Renaissance **Fig. 16c:** English Interior – Renaissance

Cultures during the same periods adjoining each other show grandeur and flamboyance in French while austerity and simplicity in the English—reflecting over space and fashion. [Mukherjee & Ghosh, 2020]. This trait is reflected in the geometric attributes of symmetry, lines, motifs, patterns, etc.
Similarly, we can draw parallels in traditional spaces. Folk designs reflect built forms, the aesthetics of built spaces, and the indigenous products of the community. in the revival of Patachitra of Pingla, in West Midnapur of West Bengal. It has been seen how the regional motifs have built the village's aesthetics, rebuilt the craft's identity, and sustained and revived a dying craft into an economic activity. The geometry of the motifs differs significantly from the Patachitra of Raghurajpur in Odisha. Although the art form is named the same, the aesthetics and style are vastly different and easily observable. Both villages are known for their crafts and visual identities. [Mukherjee & Ghosh, 2019]

Fig. 17a: Patachitra house façade, Pingla [ISVS e-journal]

Fig. 17b: Pattachitra house façade, Raghurajpur [Indian Express]

Variation of elements in crafts:

The same practice echoes in the craft of the Kutchh region. May it be in the glass-embedded mud painting or Lippan art, which also reflects in the typical embroidery Kutchh is renowned for. The motifs there are strictly geometric on both buildings and textiles with cross-culturally inspired designs, retaining both the cultures of the princely court and the nomads. The geometric floral designs show close kinship with the wood carvings of the region. The relief works, situated in a land with strong solar impact, cast harmonious shadows inside the adjoining symmetrical parts, resulting in pleasant chiaroscuro effects. The same genre of design patterns is visible in adjoining deserts in Rajasthan as well. Though the scale of the motif enhances in the latter as the spatial context changes from the closed Bhunga (hut) of Kutchh to the courtyard houses in Rajasthan, where the play of light and shade generates out of the arrangement of built structures in a land of dry hot climate. [London, 2000]

Thus, it is established over different times, regions, and cultures that traditional spaces, textiles, motifs, and patterns all emerged in their visual aesthetics out of geometric elements and principles.

2.2.2e Geometry in Music and Art

Music and numbers bear a harmonious camaraderie. In music created by stringed instruments, the length of the string and change of tension create notes and scale. In musical scales, ratios of lengths of strings and spacings of notes create octaves. Researchers have established that a harmonious, well-

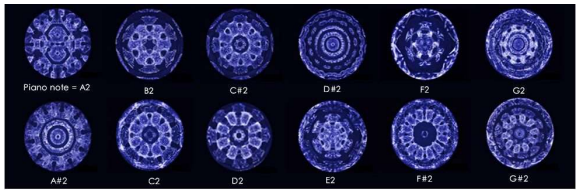
heard tone emerges from numbers. Music is governed by atomic emissions. [Srinivasan, 2009] Vibrations of strings are created by periodic motion. Cosmic movements are also subject to periodic motion, hence producing a sound. The movement of the universe's elements creates the sound of the cosmos, known as the music of the spheres. "*Music of the sphere, in the Cosmos"* – as Wilczek calls it. [Wilczek, 2016]

In Cymatics, the frequency and vibrancy of certain sounds create symmetrical patterns with energy flowing through the sound waves. [Jenny, 2007] As Jeff Volk, an associate of Jenny, reflects—

> *"Jenny's discoveries mirrored biological forms and natural processes, as well as flowers, mandalas, and intricate geometric designs …"*

The Pyramid at Giza has experimented with the sound 'OM,' the *Naadswar* of Hindu philosophy, to generate a specific pattern. It has now initiated the belief that it is the sound of the universe, as the pattern thus created largely represents the solar system. [Samantha, 2022] The patterns created by different sounds generate structures or motifs in the same outline as that of the circle of life motifs. In the ceilings of the ancient Hindu temples, we see these patterns as also in the religious structures of ancient civilizations. This demonstrates how deep the presence of sacred geometry is in religion.

In the musical pillars of Hampi, the monolithic pillars generate sounds specific to one instrument. A closer examination reveals minute changes in the shape of the pillars. This shows how significant the geometry of the external form is to the sound and its beauty. The cymatics patterns on the roof of the temple are believed to represent the pattern of sounds produced by the pillars. [Mohan, 2017]. This links the philosophy of the circle and square in the Vedas, mentioned earlier, as a representation of the Cosmos. [Vatsyayan, 1997] The energy echoes as the inherent sound of the universe as 'Om' with the planets following the path traced by the vibration.



Cymatics: **Fig. 18a:** Patterns of Musical Notes [ask. video / article]

Fig. 18 b-d : Roofs in Musical hall , Hampi [# Teamindia 067/Hampi]

Artists consciously adopt the proportion of sacred geometry in their work. Through the perspective drawings of the Renaissance period, depths and receding details could be created, visually enhancing the volume of the space holding the artwork, creating depths, and drawing attention to layers of details. Apart from the static visual elements, the human body is said to function on this sequence as in the heart beats, a similar recurrence since in musical notes, which adhere to the Fibonacci series. [Akhtaruzzaman et al, 2011]

Leonardo da Vinci focused on considerations of shape, size, and perspective, descriptive features of objects rather than the theoretical foundations as the basis of the geometry. He incorporates the principles of sacred geometry. In his volumes on *Divina Proportione.* Michelangelo utilized mathematics to its fullest extent in the frescoes of the Sistine Chapel. The beauty and harmony in his works are now attributed to the golden ratio, not just anatomical factors. [Encycl. Brit.] As the German painter Albrecht Dürer said: *".... geometry is the right foundation of all painting...."* In general, Islamic artists showed little concern for linear perspective. [Islamic Art, 2004]

Geometry remains the inherent logic for appreciating music and art forms by virtue of the numbers and proportions. It is these proportions that link architecture and fashion with geometry.

From the various authors quoted above on geometry in design, the views can be assimilated into a set of emerging attributes that determine the visual aspect of design and why we perceive it so. These factors will go ahead in identifying the parameters that determine the identification of geometry and its impact in a generic way on design.

2.2.3 Parameterization on Geometry

The above discussions on Geometry in the context of the visual world is now assimilated into a table of aspects to identify the attributes determining the reason of perceiving structure of forms visually. These factors form the basis of visual appreciation of forms and will indicate the parameters that determine the Geometry around us.

A summary of the various learnings are tabulated broadly as follows –

Table 1– Parameters on Geometry

SL	AUTHOR	CONTEXT	PARAMETERS - KEY ASPECTS
1	**Argan & Robb**	Projective geometry	Linearity, viewpoints, optics, perspective
2	**Akhtaruzzaman**	Phi and Golden Ratio	square to rectangle, spiral, numerical sequence, visual elements on mathematical principles, human body and functions on numbers
3	**S. Balaram**	Traditional arts and functionality	Form, function, beauty, regionality
4	**Bernard**	Traditional arts and crafts	Form, function, beauty, Visual elements
5	**John Casey**	Science of figured space	One to three dimension, points, lines, surface, properties of solids Planar and solid geometry
6	**Arthur Cayley**	Space and Geometry	Proportions, Euclidean Space , Physical Space
7	**Francis D. K. Ching**	Ordering of forms communicates meanings	Sequence, Repetition, Rhythm
8	**Le Corbusier**	Language of Geometry	Golden section, , Rhythm root of human activity
9	**Keith Critchlow**	Geometric order and growth in space	Space and geometric structure, flat plane to spherical form
10	**D Arcy Wentworth Thompson**	Forms and fractals generate out of systematic growth of cells and mathematical relation	Mathematical Order, sequence, balance, repeats
11	**D. Dehovitz**	Platonic solids	Five elements, microorganisms

12	**Drunvalo Melchizedek**	Sacred Geometry	Flower of Life, Golden Ratio, Fibonacci numbers
13	**F. J. Dyson**	Kepler's statement	Nature and Geometry
14	**Encyclopaedia Britannica**	Civilization and Beauty Ancient world, actions in cave paintings Application of Geometry	Measurement w.r.t Earth Order by Geometry Lines, form Mathematical rules in Egypt – land, buildings, products, Greeks – Euclid's geometry, Pythagoras' Theorem-mathematics of numbers, right angles Cube in Vedic altar and Greek ceremonial practice Ellipse in solar system. spheres and platonic solids
15	**Encyclopaedia Britannica**	Medieval period and Renaissance	Renaissance development on visual geometry Projective and perspective geometry, parallel lines, order, harmony in interpretation of buildings and object, visual frame and mapping
16	**Euclid & Casey**	Planar and solid geometry	Surfaces to planes, Curves to solids
17	**Sir Banister Fletcher**	Geometry in buildings and elements in ancient times	Lines, forms, golden section, Optical corrections
18	**Marcus Frings**	Modulor scale	Human proportions in buildings
19	**C. Gorman**	Human activities	Mathematics as component
20	**Henri Cartier-Bresson**	Meaning to the world	Sense of Geometry
21	**Heroditus**	Geometry of ancient civilizations	Geometric language of lines, planes, curves, surfaces, Measurement in land division
22	**Unesco WIPO**	Craft and culture	Symbols and elements, patterns, shapes, lines, colours, Geometry, ethnomathematics
23	**Hans Jenny**	Cymatics	Frequency and pattern, symmetry, motif, scale, repeat
24	**Kapila Vatsyayan**	Cosmos and religion	Square and circle
25	**Kazlatcheva**	Fashion and human body	patterns conform to golden sections, fibonacci sequence
26	**Johannes Kepler**	Universe and Geometry as art in creation	Spheres, ellipse, platonic solids, symmetry and beauty
27	**Stella Kramrisch**	Hindu and Buddhist Architecture	Square, Circle and human body
28	**Dori Lal**	Geometry in natural forms	shapes, tessellation. symmetry
29	**Christopher W. London**	Traditional crafts of Kutchh region	Geometric form, Shapes and elements Motifs and rhythm in repeats, harmony and symmetry, spaces, patterns
30	**P. Mohan**	Musical pillar of Hampi	Form, Cymatics, Roof pattern
31	**Mukherjee & Ghosh**	Cultures and aesthetics	Visual elements, space and form
32	**Mukherjee & Ghosh**	Regional crafts	Motifs, lines, elements, space and aesthetics
33	**Merriam-Webster Dictionary** **Oxford Dictionary**	Defining Geometry	Measurements, properties and relationship of points,lines, angles surfaces, solids, Science of properties and magnitude, parts fitting into whole
34	**Alison Lee Palmer**	Traditional built spaces	Shapes, forms, structure, scale, hemisphere, rectilinear form, spirals and curves, symbolism
35	**Auguste Racinet**	History, fashion and regions	Linearity, patterns, form and aesthetics
36	**N. A. Salingaros**	Natural form	Geometric structure, fractal, microscopic scale
37	**Samantha**	Music of the Universe	Sound of OM, shape, pattern
38	**Seidenberg**	Ritual origin of Geometry	Measuring systems, angles, lengths

39	**Urmila Srinivasan**	Music and numbers	Ratio of lengths, spacing, scale, harmony and numbers
40	**Peter Stevens**	Growth of Form	Patterns, symmetry, directions, spirals, fractals, tessellations
41	**Vega Torres**	Crafts and regionality	Visual elements and symbols, geometric patterns
42	**William Whewell**	Ancient world cultures and its relics	Mathematical expression in creativity
43	**Frank Wilczek**	Geometry of Universe Physical world and creation	Visual elements – triangles, circles, other geometric figures Atomic structures, mathematical regularity for beauty, Symmetrical forms in Platonic solids Surfaces, elements on 2d surfaces – perceptible to human vision
44	**Frank Wilczek**	Geometry in nature	2-dimensional image on 3-dimensional space, colour, texture, outlines, Numbers and measures, accuracy, right angles and equality of sides, symmetry of atoms, repetition of units, spirals, fractals, tessellations, Sacred Geometry, golden section, Fibonacci numbers, polygons, lines, scales
45	**Yudianto et al**	Ethnic craft	Form and weaving
46	**Galileo Galilei Oxford University Press**	Nature's art	Harmony and principles of symmetry in beauty Mathematical language with symbols being triangles, circles and geometric figures
47	**James Clark Maxwell**	Equations from atom and light, equations of sound and musical instruments, building blocks of nature	Mathematics, atomic structure, repetition, beauty, symmetry, perception of colour
48	**Isaac Newton**	Mathematics in natural forms and structures	Motion and beauty in atoms
49	**Plato**	Geometry of the Universe	Platonic Solids. Beauty in symmetry. Atom from shapes, beauty in proportion, structure and symmetry

The above key aspects show that the visual experience is generated through physical and psychological guides, which result in generating the aesthetics of physical forms, whether in nature or man-made. It is both quantitative in terms of measurements and qualitative with respect to the emotions generated. It defines beauty in forms and induces functionality. Geometry builds the environment and its identity.

Geometry remains so ingrained in our world. Its existence in our physical experience of the world and its built forms is summed up by the mathematician Arthur Cayley (1821-1895) in his presidential address of 1883 to the British Association for the Advancement of Science as "*Not that the propositions of geometry are only approximately true, but that they remain absolutely true regarding that Euclidean space, which has been so long regarded as being the physical space of our experience."* [Cayley, 1897]

Henri Cartier-Bresson says

> "*In order to give meaning to the world, one has to feel oneself involved in what he frames. This attitude requires concentration, a discipline of mind, sensitivity, and a sense of geometry."* [Cartier-Bresson, 1999]

Geometry thus defines this psycho-physical space through qualities as derived from the aspects mentioned above.

These can be summarised broadly into 3 parameters in relation to *Geometry for Design* -

a. *Elements*
b. *Characteristics*
c. *Attributes*

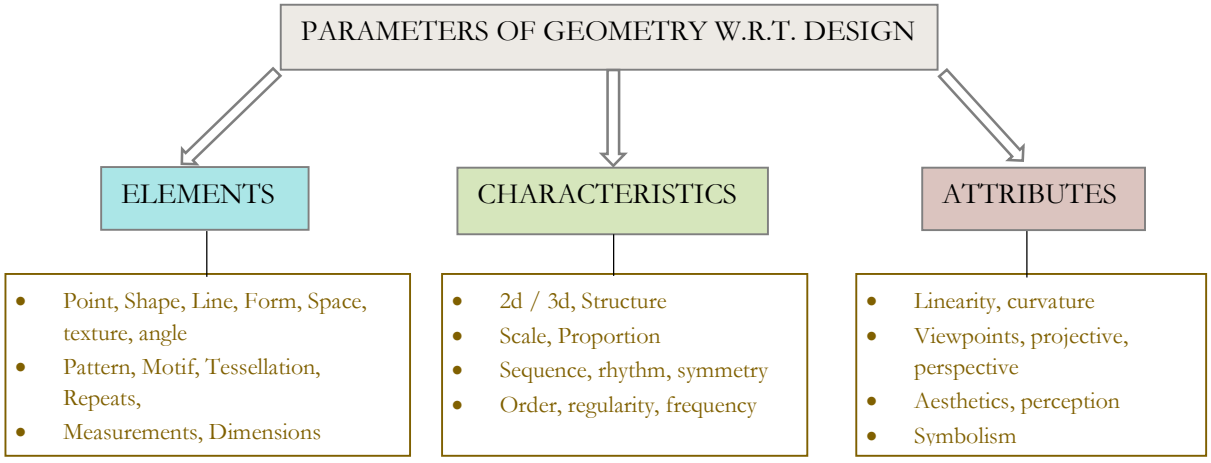


Fig. 19: Identified parameters of Geometry in Design [pc: Author]

The inter relationship of these three parameters, as identified on Geometry, emerges towards the appreciation of visual Design based on Geometric elements triggering cues. The parameters and sub-parameters need to be validated further.

2.3 Geometry based Visual perception

The geometry discussed in the literature surveys above do not pertain to the technicalities, nor the mathematical construction processes or the theoretical application of Geometric rules. It speaks about how Geometry is perceived in Design. Or rather, how perceiving visual elements in designed objects is guided by Geometrical logic and the absoluteness of geometric principles absorbed by the sub conscious human mind. Visual perception of these elements is guided by human vision, as seen through the eyes.

2.3.1 Definitions

It is understood that what our mind 'sees', is based on the correlation between the various components of a visual composition or the sight in vision and the way the human mind interprets.

"Visual perception is the brain's ability to receive, interpret, and act upon visual stimuli." [Orloff, 2004]

"It *is through perception that we can recognise objects, distinguish shapes, colours, and sounds — in other words, apprehend and understand our world."* [Desdevises, 2024]

"The various physical and processing components which enable a human to being to assimilate information from the environment are known as the visual system." [Gabrielli, 2009]

"The awareness of visual sensations that arises from the interplay between the physiology of the visual system and the internal and external environments of the observer." [Cornsweet, 1971]

"Visual perception allows individuals to understand and interact with their surroundings by recognizing, organizing, and interpreting shapes, colours, spatial relationships, movement, and other visual attributes." [IxDF, 2017]

2.3.2 Descriptions

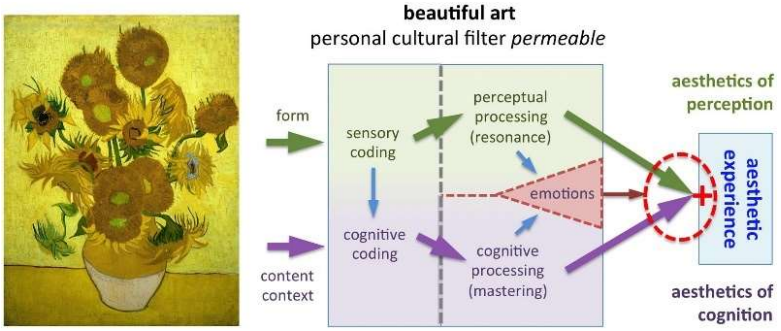
Going by these definitions, perception of design can be interpreted in different directions. Various disciplines study the way representative mental images emerge from visual perception. The value of visual perception, thus, is entirely subject-specific as well as diversified, hence appreciable in fashion and architecture in their direction of study.

In Zen meditation, the saying goes, "*Ears hear and eyes see. What then does the mind do?"* The action of the mind can be interpreted as "…*what vision does – it is always trying to make sense of its input …. Vision is active, not passive"* [Snowden et al, 2012].

2.3.2a Visual perception and aesthetics

In human vision, bio-physically, the external visual sensory stimuli are registered through the eyes, and after traveling a complex biological process through the eyes to the brain connected neurally, builds a meaningful experience in cognition is built based on one's past experience.

As Sir Ernst Hans Josef Gombrich says, from the surrounding environment of visually perceivable images, there is a constant process of segregation of relevant and not relevant information [Gombrich, 1982]. The visual quality of surroundings required perception and cognition for evaluation. The human body's sensory organs related to optics receive external stimuli to facilitate perception. It is the physical elements in the environment that send signals to the sensory organs. The cognitive experience is triggered by socio-cultural values, practices, experiences, and lifestyle. (Meader et al. 2006, Portella 2014). The appreciation of aesthetics generates these visual triggers. '*Aesthetics'* is derived from the ancient Greek *'aisthētikós',* meaning *'perceptive, sensitive, pertaining to sensory perception,'* which directly relates visual experience to perception. The term adapted from the late 18th century understanding of the word as *'relating to perception by the senses'* to mean a *'set of principles concerned with... appreciation of beauty.*' [Oxford Dictionary] The design fields being directly involved in creating aesthetic forms, perception becomes a determinant of beauty.



Perceiving aesthetics - Fig 20: Human appreciation of Art [source :Christoph Redies, Front. Hum. Neurosc., 2015]

Ghosh et al. elaborates —

> "*Articulating a theory behind beauty fascinated researchers and scientists alike for centuries. It was the center of studies since Classical Greece. Plato, Aristotle, St. Thomas Aquinas, Newton, Kant, Kaplan, and many others studied the mysterious facet of the" nature of beauty and why it affects us……. aesthetics is traditionally defined as the study and theory of beauty and of the psychological responses to it. Historically, scholars have studied issues related to visual aesthetics across three disciplines: philosophy, art, and science…….. studied four aspects of aesthetic communication: (a) visible, structural, and configurational in nature; (b) largely implicit in apprehension; (c) holistic in conveying meaning (not wholly translatable into parsed, discursive form); and (d) cognitive in a generative sense, based on a unique type of visual logic*". [Ghosh et al., 2015]

This establishes the relation between the fields involving visual aesthetics, such as design, with beauty as a purpose, thus gathering study from historical periods and learned geometers and mathematicians from ancient times in order to establish the principles that align elements into cognition and convey a meaning or purpose through unique correlation of the elements in concern with perception. Thus, aesthetic judgments resulting from perception and cognition arise from "*formal"* and "*symbolic"* factors. [Portella, 2016] These factors are integral to the visual culture through ages, manifested in the lifestyles of communities.

2.3.2b Visual perception and culture

Perception and aesthetic appreciation vary from culture to community to period. As according to Hooper-Greenhill:

> *Visual culture is an emerging field of study.... An encounter between sociology and fine arts, or the application of theories from social and cultural studies to those artifacts and practices... included within art history. such as painting, sculpture Visual culture works toward a social theory of visuality, focusing on questions of what is made visible, who sees what, and how seeing, knowing, and power are interrelated. It examines the act of seeing as a product of the tensions between external images or objects and internal thought processes and examines the visual as one dimension of culture.* According to her, '*Seeing is relative rather than absolute.'* [Hooper-Greenhill, 2000]

Different cultures express this through their socio-cultural practices and daily lifestyles. With its origin in art history and visual studies, visual culture constantly evolves as a phenomenon, as manifested in the constantly changing contemporary times. In the present-day economy, it reflects across the various channels of consumption. Visual culture has given rise to an abundance of visual information in terms of goods produced or designed, emerging into brands and symbols. Portella [2016] rightly said: "*Goods begin to have more than utilitarian value; they become part of the identity, personality, self-image, social position, attitude, and aspiration of people. In fact, it is not the material object that is desirable by people, but the image associated with these objects."*

Difference in expression of lifestyle across world cultures :
Fig 21a: Mexican American **Fig 21b:** Japan **Fig 21c:** Africa **Fig 21d**: Asia
Costumes and Jewellery of World Cultures [source : The Costume History, 1888]

The visual in visual culture is not only seen but possesses functional and / or communicative intent. Unlike artwork, which is primarily for visual experience only, the aesthetics of visual culture is to do the job it's intended for. The word 'aesthetic' in English derives from the ancient Greek word for Perception. From the purpose of aesthetics being related to things that look beautiful. Visual culture would then lead to producing or creating something to be perceived as beautiful as well. [Barnard, 1998] The forms thus generated in visual culture are realized in the way the lines, colour, and forms combine to trigger aesthetic emotions. [Bell, 1982]. Visual perception thus plays a major role in identifying designed products as an identity of a community, person, or region. This includes the holistic lifestyle of human inhabitants, thus covering both architectural and lifestyle products. The images and their perceived qualities influence people's behaviours and decisions regarding products that are integral to a lifestyle. In the study of visual culture, it is indeed necessary to understand the different definitions of the visual by social, cultural, and regional groups based on the system or structure of institutions, objects, and practices, along with visual experience, social order, and ongoing historical and social processes. Or an entire way of life for a group of people generating a visual perception [Barnard, 1998], varying from civilization to civilization.

Two distinct environments identify visual perception separately. In the natural environment, the inception of visual perception comprised "*surfaces and textures, solid objects, rich patterns of multisensory stimulation, movement, and change.*" [Gordon, 2004] The man-made environment of human culture comprises a plethora of man-made artifacts, communication, signs, etc., with their visual characteristics and physical attributes. It continues to serve as an intriguing crucible for the evolution of design and its inherent dynamic nature. There is a significant difference in terms of ways of perception based on these two genres of environment. While visual perception in nature derives from the visual elements, in human civilization, it is dictated by the dominant social classes and their tastes. As Bernard says, that culture is not unilinear and rather diverse, as seen in Egyptian, Syrian, Chinese, Persian, Indian, Islamic, etc. cultures and settlements. Race, ethnicity, and gender are equally to be considered for the purpose [Bernard, 1998]. According to him, different cultures define the form of

visual culture through independent codes. Interpretation of visual signs within a culture is being interpreted through external and internal codes—external codes indicating the situation of encountering the visual form, while internal codes are used to convey a desired impression or meaning.

Perceiving elements in culture
- **Prehistoric cave paintings:**

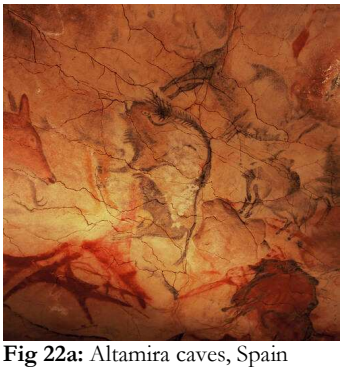


Fig 22a: Altamira caves, Spain
[pic courtesy: UNESCO]

Fig 22b: Bhimbetka Caves India
[pic courtesy: Govt. of India]

The theories of Kevin Lynch, though in the context of the city, prove that the '*imageability'* and '*legibility'* are directly linked to visual perception, being inter connected to each other. While imageability deals with the degree of impression on the components of the environment or place, legibility refers to a *'coherent and recognizable pattern'*. The same phenomenon is as much relevant to all fields of visual design and perception. [Lynch, 1960]. Arnheim says, "*Individual artists or cultures form the work after their own image. However, a well-organized line figure is visualized as the same basic shape, regardless of the diverse cultural background and individual understandings".* [Arnheim, 1969]

The above descriptions indicate how the identity of a culture is visual in its characteristics. This phenomenon is reflected through the lifestyle and practices of the human community living there. The visual aspects define and indicate the aesthetic experience, which in turn distinguishes one culture from another. The human mind perceives these elements and sequences them to appreciate the design's significance in the visual culture of communities.

2.3.2c Visual perception and Gestalt

Understanding visual perception in design stands incomplete without the Gestalt Theory. Originating in the early 19th century and formulated on the basis of the phenomena of perception, the principles of similarity, continuity, closure, figure-ground, and symmetry center around the human tendency to assimilate and coalesce scattered elements in a visual frame as information into organized wholes. [Arnheim 1969, Stroebel, et al, 1980). Gestalt theorists believe that perception is always changing, which leads to meaningful, logical, and easy ways to understand how things or representations look. [Ghosh et al., 2015]

Prior to the Gestalt school of thought, In the essay from 1890, On 'Gestalt Qualities,' Christian von Ehrenfels coined the term 'Gestaltqualität' (meaning 'form-quality') to capture the idea of a pattern that is comprehensible in a single experience. [Ehrenfels, 1890] He drew attention to the fact that groups of stimuli can form a pattern that is different from the individual parts when seen in isolation. As in a square, a quality of 'squareness' emerges, which is absent in random assembly of lines. The later Gestalt theory propounded by Max Wertheimer, Wolfgang Kohler, and Kurt Koffka works on the premise of illusions generated through outlines and colours in this world of objects, not sensations. The figure-ground perception is completely determined by the outline contour. The principles of grouping cleanse distracting elements towards a focus on characteristics, implying a tendency towards regularity and symmetry. Hence, simple shapes group and align to generate the form experience. From the aspect of perception, Gestalt generates into a whole only when the pattern generates out of its components, the visual cues, which in turn are generated from elements, colour, motion, etc. *'… a part will suggest a whole only if it is a genuine part'*. Perceptual experiences follow minimalist principles based on balance and symmetry. [Gordon, 2004]

Gestalt in Design : **Fig 23:** Gestalt principles in logo design [source - nicolavargiu.com]

As Arnheim points out, he quotes the observation of architect Eduardo Torroja.

> *'The total vision of a straight line, a curve, or a volume is influenced by other surrounding lines and planes …. The straight line of the tie member of a flattened arch may appear as a curve, whose convexity is opposite to that of the arch. A rectangle placed within an ogive has a deformed shape.'* [Arnheim, 1969]

Arnheim believes that visual shapes are what they tell us. The human mind '*hunts for parallel lines and for examples of figure and ground,'* as also *'the appearance of any element depends on its place and function in an overall pattern.'* The mind tends to strive to interpret unity and order manifest in seeing a simple pattern of lines. It expresses the outline of a pyramid as distinguished from a cloud in terms of triangularity vs. roundness. The circle is only just a plane until the roundness is highlighted in the context of the articulation of straight lines and squares only. [Arnheim, 1974] The roundness and rectangularity, with rectilinearity, are as much perceived as compatible despite the incompatibility of the circle and the square. [Ehrenfels, 1988]

Metzger states, "*In general, one must not form too narrow a concept of the term 'good' Gestalt. "It includes such simple forms as a straight line, a circle, and a square."* [Metzger, 2006]. He suggests, "*The law of good continuation and the law of closure are special cases of the general law of order or pragnanz… The law of similarity is thus again a special case of the general law of the unity of structure, or of the law of the good Gestalt."*

Likewise, alongwith the existing principles of closure, continuity, similarity, proximity, figure-ground, and later common fate, it adds the new principles that include symmetry, order, balance, unity, etc. [Guberman, 2015] It is hence understandable, without further detail on the individual principles, which maybe largely beyond the scope of the thesis, how Gestalt principles guide the visual perception in design and create a visual vocabulary for understanding and appreciating design in different contexts.

2.3.2d Visual perception and design

The term 'design' is generated from the French dessiner and Italian 'disegno', which means conceptualizing an idea and the way it is communicated. Zena O'Connor says, "Good design...is intelligence made visible." She believes vision is construction… key *principles considered fundamental to organic form and the creation of visual imagery: contrast, rhythm (or pattern), balance (and symmetry), and proportion along with unity/harmony, movement, and expression,"* ensuring that *"elements within a design relate to each other in some way"* [Connor, 2014]. *She writes, "Communicate—don't decorate" which indicates using elements in a way to trigger the perception and with our mind putting them together to read into the picture.*

Renowned digital product designer Luke Wroblewski explains,

> *"Visual organization is the deliberate prioritization of meaning within a visual design. It's the process of applying the principles behind perception—how we make sense of what we see—to illuminate relationships between content and actions." It is this organization that allows us to interpret forms in the way we see.*[https://www.lukew.com/ff/]

Malcolm Barnard defines 'visual' as '*everything that can be seen'* and '*everything produced or created by humans that can be seen,'* making it meaningful in a way, which is the way the mind perceives what it sees. All the objects identified under 'Design' may be created for a purpose, as in space or industrial design; hence beauty is not necessarily a primary aspect, while those identified in the context of fashion and crafts, aesthetics remains the primary objective. [Barnard, 1998] Sir Kenneth Clark writes about an eminent elitist upper class who will establish dominant ideologies to follow as identity [Clark, 1969], such as luxury being synonymous with civilized. Polhelmus challenges the common man, highlighting the emergence of fashion, products, and architecture that appear to be in opposition to dominant lifestyles [Polhelmus, 1994] This thesis clearly indicates the diverse directions of our areas of concern.

Marcia Pointon asserts that an object's inherent characteristics, such as form, colour, composition, and brushwork, dictate its understanding. Gombrich's account of Expressionist theories illustrates the use of shapes, lines, colours, and textures by different social groups to constitute themselves as a

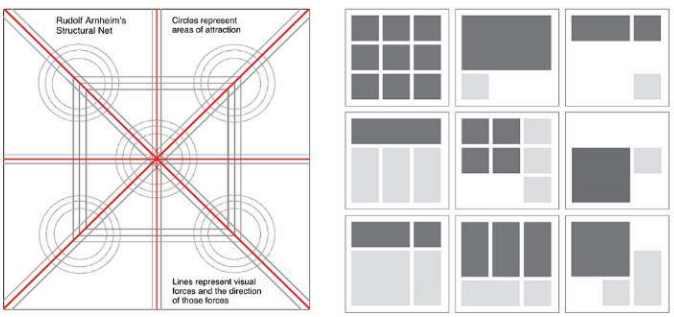
distinct group and also differentiate from other groups using another set of lines and shapes by virtue of this visual identity. [Gombrich, 1950] This construction through the cognitive process can be explained in the following words: Artist Irwin Greenberg guides "See the planes of light as shapes, the planes of shadows as shapes. Squint your eyes and find the big, fluent shapes." [Greenberg, 1954]

Perception in Design: **Fig 24a**: Church of the light, Tadao Ando **Fig 24b**: Boucheron snake double ring

David Papineau has questions "*How rich are the contents of visual perception? Does vision only tell us about shapes and colours, or does it also represent higher categories like lemon or umbrella?"* Interpreting these Geometry and the geometric elements can be explained as *'The geometry of the visual space is the geometry that describes the relations among perceived extents and perceived angles.'* [Foley et al, 2004]

The above ways of defining visual perception w.r.t. objects that we see again illustrate the role of geometric elements in constructing the image in our mind. It speaks of geometry being catalytic in seeing things in a directional manner. The definitions of perception, mentioned earlier, refer to the geometric elements that are organized by the mind to create the visual imagery. This imagery is contained within the boundary of the frame of vision.

According to Rudolph Arnheim, perception assigns objects to a plane—unique or isolated—based on their spatial location. According to him, in perceptual experience, stimulus patterns create a structural skeleton that helps determine the role of each pictorial element within the balance system of the whole. It's a continuous field of forces. Perceptual forces are both psychological and physical forces, and as in molecular movements, they are perceived through focus, direction, and Intensity. [Arnheim,1969]



Perception & spatial location: **Fig 25**: 'Rudolf Arnheim's structural nets' [pic courtesy: Wicar Akhtar]

Arnheim thus endorses the role of visual elements, as in the definitions, in determining, guiding, and building the perception of design. Arnheim establishes how visual perception directs design appreciation and the way we see it. He relates the form to its spatial orientation. Therefore, when we place objects in any unusual direction, our mind attempts to interpret them in their *'normal'* orientation. Along with the elements of design, the principles of design play an essential role in imagery.

What emerges is that perception has certain attributes. "*We know that our own and other people's perception of the world is generally stable: objects have positions, shapes, and colours that we seem to be conscious of instantly"* [Wade, 2012] Zena O'Connor believes in *"key principles considered fundamental to organic form and the creation of visual imagery: contrast, rhythm (or pattern), balance (and symmetry), and proportion along with unity/harmony, movement, and Expression."* [Connor, 2014]

Finnish architect Pallasmaa in 1996 noted in his influential work *The Eyes of the Skin: Architecture and the Senses – "Traditionally, architects have primarily designed with the viewer's eyes in mind"*. He adds, "*The architecture of our time is turning into the retinal art of the eye. Architecture at large has become an art of the printed image fixed by the hurried eye of the camera."* [Pallasmaa,1996]

Canadian designer Bruce Mau put it thus: "*We have allowed two of our sensory domains—sight and sound—to dominate our design imagination. In fact, when it comes to the culture of architecture and design, we create and produce almost exclusively for one sense—the visual."* [Spence, 2020]

To create the desired perception of space, one could change a few factors.

1. *Orientation*
2. *Wayfinding*
3. *Circulation*
4. *Spatial dimension* [RTF fresh perspectives]

Visual perception in architecture can be related to material functionality, as seen in the architecture of Le Corbusier and Zaha Hadid, in the research paper of Layla Mujahed 2022. The research findings reveal that although in many cases the flowy forms of Hadid's buildings generate emotional impact, in terms of functionality, Corbusier's buildings lead in terms of regularity and order. This establishes how strongly the visual elements control the experience of spaces. [Mujahed, 2022]

Fig 26a: Citrohan House, Le Corbusier [Source:Pinterest]

Fig 25b: Nassim Villa, Zaha Hadid

Perception to Emotion:

Malcolm Bernard elaborates on how *'fashion was guided in terms of form, colour, texture, and the silhouettes that would be interpreted as per the social order that adopted new styles. The change in linearity and fit, particularly regarding volume, introduced new designs that were embraced as fashion styles. On the other hand, the Arts and Crafts movement, or the Bauhaus, wanted to adopt industrialized structures easily within the reach of the common people. The simple outward expressions would appear functional and adaptable to the working class.'*

Western Fashion Silhouettes: **Fig 27**: Fashion through the years [pic. courtesy: Lorri Redmon]

Thus, we find how visual perception of design elements is vital in determining the choice of the people, while the social structure guides the acceptance of the design, differentiating wearables from space and lifestyle products. [Bernard, 1998]

2.3.3 Parameterization on Visual Perception in Geometry

The above elaborations on Visual Perception in the context of Design may be assimilated into a table of aspects that can be used to identify as the attributes determining the reason of perceiving visual forms. Identifying these factors guiding perception of forms can be indicative of the parameters of Perception that determine Geometry with Design.

A summary of the observations is tabulated below –

Table 2– Parameters on Visual Perception

Sl..	AUTHOR	CONTEXT	PARAMETERS - KEY ASPECTS
1	**Rudolph Arnheim**	Cultural background and individual interpretation Gestalt Theory Vision and perception Visual shapes Perceiving objects	Line figure and shape recognition, organisation and unification principles of similarity, continuity, closure, figure-ground and symmetry Line, curve volume influenced by suurounding line and planes. Parallel lines, pattern, figure and ground, distinguish outlines, shapes w.r.t. shape / line Structural skeleton perceptual forces, psychological and physical, focus, direction, intensity, visual elements, form to space orientation
2	**Malcolm Bernard**	Interpreting Fashion Visual design aesthetics related to beauty Designed products as identity Man made environment and objects	Form, colour, texture related to social order Linearity and volume, design elements to social class, distinguishing expression Visual elements, characteristics, physical attributes, diversity, race, ethnicity, gender External codes in visual form, internal codes for meaning Visual experience and purpose System and structure, practices, social order and processes, regional, civilizational variance

3	**Clive Bell**	Forms in visual culture	Lines, colours, forms to emotions
4	**Kenneth Clark**	Social class	Aesthetics as identity, luxury as civilized
5	**Tom Cornsweet**	Visual system	Visual sensations, physiology, internal, external environments
6	**Joy Desdevises**	Recognise objects	Distinguish space, colour, sound
7	**Ernst Hans Gombrich**	Segregation of information Visual characteristics	Environment with visually perceivable images Response to form, colour, composition, brushwork, shapes, lines, colours and textures for identity
8	**Foley**	Visual space and forms	Geometry and geometric elements, relation between lines and angles
9	**Silvia Gabrielli**	Visual system	Physical and processing components, assimilate information
10	**Mainak Ghosh et al**	Psychological responses to beauty	Aspects of aesthetic communication – visible, structural, configurational, apprehension, holistic, cognitive
11	**Ian E Gordon**	Gestalt grouping Perception in natural environment	Figure -ground, outlines, colour, contour, regularity, symmetry, pattern from components, visual cues from elelments, balance Surfaces, textures, solid objects, patterns, multisensory stimulation, movement, change
12	**Irene Greenberg**	Cognitive process	See visual planes as shapes
13	**Sheila Guberman**	Gestalt principles	Symmetry, order, balance, unity
14	**Eilean Hooper-Greenhill**	Visual culture related to artefacts and practices	Seeing as tension between external images / objects and internal thoughts, relative not absolute
15	**Interaction Design Foundation**	Organizing surroundings	Interpreting shapes, colours, spatial relationships, movement, visual attributes.
16	**Kevin Lynch**	Urban space and visual design	Imageability and components, legibility and coherent pattern
17	**Meader, Uzzell & Gatersleben**	cognitive experience and socio-cultural values, practices, experiences and lifestyle	Physical elements in visual environment
18	**Layla Mujahed**	Perception of space	Materials, functionality, regularity, order
19	**Zena O'Connor**	Design Fundamental of form and imagery	Construction, organic form, imagery, contrast, rhythm, balance, proportion, movement, expression Relate elements, contents and action communicate organise, interpret, Principles of Design – Contrast, Rhythm, Balance, Proportion and Unity, Movement, Expression
20	**Juhani Pallasma**	Architecture as Image	Perception, image and art
21	**Ted Polhelmus**	Design and lifestyles	Fashion, product, architecture emerging and opposite to dominant styles
22	**Adriana Portella**	Aesthetics and perception in Visual cultures	Principle of aligning and correlating elements, formal and symbolic factors, visual information on goods designed, brands, symbol, identity, personality
23	**rtf fresh perspectives**	Space perception	Orientation, Wayfinding, Circulation, Spatial dimension
24	**Susan Schriber Orloff**	Physical Interpretation of perception	Visual stimuli
25	**Charles Spence**	Design imagery	Forms for visual sense, image, human sense of sight and sound
26	**Stroebel, Todd, & Zakia**	Gestalt Theory	Assimilate, coalesce scattered elements as information, organized into wholes Dynamics
27	**Ian Verstegen**	Gestalt & Art	Cognitive Perception, Visual qualities, human visual systems, geometric forms, projective and perspective qualities
28	**Wade, Swanston**	Attributes of perception	Stability of objects, position, shape, colour
29	**Metzger Wolfgang**	Gestalt	Straight line, circle, square, continuation closure order, similarity and unity
30	**Luke Wroblewski**	Visual Organization in Visual Design	Principles behind perception , relationship of content and action

These aspects, as tabulated above, illustrate how human eyes and minds perceive design forms. They show that characteristics of objects—physical and psychological— lead to the perception of forms, differing from person to person but remain generic largely. Human mind reads geometry subconsciously within outlines and forms. Guided by the social structure, visual elements and their emotional impacts, can differ in context but not in the physical understanding of built forms. This is where geometry remains the key to the construction of a visual image for perception.

As Liliana Albertazzi and others show through their experiments,

> '*Visual lines may have different appearances and behave differently in perceptual space… Each of these appearances plays a specific role in visual organization… …In visual arts, indeed, we have most of the drawn phenomenology of visual lines, able to contribute to their classification.* [Albertazzi, et al 2022]

When Ian Verstegen writes, *"As Arnheim says, 'all perception is the perceiving of qualities, and since all qualities are generic, perception always refers to generic qualities,' " and also exemplifies, "…the human visual system tends to improve visual forms over their geometric and projective literalities,"* he clearly indicates that cognitive perception in visual arts generates from geometry and moves in diverse ways of appreciation in a qualitative manner. [Verstegen, 2005]

It is understood hence that perception towards design through forms through visual characters that the eye sees and the mind reads – in order to create a whole from the parts.

These can be categorised broadly into 3 parameters w.r.t. visual perception of geometry in design—

a) Physical Aspects
b) Visual Aspects
c) Cognitive Aspects

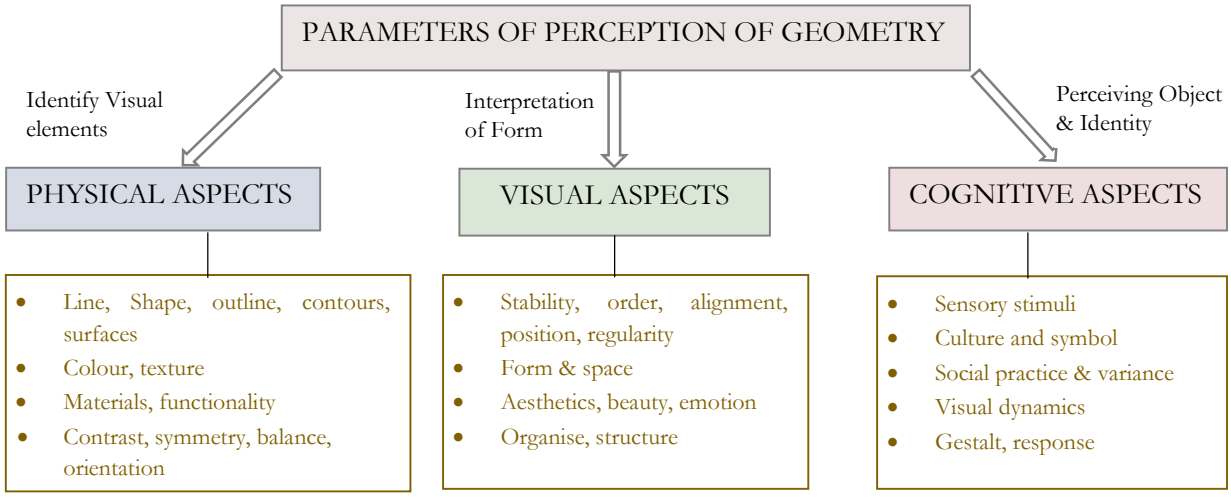


Fig 28: Parameters of Visual Perception [pc Author]

The complex inter relationship of these three parameters identified emerges on perception towards the appreciation of visual Design based on aspects that are subjective. The parameters and sub-parameters identified above need to be explored further.

2.4 Geometry in Design

Design is a broad perspective topic, as anything creative can be considered as 'design.'

".....the terrain of design practice, education, and research, and its subsequent points of inquiry, are continuing to shift and extend well beyond the boundaries of the (single) discipline... Now the idea of design includes multiple disciplinary perspectives (i.e., multidisciplinarity) and cross-disciplinary pursuits...." [Rodgers, Barry, 2017].

This serves to elucidate the significance of a cross-disciplinary approach to design and the multidisciplinary perspective, which forms the foundation of our thesis. Design is for a purpose with aesthetics. As Charles Eames explains, "I would rather say it's an expression of purpose. It may, if it is good enough, later be judged as art" [Design Q&A, 1972].

Hence, it is understood that every work of creativity needs to have a purpose to be termed as Design. And the purpose, i.e., the functionality, of the design remains dependent on its geometric structure, leading to the effectiveness. For the purpose of this thesis, discussions are to be restricted only to the two directions in the hypothesis – Architecture and Fashion – and the aspect of visual perception towards appreciating the aesthetics in either.

2.4.1 Definitions

A generic definition of Design can be related to the two directions of this thesis. As the following shows, Design can be related to Architecture and Fashion in terms of buildings, garments, etc. The definitions may be:

As in the Oxford Dictionary:
"*a plan or drawing produced to show the look and function or workings of a building, garment, or other object before it is made"*

States Merriam -Webster Dictionary: "*to create, fashion, execute, or construct according to plan"*

Going by Charles Eame*s's definition*—
"One could describe Design as a plan for arranging elements to accomplish a particular purpose" [Design Q&A, 1972]

The emergence of the term *'Plan'* in all of the above indicates the preparation of a drawing or specifications that allow the design to be physically realized. It automatically illustrates the inevitable presence of geometry in technical drawings and form generation, without which the action described above cannot be real or visible. This indicates defining Architecture and Fashion in the manner to correlate to Design and maybe establish their interdependence. There are multiple definitions that define the two. For this thesis, we will restrict the same to the objective of the hypothesis only.

Here onwards, the literature survey focuses primarily on the two selected streams of Design – Architecture and Fashion.

2.4.1a Architecture -

A well-known definition remains as '*the art and science of buildings.'* Architecture is the *'art or practice of designing and constructing buildings'*, as stated in Oxford Dictionary. Encyclopaedia Britannica highlights it as a design with purpose and aesthetics. In this thesis, it is considered a key direction in design where creation, with its visual aesthetics and the geometry within, is the subject of study. In this literature survey, it is to probe the understanding and application of Geometry in architecture. Hence, we will look into Architecture defined from that point of view.

It is summed up by Alvaro Siza in one line, *"Architecture is geometry."* – [Johanna, 2020] as a testimony to his entire gamut of design that includes architecture to furniture and objects.

In his Ten books of Architecture, Roman architect Marcus Vitruvius had defined it as – "*Architecture is a building or object that is structurally sound, functional, and beautiful"* [Morgan, 1914]

In the words of Paul Rudolph, *"In terms of how one goes about designing anything, ... There are so many elements that come into play.... Architecture... It's the art of what is possible."* [Rudolph, 2019]

Charles Moore and Kent Bloomer describe in their book 'Body Memory Architecture' *".... architecture is generally assumed to be a highly specialized system..... manifested in the reliance on two-dimensional diagrams... and three-dimensional qualities of the whole architectural experience."* [Bloomer & Moore, 1979]

Thus, from the above definitions emerges that architecture is like a creative art, a design with purpose and beauty, an experience of visual elements expressed through 2D drawings out of geometry.

2.4.1b Fashion –

In this leading journal, Sue Taylor states: *'Fashion design is a form of art'* [fibre2fashion.com 2006]

Christene Barberich, co-founder and editor-in-chief of Refinery 29 and consultant to leading Fashion brands said in an interview, *"I know practically, fashion is art, it's commerce, it's function, it's expression."* [wordpress.com, 2021]

"The word fashion comes from the Latin word facia, meaning 'to make' or a particular make or shape" [Kawamura, 2005]

Andy Warhol, one of the most influential pop artists, started his career in the fashion world as a fashion illustrator for Harper's Bazaar and Glamour Magazine. Quoting Andy Warhol—*"Fashion is more art, than art is."* [Mongamelli, 2022]

On the act of Fashion, the Oxford Dictionary states – to *"make into a particular form"*

Stella Blum, Curator of Costumes, Metropolitan Museum of Art, New York, says on the desire to alter or add to the natural physical form of human species, *"graphically and consistently reflects social and cultural patterns...in which individuals within a society alter their original appearance....gives definition to the word 'fashion'"* [Batterbury, 1982]

The above definitions reflect that Fashion is form generation in the same way as art is, to add beauty to the human body. The human body's geometry and structure make this possible.

2.4.2 Descriptions

The definitions of Geometry in Design, hence Architecture and Fashion, express the need to create form to enhance the aesthetics – be it space or the human body. In order to achieve this, the process adopted is a transition from 2D design to 3D form, achieved through a structured layout adopting geometry and its elements to fulfil the end objective of the design. Let us elaborate on the aspects that have been revealed through this literature survey. For the purpose of the thesis and its statement, Architecture and Fashion aspects are to be considered only as visual forms. The understanding of the functions, materials, and technicalities will solely focus on the aesthetic aspects of these forms.

The study will first focus on understanding Architecture through definitions and descriptions of the different directions leading to architectural forms/spaces. Broad areas of relevance of Geometry in each stream, found significant to its existence, is considered for elaboration of the study.

2.4.2a Architecture

> Quoting one of the greatest architects of our times - Frank Lloyd Wright-
> *"Architecture is the triumph of human imagination over materials, methods, and men, to put man into possession of his own Earth. It is at least the geometric pattern of things, of life, of the human and social world. It is at best that magic framework of reality that we sometimes touch upon when we use the word order."* [Spirn et al, 1996]

As Christele Harrouk, editor-in-chief, Archdaily, illustrates: *"The architectural realm has always been torn between artistic and rational cosmos"* The sense of order echoes in Le Corbusier's words*: "To create architecture is to put in order. Put what in order? Function and objects."* Corbusier endeavoured to differentiate and characterize functions as *'organs'* - which came together to compose a *'plan'*. [www.archdaily.com, 2021] On the creation of a plan, Charles Eames adds - *"Design is a plan for arranging elements in such a way as best to accomplish a particular purpose."*

Mies Van Der Rohe puts it differently: *"Architecture is achieved through a whole and not only through a plan,"* meaning that structure and form are interlinked pieces. In the exhibition of his works at MoMA, New York, Van Der Rohe adds, *"Architecture is the will of an epoch translated into space."* [Johnson, 1947]

As Louis Kahn is quoted on his architectural philosophy—

> *"A great building, in my opinion, must begin with the unmeasurable, go through measurable means when it is being designed, and in the end must be unmeasurable. The design, the making of things, is a measurable act....* [Green, 2011]

The statements of these stalwarts of architecture set the foundation for understanding the relevance of underlying geometry in architectural design. This is reflected in the measurements, order, and connection of components that serve the purpose of the constructed space. In the subsequent study, now we would try to analyze architecture in different contexts that determine its visual attributes. This will be based on the evolution and practice of Architecture and its influences as studied below.

i) Nature and Architecture

Alvar Aalto said '*form must have content, and that content must be linked with nature.*' [RTF, 2021] setting the pace for the study on Nature's influence on Architecture. This influence is explicitly narrated in the works of Spanish Architect Antoni Gaudí. Gaudi believes, *"Nothing is art if it does not come from nature"*. [Strautman, 2017]

As Encyclopaedia Britannica states –

> *"The architectural work of Gaudí is remarkable for its range of forms, textures, and polychromy and for the free, expressive way in which these elements of his art seem to be composed. The complex geometries of a Gaudí building so coincide with its architectural structure that the whole, including its surface, gives the appearance of being a natural object in complete conformity with nature's laws."* Gaudi speaks—*"Anything created by human beings is already in the great book of nature.*" and *"There are no straight lines or sharp corners in nature. Therefore, buildings must have no straight lines or sharp corners."* [www.brainyquote.com].

Gaudi's forms reflect the fluidity of Nature in the use of curved structures and nature inspired built structures. Architecture, whether biomimetic, mimicking the systems and processes of nature, or biomorphic, taking inspiration for the design from organic forms, has been greatly inspired by the functioning and mechanism of adaptation of natural objects and organisms to their surroundings. The interpretation in architectural forms reflects by use of geometric processes, shapes and forms, unlike the completely free-flowing organic structure as seen in nature. This is often to fulfil the purpose and objective of the Design [Dixit & Stefanska , 2022]

Nature inspired Design: **Fig. 29a:** Sagrada Familia staircase Antoni Gaudi **Fig. 29b:** Natural shell [pc Vacatis.com]

'We borrow from nature the space upon which we build' – Tadao Ando says. [Basulto, 2012]

This experience of interaction with nature is comprehensively analyzed by the words of Frank Lloyd Wright. His perception of the cohesion of building within nature reflects in his philosophy—

> *"to make the landscape more beautiful than before the building was built." His coinage of' 'Organic Architecture' was way before the term 'organic' was in.* [Hoory, 2016] Wright says, "*organic buildings are the strength and lightness of the spiders' spinning, buildings qualified by light, bred by native character to environment, married to the ground."* [Fandel, 2006]

It is manifested in his Guggenheim Museum where it is said,

> *"Wright often brought aspects of nature into his buildings with his use of natural light, plants, and water. At the Guggenheim Museum, it is thought that a nautilus shell inspired the spiral ramp and that the radial symmetry of a spider web informed the design of the rotunda skylight." Wright's grandson Eric Lloyd Wright, who was his apprentice for the Museum as well, recalls,"...every Sunday at breakfast he'd give us a talk..." And occasionally he would have placed before him a whole bunch of seashells. And he said, "Look here, fellows. This is what nature produces. These shells all are based on the same basic principles, but all of them are different, and they're all created as a function of the interior use of that shell."* [Guggenheim Museums & Foundation, 2009]

Geometry From Nature:

Fig. 30a: Structure of Spider Web

Fig. 30b: Geometry of Web

Fig.30c: Rotunda – Guggenheim Museum

This provides a perfect explanation of the different aesthetics of form, all serving the same purpose. According to the austerity of nature, forms are being generated optimally for the purpose; the variety of the design forms fascinates with its options, made possible through the interplay of geometry in the 2D surface pattern and the 3D shape of the shell. The ethos of these feelings echoes in *"I think the universe is pure geometry - basically, a beautiful shape twisting around and dancing over space-time."*- quoting Antony Garrett Lisi, Physicist [www.brainyquote.com]. Architecture absorbs these beautiful shapes of nature and imbibes them into its spaces and built structure.

ii) Evolution of Architecture – selective periods

Architecture, related to space design, is considered as *"a branch of mathematics that deals with the properties, measurement, and relationship of points, lines, angles, and solids, deduced from the defining conditions by the means of certain assumed properties of space"* [Ching, 2012] Shelter being one of the most primal needs of humans, architecture existed from prehistoric times for the basic need of protection. This literature survey will not go into each period in history, as such a study is too vast for the scope of this thesis. Instead, it will objectively analyse the visual characteristics and distinctiveness that lead to the identity of periods, regions, and movements.

Since prehistoric settlements, built structures follow conical, domical, or cuboidal forms, dependent on the materials for construction. Which later evolved into cuboidal spaces with inclined roofs typical to huts. With plans that remained within rectangles or circles. The linearity of stones shows the interplay of form and sunlight. Stonehenge, 3000 BC, is the most known. The same techniques are seen elsewhere in a similar way.

In the Egyptian period, around the same time, we see a highly developed technique of building gigantic geometric forms. Similarly, the Mesopotamians reflect the rectangular and rectilinear structures using cuboidal mud bricks. During the same timeline, the Mohenjodaro and Harappan cities remain a testimony to structured urban planning with rectangular grid layouts. Similar grids are seen in all semi-urban settlements of the ancient world. Egypt, being a monarchical empire, is reflected in the decorative aspect of buildings.

Geometry in Ancient Cities:

Fig. 31a: Mari, Sumeria
[Reconstruction images: pc reddit.com]

Fig. 31b: Karnak, Egypt

Fig. 31c: Mohenjo Daro, India

With the capitals of columns inspired by natural elements like buds, lotus, or papyrus leaves. The linearity of the natural fauna seems to reflect in the aesthetics of Egypt. The rectilinearity continues and gets enhanced in the Greek period, with the arrangement of building components to accommodate public activities. [Fletcher, 1996] The knowledge of geometry and the great Geometers Greece had, the optical corrections applied to the buildings towards greater visual experience, showed the conscious application of the Golden Section and the Divine proportions on the visual experience of facades, thus giving magnitude to the beauty of Greek buildings.

Art & Architecture - Rectilinearity in Egypt & Curvilinear in Greece:

Fig. 32a: Hieroglyph, Egypt

Fig. 32b: Ramesseum, Egypt

Fig. 32c– Artwork, Greece

Fig. 32d – Erechtheion, Greece

Mathematician Alexey Stakhov, writes *"In the pentagram, the Pythagoreans found all proportions well-known in antiquity: arithmetic, geometric, harmonic, and also the well-known golden proportion, or the golden ratio.... Probably owing to the perfect form and the wealth of mathematical forms, the pentagram was chosen by the Pythagoreans as their secret symbol and a symbol of health. - Alexander Voloshinov"* [Stakhov & Olsen, 2009]

In 1923, Le Corbusier wrote in the article 'Eyes which do not see'- "*The Parthenon is a product of selection applied to a standard."* [Corbusier, 1931] The Parthenon remains an example of the sum of inevitable elements with a harmony achieved in a degree of perfection appreciated with a limited range of sensation or perception. It can be applied in standardization only, based on intellectual action based on mathematical analysis of a higher order. Harmony and beauty thus remain the norms of the universe, governing all. [Gorman, 2003.]

In Greece, the curved motifs emerged in the column capitals, evolving from simple to ornate, over the Doric, Ionic, and Corinthian orders, only to enhance the aesthetics of the buildings over patterns, not in the inherent structure of the buildings. The transition of form from rectilinear to curved ones in the Roman period was an expression of technological development and hence was shorn of much adornment to reveal the geometric beauty of the arcs and vaults. Roman engineering feats are expressed through bold architectural features working on the interrelated geometry of the components of the building. [Fletcher,1996]

Geometry in elements & space -

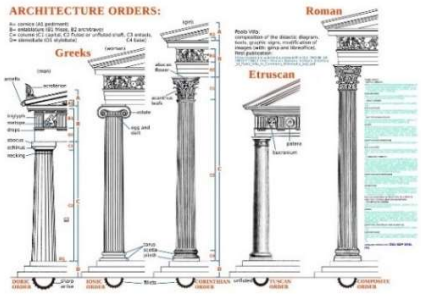


Fig. 33a: Greek & Roman Orders [source : Wikipedia]

Fig. 33b: Greek house [source : Auguste Racinet]

Fig. 33c: Roman house

Vitruvius says that geometry affords much aid to Architects, in the use of right lines and circles, levels, and squares. Geometry assists in addressing the questions on different proportions [Gwilt, 1826]. De Arhitectura, written by Vitruvius, remains the earliest known treatise on Architecture which lays down the canons for aesthetic and technical principles for buildings.

Roman glory magnified into further exploration of structures in terms of scale in the Byzantine era. The juxtaposition of the circle of the dome on the square base introduces the triangular pendentives and reveals the vastness of scale in Hagia Sophia, Constantinople. This period also introduces tessellation patterns of geometric motifs on 2D surfaces. In the subsequent eras Buildings undergo structural changes as well as decorative elements on the surface with intricate motifs and repeats. These are graphically illustrated by Ching in comparing the geometry of the arch. [Ching, 2012]

This brings forth the significant aesthetic changes in a building based on the geometry of its components. A short comparison of a few of the historic eras for architectural changes also brings forward the need to discuss the visual impact of some of the various movements of art and the schools of thought that made a significant impact on Architecture.

The elegance of the decorative arts of the Renaissance, followed by the excessive superfluousness of the Baroque and the Industrial Revolution with its newly invented materials and hence machine-driven designs, naturally paved the way for looking at decorations from a different perspective, leading to the Arts and Crafts movement of the late 18th century. It was a revival of crafts for aesthetics. The belief in craftsmanship, which emphasizes the intrinsic beauty of the material, the significance of nature as inspiration, and the value of simplicity, utility, and beauty are the fundamental characteristics of the Arts and Crafts movement. Victoria& Albert Museum says –*'Arts and Crafts also had a significant impact on architecture.'* [V&A, 2023] As Hermann Muthesius and Henry van de Velde write in 'Statements from the Werkbund Conference of 1914'—*"Standardization of products and products being a platform for stylistic expression was the objective of the German Arts & Crafts movement and the Deutsche Werkbund."* [Gorman, 2003] This standardization of production required geometric intervention as all mass production does. The presence of geometry in art, echoed by Albrecht Durer in his 'Underweysung der Messung', 1525-*"And since geometry is the right foundation of all painting, I have decided to teach its rudiments and principles to all youngsters eager for art."* [Durer & Alberti, 1981]

In a similar timeline, the Art Nouveau movement was as influential in experimenting with the geometry of Architecture.

Fig. 34a: Art & Craft Movement-
Red House, London

Fig. 34b: Art Nouveau
Casa Batllo, Barcelona

Art movements & Visual Geometry:
[pc: Wikimedia Commons]

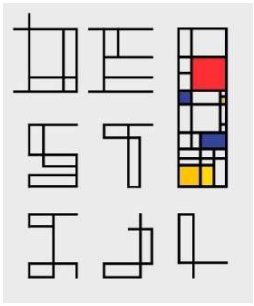
Encyclopaedia Britannica writes –

> *"In architecture and the other plastic arts, the whole of the three-dimensional form becomes engulfed in the organic, linear rhythm, creating a fusion between structure and ornament. Architecture particularly shows this synthesis of ornament and structure; a liberal combination of materials—ironwork, glass, ceramic, and brickwork—was employed, for example, in the creation of unified interiors in which columns and beams became thick vines with spreading tendrils and windows became both openings for light and air and membranous outgrowths of the organic whole. This approach was directly opposed to the traditional architectural values of reason and clarity of structure'.*

Hence the curvilinear forms went hand in hand with rectilinear forms.

Cubism of the early 20th century was moving toward the abstract geometry of forms. Modern architecture has been most influenced by the creative revolution of Picasso and Braque in the early 20th century. The traditional four-wall, single-roof architecture gave way to modernism through the abstract and multi-perspective cubism approach of art, where architects saw structures as various

components rather than a single form. In a similar fashion, the Dutch De Stijl movement influenced Architecture and its forms. Its purpose was *"to highlight the ideal fusion of form and function."* Their polished geometric shapes—such as squares, rectangles, straight lines, and primary colors—created a visual language that later impacted architecture by serving as the impetus for the 1920s and 1930s International Style, also known as Modernism. With no hierarchical room configurations in floor plans and simply independent surfaces that build a space based on the user's duties and requirements, this design approach brought flexibility and change to the field of space. [Saha, 2022]



De Stijl elements & Geometry:

Fig. 35a: Explorations [source: hsedesign.com]

Fig. 35b: Gerrit Rietveld designs. MoMA

Fig. 35c: Schroder House, Utrecht [source: Khan Academy]

When in 1925 Helen Appleton Read writes in her 'The Exposition in Paris' –

> *"As Cezanne said, all forms could be reduced to the cone, the cylinder, and the cube—indicating that all geometric forms and intersections create beauty in terms of that seen in natural organic forms. From the decorative ornamental forms emerges the beauty of geometric designs and elements. The simplicity of outlines emerges from American designs, which summarize that making a design geometric in the best designs makes it easier to adapt to mass production."* [Gorman, 2003]

- it sums up the expression and influence of these movements on design.

To date, Bauhaus remains the most significant and influential school of thought in architecture and Design. In 1919, Walter Gropius writes on 'Statliche Programme in Bauhaus in Weimar'-

> *"Organic forms based on manual skills, without rigidity and freedom of creativity and individuality. Harmony of all elements that become components to building as in architecture. Geometry remained a core component of generating drawing as an expression of Design"* [Gorman, 2003]

While teaching, Paul Klee, at the Bauhaus for 10 years, his lesson from his Pedagogical Sketchbook, a curriculum he designed for his art students there, mentions, *"A drawing is simply a line going for a walk."* - a most simplistic acknowledgment of the geometric element [https://www.paulklee.net, 2023] The influence of all these timelines and periods giving identity to architecture has been comprehensively summed up in the statement of Mies Van Der Rohe, as spoken by him in his conversations: *"Architecture depends on its time. It is the crystallization of its inner structure, the slow unfolding of its form."* [Van der Rohe & Puente, 2008]

The above statements and observations illustrate how significantly geometry played its definitive role in form generation, form transformation, and form realization in the context of Architecture. How it

led to distinctive period identity across historic timelines, which transcended the boundaries of nations and sustained over long stretches of time, leading to a permanent stamp in the history of design. So distinct that it emerged as symbolic of art movements and schools of thought, distinguishing one from the other, with visual appreciation moving across decorative elements to stark structures, from 2D surfaces to 3D spaces, merging the organic to the inorganic.

iii) Architecture and Society

In the study of Architecture, apart from natural and periodic influences, another major contribution to its evolution lies in the socio-cultural parameter that shaped it. As a result, architecture varies from region to region, being different across cultures, bearing the identity symbolic to that culture.

The social connection is expressed precisely by Louis Sullivan *"Once you learn to look at architecture not merely as an art more or less well or more or less badly done, but as a social manifestation, the critical eye becomes clairvoyant."* [Aritter, 2014] Mexican Architect Luis Barragán argues. *"Architecture is an art when one consciously or unconsciously creates aesthetic emotion in the atmosphere and when this environment produces well-being. In fact, one of the principal roles of architecture is to trigger emotions."* [Jacob, 2017] Culture and space are social constructions that are produced via the process of influencing people's self-perceptions. Space is crucial in supporting cultural transformation because the expected patterns of conduct in a given place reflect the specific cultural norms.

Fig. 36a: Charminar, Hyderabad

Fig. 36b: Princep Ghat, Kolkata

Fig. 36c: Connaught Place, Delhi

Spaces & social aesthetics: [source: A Gupta]

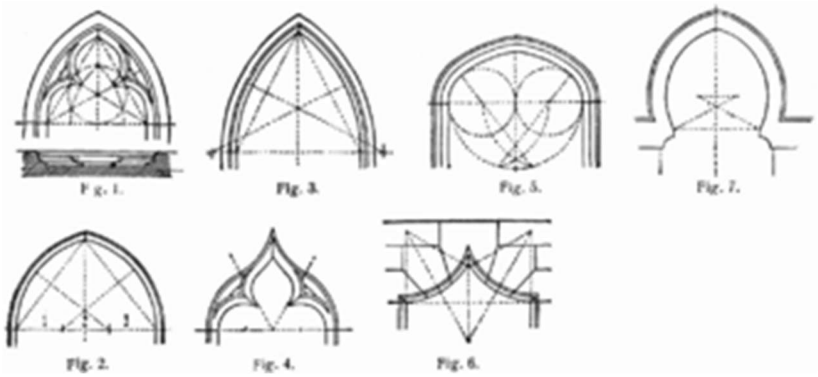
This goes to establish the significance of geometry in culture as an influence on architecture. Corbusier writes in his epoch-making book, 'Towards a New Architecture'—*"Geometry is the language of man... he has discovered rhythms, rhythms apparent to the eye and clear in their relations with one another... They resound in man by an organic inevitability, the same fine inevitability which causes the tracing out of the Golden Section by children, old men, savages, and the learned."* [Corbusier, 1931], illustrating the subconscious knowledge of geometry across ages, time, and societies.

The influence of ethnic settlements on architecture emerging as distinct styles is well known. Such that resulted from cross-border exchanges as well. An example is seen in Kutchh, India, bordering the western sea coast of the Arabian Sea, which promoted trade in earlier times. It encouraged and enabled contact with the outside world more since the interior land barriers prevented ease of

connection with the interiors of the subcontinent. This resulted in infinite combinations of vibrant colours and geometric motifs in various media, illustrating Western and Asian influences as would generate from trade with the coasts of Africa and Central Asian influences. The motifs on the walls show influence from Central Asia's grazing lands and deserts, with a common nomadic society. The geometric patterns are reflected in daily objects in the motifs of quatrefoil or six-petal flowers, diaper patterns, and improvised lozenges, varying in shape from squares to elongated rhombuses. With striking resemblance to patterns on African huts or Babylonian mosaic

Geometry in Cultures: **Fig. 37a:** Painted Hut, Africa [www.pinterest.com] **Fig. 37b:** Mirror work 'Lippan Art', Gujrat [source: Mukherjee & Ghosh,2020]

The application of each number or shape's use in any kind of art or activity depended on both the characteristics and attributes of the shape or number and the activity's numerical and visual elements. As a result, the architectural arts employed and took into consideration shapes and numbers that were consistent with mathematical, geometric, and less tangible aspects of this land's art and culture. Examples of these include the number four, the characteristics of squares and circles, cubes, sphere-shaped volumes, four arches, etc. [Ettehad et al, 2014]



Shapes and numbers: **Fig. 38:** Type of Arches in buildings [source: Wikimedia Commons]

Such is the simplicity of socio-cultural design that adorns the simplicity of geometry and the austerity of resources and shorn extravagance and flamboyance. Quoting Adolf Loos, who writes in 'Ornaments and Crime' (1910), *"The evolution of culture is synonymous with the removal of ornament from objects of daily use...Ornamentation of products is considered with degenerative tendency or digressive by highly productive nations or cultures."* [Loos, 2019]

The same concern is a reflection of Owen Jones's writing in his 'Grammar of Ornament' [1868], saying,

> *"Ornamentation by ethnic societies generate out of natural instinct. Civilized societies generate repetition, which often makes it unimpressive. It is the unity in design with skill and judgment in the application of the art of the East, like India or the Muslim countries like Egypt, Turkey, and Tunisia, that we find ornamentation that is not superfluous. Division and subdivision of lines and the flowing styles are generated from observing nature and the regulation of arrangements in it".* [Jones, 1868]

Reflection of the same can be seen in the structure of pandals of the Durga Puja in Kolkata , India, a UNESCO recognized Intangible Cultural Heritage, where materials, crafts and Geometric properties create ornamented spaces with perfection integrating aesthetics to socio-cultural actions. *"People tend tp remember for long the compositions by virtue of the ordered arrangement of elements into a completely different visual space as also the entropy generated by the movements of visitors"* [Mukherjee & Ghosh, 2020]

Elements & Geometry in place making: Fig. 39: Crafts and Materials in Durga Puja Pandals [source: Mukherjee & Ghosh , 2020]

Christopher Dresser elaborates further in 'Principles of Decorative Design' (1873). According to the Author-

- *Proportion. like the curve, must be of a subtle nature*
- *A principle of Order must prevail in every ornamental composition*
- *The orderly repetition of parts frequently aids in the production of ornamental effects*
- *Alternation is a principle of primary importance in certain ornamental compositions*
- *Elements of nature applied for ornamentation must not be treated imitatively, but to be adopted conventionally or rendered into ornaments"* [Dresser , 1873]

The above views go a long way in reiterating the adoption of simple geometry by ethnic settlements and societies over periods of time to generate the aesthetics in Architecture of communities across settlements and cultures.

2.4.2b Fashion

Coco Chanel said : *"Fashion is not simply a matter of clothes. Fashion is in the air, born upon the wind. One intuits it."* and that it *"is not something that exists in dresses only. Fashion is in the sky, in the street, fashion has to do with ideas, the way we live, what is happening."* [Neel, 2017]

Diane Vreeland, Fashion editor adds - *"Fashion is part of the daily air and it changes all the time, with all the events. You can even see the approaching of a revolution in clothes. You can see and feel everything in clothes."* (Bateman, 2015)

The editorial policy of Fashion Theory: The Journal of Dress, Body & Culture defines *'fashion'* as the *'cultural construction of the embodied identity" which encompasses Haute Couture to street styles*' [Steele, 2012]

According to Miuccia Prada, the legendary Fashion Designer – *'Fashion is Instant Language'* [www.savoirflair.com], one that communicates with the world around.

According to leading constructivist artist Varvara Stepanova, contemporary clothing must be seen in action— that is, in the functional context. The context defines the shape of a dress. *"the mechanical essence"* of human body, and she did it by symbolizing body parts through elementary geometrical figures. "*Fashion is replaced by clothes that can be worn everywhere, which have no independent value and are not an art product,"* she stated.

The French Artist, Alexandra Exter also contrasted 'fashion' with practical everyday dress. *"Modern fashion, which changes at the whim of merchants, must be resisted with clothing that is efficient and beautiful in its simplicity."* [Wallenberg & Kollnitz, 2019]

> *" theories of fashion have focused almost exclusively on why people dress the way they do, while very little has been said about how they ….get dressed in the first place. To put it in other words, the emphasis has been on the communicative aspect of clothes, with a veil of silence thrown over the taken-for-granted spatial practices that underpin the sartorial system."* - Verbeek (2005) makes it clear how we interact with the things we make by stating that *'humans shape things, and things shape humans'* [Valle-Noronha, 2019]

i) Fashion and the Human body

As in Architecture, design works around physical space, Fashion designs around the human body as the space. The designs related to clothing, shoes, jewellery, personal products, lifestyle products, consumer products, all relate to the human body, its proportions or ergonomics. Hence Human body plays the most vital role in determination of forms related to Fashion.

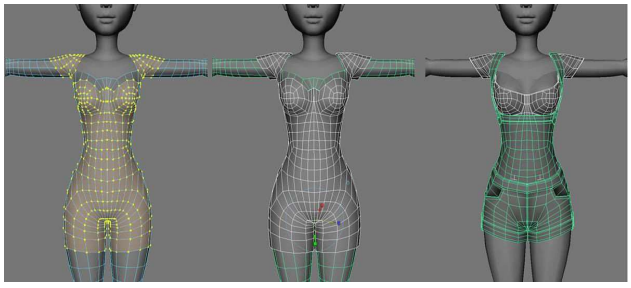
The aristocratic French fashion legend Hubert de Givenchy once said:

"The dress must follow the body of the woman, not the body following the shape of the dress." [Yan, 2018] *"The dress must not hang on the body but follow its lines. When a woman smiles, a dress must smile with her."* – said Madeleine Vionnet, legendary French designer who pioneered the 'bias-cut'.

While the former worked on silhouettes that considered the whole body as a form, the latter worked towards the contours as lines that draped around the form.

"I think our bodies are beautiful, and I think celebrating them and being comfortable in them—no matter what age you are—is important." —says actress Jennifer Aniston on Fashion making beautiful statement on the human body as well as being as functional in its purpose . [Harper's bazaar. 2022] Anthropologist and Linguist Edward Sapir noted with his insight that every new style of clothing draws attention based on the form of the human body. [Sapir. 1931]

Fashion, the word, relates primarily to clothing, which is completely body specific. The form of the human body identifies the way a dress covers or highlights or projects it. Common body shapes that guide the patterns of garments can be broadly classified as hourglass, triangle, inverted triangle, rectangular, tubular, oval, rounded, elliptical, and diamond [Maehren, B., & Meyers, S. (Eds.). 2005]



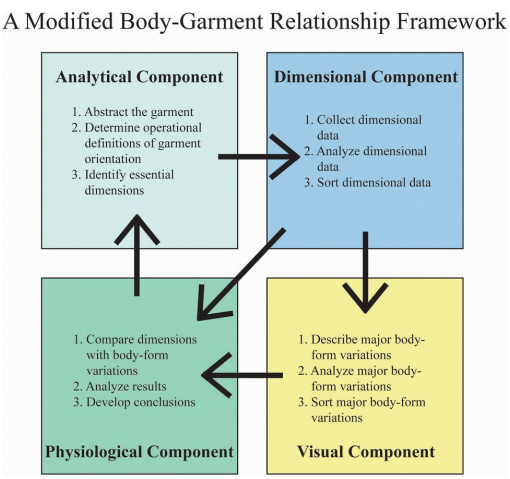
Body form & clothing: **Fig. 40a:** female body structure [www.blogcsdn.net]

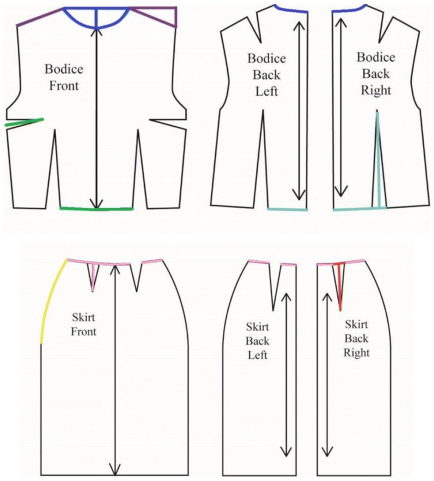
Fig. 40b: Body types [www.mic.com]

This is entirely based on linear measurements, scales, proportions, as well as body configurations and key body components, their inter-relations and postures and actions. Major body components include: the neck, shoulders, back, chest/bust, arms, waist, abdomen, hips, buttocks, and thighs.

This indicates also that sizing standards cannot be generalized across population since study *'findings indicate that even with similar circumference measurements, subjects may still vary in body-form, as linear measurements do not indicate the depth or volume of body features.'* The understanding of designing for a particular body type remains the same as the inherent geometry do not change – as in the pattern making for an hourglass figure would be generally identical for all body types with the same silhouette. Custom clothing being the perfect method of reading the geometric outlines, cannot be applied for mass produced apparels and hence need to be generic based on overall Geometry. (Palmer et al, 2007)

The form generation of a clothing in figure below explains how dimensions relate to body forms to generate visual component and finally the physical prototype. Fig B illustrates how the patterns differ in terms of front and back of a dress, only due to the contour difference in depth of the body while length and breadth remain the same :

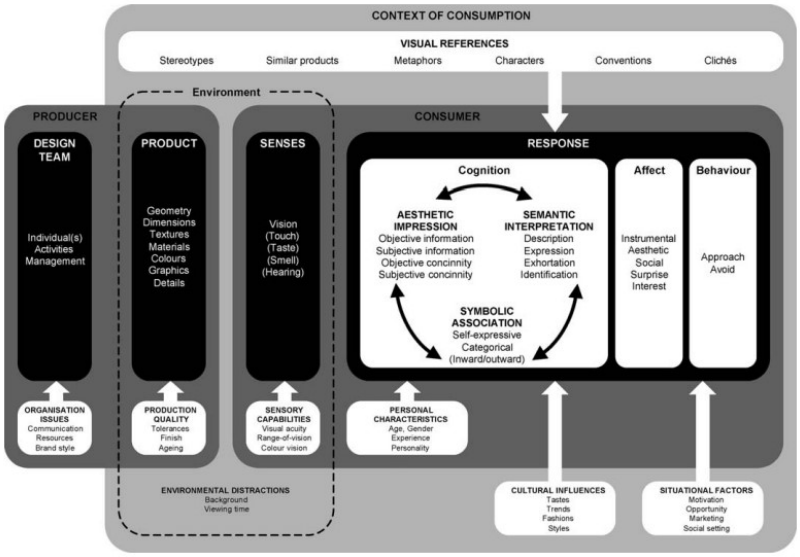




Body structure & garment patterns: **Fig. 41a & b:** Body-garment relation [source:www.researchgate.net]

Contour reduction/enlargement is used towards alignment of the garment to the body's natural contours occurring at the different such as neckline, armhole, side seams, or at the horizontal divisions that occur at the bust, waist and shoulders. The body anatomy remains vital to the identification of major pattern points, which, if moved horizontally or vertically, changes the visual impact of length, breadth, curvature etc in Fashioning a body. Thus defines the visual component in relation to the physical and hence physiological components in generation of form in fashion. [Carufel & Bye , 2020]

Fashion may largely be expressed through clothing, but other articles of human use are equally dependent on body ergonomics. In short, all lifestyle and personal products are geometry-centric in functionalism leading to its aesthetics. The overall design experience of a product is illustrated below. It narrates the visual impact towards physical realization of a designed product based on parameters that starts with Geometry and allied aspects of the product [Karwowski, 2022]



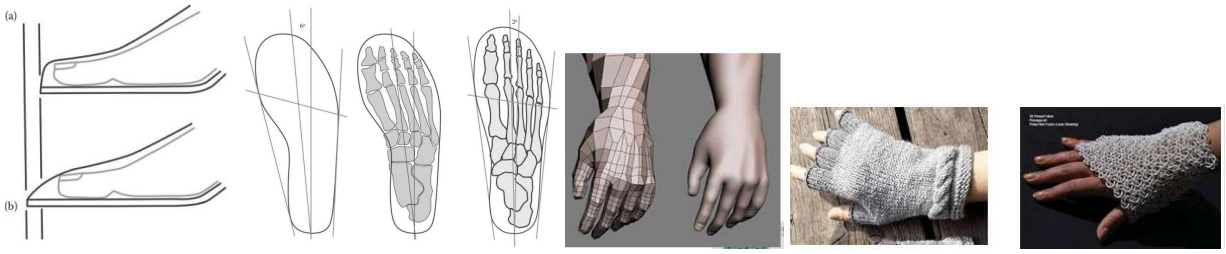
Aesthetic impact of product: **Fig. 42:** Design – response relationship [source: www. sciencedirect.com]

In the context of watches. Coates explains the perception of a product designed in terms of –

a) *Objective information* – from qualities generated out of combination of lines, colours, textures and details that comprise the product's visual form
b) *Subjective information* – based on the consumer's familiarity with other products, entities and concepts influencing aesthetic impression.

It is seen that products deviating from familiar ones brings novelty. It is determined by the radical departure in terms of utilisation of shapes and lines. Similarly Certain lines, proportions, shapes and colours were believed to be inherently attractive [Arnheim, 1992] Many historical forms are based on inherent pleasing proportions like Golden sections as well as strict Geometric Rules [Elam 2011] The Gestalt Theory reflected in the rational design of products from the Bauhaus, in terms of symmetry, regularity, harmony or with emphasis on proximity, similarity, continuity, repetition and closure. All

of this leading to aesthetic balance in the product. [Crilly et al, 2004] A significant example can be considered in shoe design where the health of the feet and functionality is completely aligned with the shape and size of the shoe based on the Geometry of the feet.



Body structure to product: **Fig. 43a & b:** Footwear geometry [source: www.researchgate.net]

Fig. 43c & d: Hand topology & accessory [source: Pinterest / Amazon / Electroloom]

The above properties and process reflects in all fashion and associative products in human lifestyles. The characteristics differ across eras and from region to region. The following sections elaborate on this aspect.

ii) Fashion history - significant periods

Louis XIV in claimed to have famously said - Fashion is the mirror of history – which indeed sums up a historic period recorded by its fashion to reflect the lifestyle of that age. Though clothing indeed is a significant object to identify with fashion, period fashions come along with headgear, bags and footwear as much as makeup and hairstyles. So much so, that in emulating the retro fashion styles, these characteristics are extracted and imitated. The elements generate from the Geometric structure of the forms. Traditional Anthropometry focussing on linear measurements fall inadequate, requiring study of body blocks for garment construction The primitive clothing generated out of animal skin, which being a planar material, would be tied to hold in place. With the advent of fibres such as flax, hemp, wool etc came the process of knotting, knitting and most importantly weaving. While the clothing with knitted and woven textiles generated fabrics in various shapes such as rectangles, ellipse, which could adapt to the shape of the wearer and change size according to body form, the introduction of tailored clothing, with its detachable components followed the contours of the body such as flat or round collars, or voluminous hip pants. It is believed that the division of clothes possibly a development on the knightly armour with its parts. The volume and shapes played an integral role in regulation of the individual parts of the body. [Caroufel & Bye, 2020]

As Lou Taylor identifies, a clothing retains its date within its flounces, pleats folds and other components, with overlaps and transitions between the styles. It is the techniques, garment styles and period illustrations that help in identifying the garment to a period or region. An observation that leads to distinguishing a Thai garment from being labelled as Burmese or Siamese. [Taylor 2002].

Garment & regional identity : **Fig. 44a:** Thai garment [source: Wikipedia]

Fig. 44b: Burmese garment

Travelling across various eras in history, one finds a remarkable identity of Fashion with its community or region. This reflects in their garments as much as the surroundings and the artefacts. In ancient Egypt, the body of the Egyptians were tall and slender, with powerful shoulders and narrow hips, slender hands and wiry legs, besides a large head. [Racinet, (1888) 2009] the common garment was a tubular tunic generated from a single rectangular piece of fabric, folded into parts and sewn at the edges, with cutting and shaping not adapted to. It was the natural fall of the material that was used, primarily linen. As because the Egyptian art shows idealization of the proportions of the body, clothes followed the contour of the body blocks with elegant clothing which retained linearity as in skirts, kilts, loin cloths, robes as well as straight hair or wigs, compounded with linear tall headdresses. [Steele, 2005] The Graeco Roman periods to follow, shifted to draped garments, mostly unstitched and with ties. The same fabric could be used as a garment, shroud or blanket [https://www.moma.org], converting a 2D plane into a 3D form.

The research and studies by the Fashion Institute of Technology, New York, One of the most prestigious institutes of Fashion, illustrate the changes in Fashion across time periods which can be chronologically stated: *"Clothing during the Byzantine era was strictly regulated based on identity, status, rank, and gender"* This reflected in the form of the tunic or robes which varied in length, being shorter for the men. From The tunics named differently as chiton, himation etc for their visual form and identity or the semi-circular robes evolving into the Kaftans under Persian Influence, worked on the basic folds of the fabric and its drapes to generate the flowing structure. The headgear added to lengthen the form. [Lattanzio, 2018] The 14th century sees a transition to the garments fitting the figure for women, with fitted sleeves up to the knuckles, while the men also wore fitted short length shirts with breeches and headgears became more tall and pointed to add length to the human figure. While the men also are seen with voluminous topwear in contrast with fitted bottoms [Font, 2018]

In the mid 16th century one sees the early introduction of the conical corset style fitted upper garment paired with a voluminous lower part of gowns. The headgears are now flattened. Regular silhouettes

are adopted in menswear. In the 19th century the same gowns adopt a bell shaped and fuller structure following the form of the human body. And the men would wear clothing matching the body form and coats were square cut. [Font, 2018] The 20th century saw the entry of the garment matching the body outlines and shaped to its contours, with the adaptation of the bias cut for fluidity in body-skimming garments. This was simultaneously countered with precisely tailored outfits along the body outlines and curves. [Reddy, 2018] Eventually the formality of opulent wears was superseded by the informality of daily workwear.

Fig. 45a: 16th Century

Fig. 45b: 20th Century

Fashion & body:
[source: FIT NYC]

Although the evolution of Fashion has more study in the European regions, the Asian settlements are as much noteworthy. The Japanese clothing simplified from the 12 layered junihitoe with vibrant patterns to the simpler Kimono which has drawn the attention of designers across. [https://textilevaluechain.in, 2021] In India, with the invention of textile weaving in the ancient eras, generated the finest of fabrics. Thus, Indian sub-continent shows evolution of the properties of the unstitched 6 m cloth which can be draped in hundreds of alternative ways adopted across regions. The male counterpart being the dhoti, smaller in length but equally adaptive to the draping in multiple ways. The Gandhara school of Art records the fine draping generating the lines and contours of the garments. The technique of using length of fabric is also seen in the upper wear as in shawls or chunris, or in the designs of folding into turbans,[https://smarthistory.org/, 2019] This clearly illustrates the possibility of generating forms from one planar material by using folds around the form of a human body.

Fig. 46a: Sari draping
[source: Wikipedia]

Fig. 46b: Turban folding
[source: Racinet]

Folding fabric in different ways:

Geometric shapes have always played their major role in forming of garments. Rectangular pieces of cloth being folded and / or joined to cover the body or form a garment was the practice in the Graeco- Roman Period [http://www.historyofclothing.com/ 2020] While the pleated skirts of Egypt bore its linearity, Mesopotamian motifs were primarily geometric. In the Greek period one sees the patterns from natural elements in repeats, circles and stripes. Unlike the rectangular piece of fabric used by Greeks for their draped Himation, the Roman Toga was draped out of a segment of a circle with a chord length of 5.5 meter and widest length being the same too. In the native American and Mayan cultures, the geometric motifs emerge out of the weaving. In Arab culture, a square piece of fabric is used and folded in triangle, to prepare the headdress which is so placed to allow the 3 vertices around the neckline. From Byzantine to Medieval periods, rich textiles developed based on Geometric motifs. The later periods saw the experimentation with forms of skirts, hats,, necklines. breeches, varying from full and voluminous to bell shaped, conical, pyramidal, horseshoe shaped etc. [Encyl. Brit.]

The Chinese Fashion evolved on linear clothing loosely fitted to the body with plain fabric look [https://www.historic-shanghai.com, 2021]. According to Yang Ming, square and circular forms of decoration are prevalent with cultural meanings in Chinese costumes. [Zhu & Yue, 2018] In contrast to with 'Square' being the masculine element with its continuous straight lines and less detail, supported with bold colour and stiff fabrics, the 'Circle' represented the feminine aspect, with aesthetic contours and curves, soft discontinuous lines, with less colour contrast and soft light fabrics. [Zhu & Yue, 2018] The round sleeves represent 'spherical heavens' while the square neck is symbolic of the 'square earth'. Geometric shapes were vital to Chinese garments with lapel crossing based on Yin and Yang. [https://en.wikipedia.org]

Symbolism of Chinese Collars : **Fig. 47a:** Square [source: Wikipedia]

Fig. 47b: Circle [by Anagoria- own work]

Fig. 47c: Yin & Yang [gifted by MoMa]

The above timelines and styles illustrate how Geometric were integrated i form generation, of clothing and accessories and their components w.r.t Fashion. It shows how Fashion imbibed the identity in cultures and distinguished one from another, from one era to the other, and emerged as styles characteristic of its history. It goes to show how exploration was done with 2D shapes and materials in generating 3D objects in multiple ways, each creating distinct aesthetic elements which have retained their exclusivity across time periods.

That Fashion and Form exist with specific intent across cultures and periods can be summed up in the words of Valerie Steele - American fashion historian, curator, and director of the Museum at the Fashion Institute of Technology, and a pioneer in Fashion History -

> *"Fashion is a part of the world and part of history. It's not a meaningless swirl of meaningless clothes. They (clothes) reflect the times'* [https://www.museumofclothing.org/ 2022]

iii) Fashion and Cultural Identity

"Fashion is only the attempt to realize art in living forms and social intercourse." — Sir Francis Bacon [Jen, 2014]

"The chief difficulty of understanding fashion in its apparent vagaries is the lack of exact knowledge of the unconscious symbolisms attaching to forms, colours, textures, postures and other expressive elements in a given culture. The difficulty is appreciably increased by the fact that the same expressive elements tend to have quite different symbolic references in different areas." [Sapir, 1931]

In historical dress research, clothing is examined in the socio-cultural and historical context. The structure of the garments become properly fused into the respective cultural and economic setting [Taylor 2002] Fashion and clothing reflect the society and its norms, likings and mindsets. In Assyrian culture and its diktats, harsh and cruel treatment against Women, possibly introduced the veil, to maintain the piety. However merely 800 miles away the Egyptian culture were lenient on women, who even exerted their authority. Hence the hairstyles that often enlarged into nearly pyramidal shapes, a triangular form that reflected into their headdresses, for both sexes.

Identity of Women in Ancient culture :

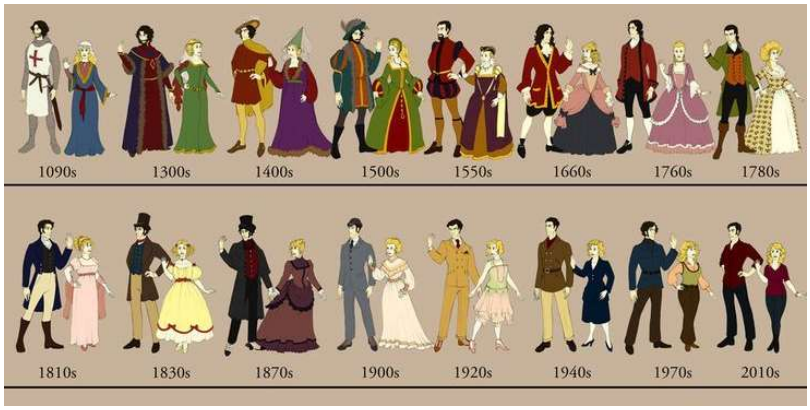
Fig. 48a: Egyptian Queen with crown [source: National Geographic]

Fig. 48b: Assyrian woman in veil [source: Getty images]

The Egyptian obsession with lines reflects in their slender figures. The same triangular form transcends into hats, turbans, berets or pointed caps of the Cretan women. Measurements pertaining to the length of the body played immense role for the Greeks. While Nudity was viewed with respect by Greeks in appreciating perfectly toned bodies and silhouettes in social events and sports, the nearby Persians was in horror of the same and thus fully clothed. [Batterberry, 1982] The role of the social changes reflect in the European fashion from the medieval period till the 19th century as is seen in the prominent headgears. From hoods framing the face, one sees the elaborate coiffures, wimples, hats with veils etc., each in its own way highlighting the head part of the body and creating

visual forms. The same can be seen in creating silhouettes by use of corsets, hoop skirts and baskets or paniers, changing shape from round to oval, to create slender torso and small waist. [Encycl. Brit.]

Jennifer Thao writes on culture playing a key role in one's identity. Culture reflects a way of life shared with a group made up of certain values and norms. [Gupta,2015] With approximately over 3000 cultures in the world [Foley & Lahr, 2011], each one impacting the identity of the group, Clothing is a reflection of a culture as seen through details in the community and one way that the people wish to express themselves [Thao, 2021]. The relation between social classes and lifestyle groups and the art and design that reflect in their communities is neither static nor monolithic. Fashion and clothing are probably the most obvious areas whose different styles, colours, cuts, textures and fabrics are used to construct and communicate these social and cultural identities. The Gentleman's lounge suit, developed in the 19th Century from the earlier Frock Coat is an example of use of a garment in different forms by different cultural groups. The geometric structure of the suit went for transformation in the quest of cultural and social identity. The Zoot suit with its wide flare is a further example of such an identity by the same garment. [Bernard, 1998] Graphic design, Fashion and textiles, Industrial Design were used to change social order. The visual culture of the society thus reflected through the Suprematist and Constructivist designs that continued until late 1920's, when Geometric Design became suspect politically. [Gorman, 2003]



Transformation of garment styles over 200 yrs : **Fig. 49:** Change in garment shapes over eras [source: Pinterest]

In ethnic societies the influence of Geometry and geometric patterns manifest more predominantly. In his research in the Kutchh region of Western India, Christopher London cites an interesting study. Kutchh retains its culture of both the courts that ruled in the princely state for 400 years, a legacy of the rich and powerful, as also that of the nomads, who were the inhabitants of the soil. Between later 12th – 20th Century, The region exhibited a fascinating manifestation of a cross culturally inspired designs and patterns. While the sea coast location encouraged and enabled contact with the outside world, the interior land barriers prevented easy contact with the interiors of the subcontinent. The geometric patterns and motifs demonstrate that a diffusion of cultures happened- derived from trading with the coasts of Africa and the interiors of Asia, or brought to Kutchh by its nomadic,

ethnic and indigenous populations.. The diaper patterns, lozenge shapes, squarish to elongated diamonds and rhombus used to form the quatrefoil and six petal flowers visible in the wall paintings, the embroidery motifs or the containers of the Rabari or Meghval tribes and craftsmen are strikingly similar to African textiles. [London, 2000] These motifs generating from square based Geometric pattern, rhythmic repeats are seen in textiles across different tribes, in their weaves , embroideries and patterns, where ethnomathematics emerge as an expression of cultures, strikingly different from tribe to tribe. [Fouz & Amit, 2020] From the Bedouins to the Bontoc tribes, this reflects in the fashion of traditional clothing and bear striking resemblance to the Kutchh motifs. [Gayagay, 2021]

Fig.50a: Rabari India

Fig. 50b: Bedouin Kuwait

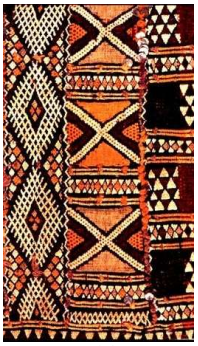


Fig. 50c: Tribal Africa

Ethnomathematics in Tribal Textiles: [source: Pinterest / WIPO]

The above evolution of fashion exemplifies the conscious and sub-conscious application and integration of Geometric principles based on the human body as a form and to create an ethnic identity for communities and eras. The study will now focus on the inherent aspect in design which controls its aesthetic appreciation – the mathematics and perception of the Divine Proportions and understood as Sacred Geometry owing to its intriguing recurrence in objects both natural and man made. surroundings

2.4.3 Parameterization on Geometry in Design

The above elaborations on Geometry in the context of Design may be summarised into a table of aspects that can be used to identify as the attributes determining the reason of perception of visual forms in Architecture and Fashion through their respective inherent geometry.

Table 3– Parameters on Design

SL	AUTHOR	CONTEXT	PARAMETERS - KEY ASPECTS
1	**Barry Rodgers**	Design practice	Multi disciplinarity
2	**Charles Eames**	Purpose of design	Aesthetics, arrangement of elements for a purpose
3	**Oxford Dictionary Merriam- webster**	definition	Create for a purpose, drawings

2.4.3a) Parameterization on Geometry in Architecture

The discussions on Architecture in the realm of Design may be summarised into a table of aspects that can be used to identify as the attributes determining the reason of perception of visual forms. Identifying the factors guiding perception in forms can be indicative of the parameters determining the identification of Geometry within Design.

Table 4 – Parameters on Geometry in Design: Architecture

SL	AUTHOR	CONTEXT	PARAMETERS - KEY ASPECTS
1	**Encyclopedia Britannica**	Design of buildings Art Nouveau	Purpose and aesthetics 3D Form in organic, Linear rhythm, structure and ornament, curvilinear form with rectilinear ones
2	**Alvaro Siza**	Architecture to products	Geometry is integral
3	**Marcus Vitruvius**	Building or object	Structurally sound, functional, beautiful
4	**Paul Rudolph**	Design	Elements, Possible Art
5	**Charles Moore and Kent Bloomer**	Specialized system	2 D diagram to 3 D experience
6	**Frank Lloyd Wright**	Imagination over materials, methods and the human aspect Organic Architecture	Geometric pattern in human world society, order Strength and elements from nature, spirals, symmetry, different exterior design on basic principle of use, geometry of 2D surfaces on 3D forms
7	**Christele Harrouk**	Architectural realm	Artistic and rational cosmos
8	**Le Corbusier**	Function and objects	Order
9	**Charles Eames**	Design	Arranging elements for a purpose
10	**Mies Van der Rohe**	Architecture as a whole	Interlinked structure and form Translated into space
11	**Louis Kahn**	Design of building	Measurable act, unmeasurable in thinking
12	**Alvar Aalto**	Form	Must have Content, linked to nature
13	**Antoni Gaudi**	Art and form	generating from nature, forms, texture, free expressive forms, complex geometry, natural lines and corners
14	**sustainable architecture**	Biomimetic or biomorphic	adapting natural objects and organisms in functioning and mechanism
15	**Antony Garett Lisi**	Beauty of nature	Pure geometry of Universe, shapes around space-time
16	**Boulos**	Pre-historic settlements	conical, cuboidal, domical forms, rectangular and circular plans
17	**Ching**	Space design Elements on surface	Mathematics of properties and measures of point, line, angles, solids, intricate motifs and repeats
18	**Fletcher**	Different era and settlements	Monumental scale, rectangular and rectilinear structures, grid layouts, decorative elements inspired from natural forms, arrangement of building elements, optical corrections, golden section, divine proportions, transition of rectilinear to curved forms, simple technical structures over decorative facades, inter-related geometry of elements
19	**Alexander Voloshinov**	Pentagram	Proportions - arithmetic, geometric, harmonic- mathematical forms
20	**Le corbusier**	aesthetics of building w.r.t Parthenon New Architecture	standardization, mathematics of higher order, Harmony in beauty govern beauty Rhythms, apparent to eye and relation to each, perception of golden section
21	**Vitruvius**	geometry as tool	right line,circle, level squares, proportions
22	**Palmer**	Structure	Scale, tessellation, juxtaposition of cit=rcle on square, motifs,repeats
23	**University of Maryland**	Arts & crafts movement	crafting from materials, Simplicity, utility and beauty
24	**Herman Muthesius & Henry Van de Velde**	Werkbund Conference1914	Standardization of products for stylistic expression, geometry integral
25	**Albrecht Durer**	Art	Principles and rules of Geometry in paintings
26	**Saha**	Cubism De Stijl	
27	**Helen Appleton Reed**	Forms	beauty from natural forms, geometric designs and element, geometry in design for character and mass production
28	**Walter Gropius**	Statliche Programme, Bauhaus	Organic forms, rigidity and freedom, geometry core to expression of design
29	**Paul klee**	Painting and Geometry	Line in drawing

30	**Mies Vn Dder Rohe**	Timelines and periods	identity based on form out of structure
31	**Louis Sullivan**	Social aspect	Expression of Society
32	**Luis Barragan**	emotion of form	Elements trigger emotions, Individual perc eption
33	**Ettihad et al**	Space and culture	behavior pattern and features
34	**Diba 1999**		shapes, numbers numerical and visual features to properties of shape to numbers square & circle characteristics, characteriustc bb
35	**Kutcc**	Motifs in traditional crafts	exchange across cultures, geometric patterns, shapes from squares to rhombus, patterns in mosaics
36	**Adolf Loos**	Ornamentation of products	simple features of objects of use
37	**Owen Jones**	Ornamentation of designs	Integral through elements, repeats, division of lines, influence of nature and regulation of itsarrangemen\ts
38	**Christopher Dresser**	decorative design	Subtle principles, order, repetition of parts, alternation, elements of nature adapted

2.4.3b) Parameterization on Geometry in Fashion

The above deliberations on Geometry in the context of Fashion is now tabulated on aspects that can be used to identify the attributes that determine application in design. Identifying these attributes guiding geometry in Fashion will lead to the parameters that identify Geometry within Design.

Table 5 – Parameters on Geometry in Design: Fashion

SL	AUTHOR	CONTEXT	PARAMETERS - KEY ASPECTS
1	**Fibre2fashion**	Design	Art
2	**Christene Barberich**	Definition	Art, Commerce, function, expression
3	**Kawamura**	Facia, Latin source	To make or shape
4	**Andy Warhol**	Definition	More art in form
5	**Oxford dictionary**	Definition	make into form
6	**Stella Blum**	Defining	Altering appearance, add to natural physical form, reflect socio-cultural pattern
7	**Coco Chanel**	Existence of Fashion	Ideas, way of living and world around
8	**Diane Vreeland**	Expression	reflects time, indicates Change, action
9	**Varvara Stepanova**	Clothing	In action, context and shape, mechanical sequence of human body, body parts to geometric figures
10	**Alexander Exter**	Modern Fashion	Clothing that is efficiency, practical, beautifully simple
11	**Cwerner**	Dressing humans	creating the dress for the body
12	**Verbeek**	Creating dress	Shaping humans
13	**Fashion Theory journal**	Defining	Constructing identity of culture
14	**Miuccia Prada**	Instant language	Communicates with surroundings
15	**Hubert de Givenchy**	creating dress	Body shape to guide shape of garment, whole body as form
16	**Madeleine Vionnet**	Dress to adapt to body	Lines and contours
17	**Jennifer Aniston**	On Fashion	Beauty of body, comfort
18	**Edward Sapir**	New style Fashion and symbolism	Form of Human body Form, colour, texture, posture, expression
19	**Maehren & Meyers**	Common body shapes	Hourglass, triangle, Inverted triangle, rectangular, tubular, oval, round, elliptical, diamond
20	**Palmer & Alto**	Body shapes	Linear measurement s, scale, proportion, configuration and components of body, postures, actions, variance, voplume, features, geometry basis of patterns,
21	**Lamport**	Contours	contour difference, reduction / enlargement based on body components, axial movement of points, impact on visual form
22	**Wldemar et al**	Ergonomics	Geometry centric functionalism, parameters from Geometry
23	**Arnheim**	perception	combination of lines, textures, details, shapes, proportions define aesthetics
24	**Elam**	Golden section	proportions to please
25	**Crilly et al**	Gestalt principles	Aesthetic balance

26	**Caroufel**	Fashion styles	Elements from Geometric structure, Anthropometry focussed on linear measures, body blocks
27	**Aishwarya**	Primitive clothing	Planar materials
28	**Shikorovich**	Clothing components	Techniques generating shapes - rectangles, ellipse, flat and round collars, volume of hip,
29	**Racinet**	Regional identity	Clothes following body shape of the region, slenderness height etc
30	**Ebeid**	Constructing dresses	planar material to form
31	**Canadian**	Clothing in Egypt	Proportion of
32	**MOMA**	Draped garments	converting 2D form to 3D by folding
33	**Lou Taylor**	Clothing features	identity by folds pleats, overlaps and translation
34	**Lattanzio**	identity of clothing	basic fold and drape
35	**Lourdes Font**	14th Century clothing	Fitted to human figure
36	**Justin de Young**	16th Century clothing	fitted upper, voluminous lower part, conical, bell shape, square cuts
37	**Karina Redy**	fitted forms	body outlines, bias cut to fit curves
38	**Historyofclothing.com**	shapes of clothing	Geometric shapes, Rectangles to forms
39	**Encyclopedia Britannica**	Geometry of clothing Social change on Fashion	Linearity, motifs and patterns, draped from rectangles and squares, measures based on body units, bell shaped, conical, pyramidal, horseshoe shaped Change in headgear forms, corsets, skirts, shapes from pyramid, round, oval, visual slenderness
40	**textilevaluechain.in**	Japanese clothing	Layers as per body
41	**smarthistory.org**	Indian textile	measured cloth to fold in drapes for different forms for different body parts, lines generated
42	**history-shanghai.com**	Chinese fashion	Linera clothing loosely draped
43	**Yang & Sun**	Shapes	squares and circles with cultural meaning
44	**Zhang**	Geometric shapes	Squares masculine,straight lines, circles feminine, curved lines, symbolic
45	**Valerie Steele**	Fashion in History	Symbol of era
46	**Sir Francis Bacon**	Fashion	Expression of art
48	**Taylor**	History of Fashion	structure of Clothing based on culture and economy
49	**Batterberry**	Societal norms	Visual form reflect social system, tall headdresses, linearity, triangular headgear, body measurements and body contours
50	**Jennifer Thao**	Culture and Fashion	Identity with clothing, details of expression
51	**Bernard**	Clothing and Fashion	Colour, cut, texture, construction for identity, geometric transformation of suit
52	**C Gorman**	Geometry and society	Graphic design, Textile, Industrial design as change of society, Geometry interlinked with Political order
53	**Christopher London**	Design in Kuchh	Geometric patterns reflect cultural contrast, diamonds, diaper pattern, shapes from flowers, square based pattern, rhythmic repeats

The above aspects emerging from the various literature sources generate cognizance towards the way a form is created, appreciated and adapted for the human space, in body and physical surroundings. The elements and principles which generate the form, also guide the aesthetic appreciation and the human mind can read the visual form by gauging its proportions. While the elements are absolute in existence and repeated in multiple ways, the creative action goes from imagination to realization, so as to emerge as the desired outline to be seen, or understood in the manner the elements trigger response of the viewer within inherent proportions. It establishes that a certain Geometry within a form leads to its development, understanding and utility as a physical prototype. It leads to decision making in Design.

As J.G. Ellinwood lists Design as a 'Tangible visual solution'- while in Fashion, Structural Design contributes to aesthetics and function, conceived for the body as an environment, for Architecture, Structure is self supporting, conceived as an environment for the body. Folkmann says :

> *"Beauty has for a long time been affiliated with aesthetics in general and therefore also with design aesthetics. Function is a rather new and more design-specific concept in relation to aesthetics. Both concepts put emphasis on qualities of the design solutions in question, even if the actual evaluation of these qualities always is dependent of individual perception."* [Folkmann, 2023]

Annina Schneller writes

> *'In this cornucopia of things that provoke aesthetic experiences in our daily life, design is special because it deliberately and purposefully does so and because of its special form-giving skills.'* [Schneller 2018]

In the context of Design, it can be derived thus that in generating the aesthetics vis-à-vis the functionality of a product and its experience, depends largely on how it is defined and eventually realized through Geometric principles out of the above observations, based on cultural perception. The parameters emerging can be largely categorized in four aspects –

a) *Structural form*
b) *Functionality of purpose*
c) *Aesthetic identity*
d) *Proportion and cognition*

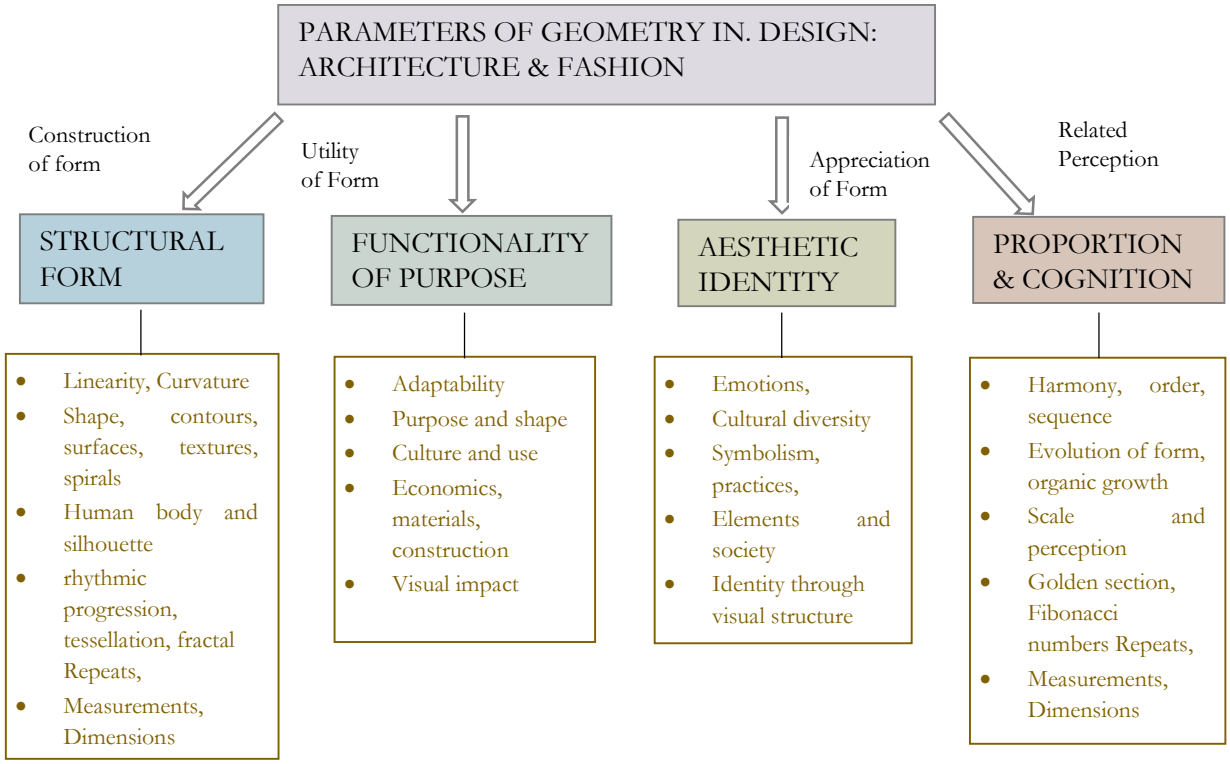


Fig 51: Parameters of Geometry in Design: Architecture & Fashion [pc: Author]

The literature survey on Geometry in Design elaborates on the complex inter relationship of these four aspects towards the visual experience of Design based on Geometric elements triggering cues. The various parameters and sub-parameters will need to be analysed in broader perspective to link these to the Thesis.

2.5 Inference

The elaborate Literature survey was conducted towards identifying development and visual appreciation of form, in the context of Geometry and its principles being catalytic to the experience, dependent on the sublime inter-relationship of Architecture and Fashion

Based on the observations and learnings of the survey as conducted, the subsequent discussion will now focus on –

- *Common perspectives of Design generation in Architecture and Fashion*
- *Interdependency of Architecture and Fashion*
- *Gap identification perception of Geometry in Architecture and Fashion*
- *Summarizing the parameters*

2.5.1 Common perspectives of Design generation in Architecture and Fashion

Design in either of the above directions being discussed in this Thesis, Architecture and Fashion, is explicit in their parity with each other and consonance, in terms of ideation, expression and realization. According to Vitruvius, *"no building can be said to be well designed which wants symmetry and proportion. In truth they are as necessary to the beauty of a building as to that of a well formed human figure, which nature has so fashioned"* [Gwilt 1826], which sums up the aesthetic relation of Architecture with fashioning the human body, possibly in terms of his 'Venustas'.

Architecture has been a great influence on Fashion forms, while Fashion has influenced Architecture in terms of its details and surface elements. They have much parallel which often erases the thin line demarcating separation of the two design fields. We see many an Architect shifting career into Fashion and many a Designer becoming an Architect. The ease of this transition is well established in their own words.

2.5.1a) Architects who ventured into Fashion speaks –

Ar. Oscar Neimeyer says *"I am not attracted to straight angles or to the straight line, hard and inflexible, created by man. I am attracted to free-flowing, sensual curves."* [RTF.com] Pritzker Prize-winning architect Toyo Ito says *"But I have always intended to design architecture to look more beautiful with humans present."* He adds: *"When I think about architecture, I think of it as a piece of clothing that must be wrapped around human beings."* [Hobson, 2014]. Zaha Hadid, the only Female awardee of the same prestigious award and the most famous Woman Architect of the century, known for the fluidity in her designs says in an interview to Simon Hattenstone *"There are 360 degrees, so why stick to one?"* [Hattenstone, 2003]. She states *"Architecture is how the person places herself in the space. Fashion is about how you place the object on the person."* She speaks on her philosophy in this interview for Vogue adding *"In a sense, I'm into fashion because it contains the mood of the day, of the moment—like music, literature, and art."* [McCready, 2011]

2.5.1b) Designers with Architecture background speaks –

For those with an Architectural learning and later shift to the world of fashion, Architecture remains an inherently strong influence which distinguishes their styles.

The French Couturier, Pierre Balmain initially studied Architecture at the École des Beaux-Arts in 1933, before being attracted to Haute Couture. according to him *"Dressmaking is the Architecture of movement",* as spoken to Elle magazine.[Encyc. Brit.] Architectural form and design thinking, influenced his vision of the dress as construction, as in creation of buildings themselves, offering form, function and beauty. In the post war period he continued to challenge the boundaries of glamorous and classical fashion, proclaiming dressmaking to offer fluidity for it is kinetic architecture of the body.[Leete 2022]. The renowned Fashion Designer Pierre Cardin, his architectural education remained a strong influence on his designs. The avant-garde, space-age designs he was renowned for—such as bubble dresses, the worldwide fad he started in 1954—put the emphasis on clothes as bodily architecture as opposed to just pieces of fabric. Like a classic architect, his designs focus more on geometry than on the female form. [Rodgers, 2017]

For the iconic designer and filmmaker Tom Ford, Ford. *"Fashion is everything. Art, music, furniture design, graphic design, hair, makeup, architecture, ……-all those things go together to make a moment in time, ……."* [Luscombe, 2001] While studying architecture in the Parsons school of Design….' at NY and Paris, he' [Shamussico, 2015]. The Sudanese Designer Omar Asim's architectural and diverse background is most visible in his elegant, minimalist designs. with garments revealing a preoccupation with structure, keen to make the connect of his work to architecture. Similarly, the Brazilian Architect turned Designer Gustav Lins started his application on pattern making, moving on to overlap architecture and fashion in his designs, drapery and fluid cuts emphasising of structure to his aesthetic. Lins spoke to Creative Mapping about the interplay between the two disciplines in his work, largely influenced by Japanese architecture, especially tatami, floor mats [Atkinson, 2016]

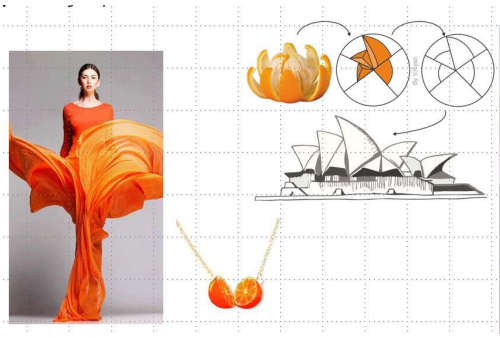
Thus, the understanding of the experts of the two streams can be summed up in the statement of the Architect turned fashion designer, the late creative director of Louis Vuitton, Virgil Abloh, who said *"The whole point of collaboration is that you give and take from each other, and that's how you create things that are totally new."*[https://theartgorgeous.com/2021] Virgil was known for Establishing bridges between different professions and creating *"pathways for greater equality in art and design"* [Harrouk 2021] *"pathways for greater equality in art and design"* with a Masters in Architecture from the Illinois Institute of Technology before transitioning into the world of fashion design, inspired by the work of the Bauhaus movement, converging elements of art, craft and design into one practice.[Leete, 2022] His collection of concrete furniture for Galerie Kreo in Pariswas described as "a landscape where the rigidity of structures and urban planning meets the randomness of organic growth, human

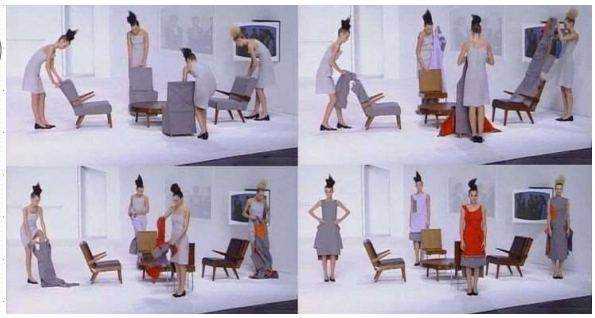
appropriation, and mark-making." [Kieghran & Nielson, 2021] He had said *"I made a brand to sort of investigate architecture in a way."* as he didn't *"believe in disciplines"*. It is this approach towards collaboration and going without boundaries, that eases the transition of one stream of Design into the other.

2.5.2 Interdependency of Architecture and Fashion

In terms of form generation and development of creative concept in Design, the concerned directions of this Thesis, Architecture and Fashion, illustrate similarity of design process influencing each other and also diverse approaches specific to retain individual characteristic of the domain. Garments and buildings protect and provide shelter to the human body, expressing as a socio-cultural identity [architectureandfashion.wordpress.com, 2011].

Fashion and architecture are completely different and independent from each other. While one is about to building space for human action, the other one is to build for the human body. Although they have completely different type of materials construction, techniques, and even function; but they meet in the concept of design. The two fields are connected in Form, Materials and Design process. [Farahat, 2014]. The objective of both domains remain to provide Shelter –while clothing is termed as the "second skin" which covers and shields the human body from the external elements and also serve as an aesthetic function, buildings are named as the "third skin" which serves the same protective and aesthetic functions on a larger scale, both creating with regard to the human body and its private environment. [Lubczynski. 2014].





Form generation based on Geometry :

Fig. 52a: Orange inspired Sydney Opera House by Jorn Utzon, Gown & Jewellery [source: Pinterest]

Fig. 52b: Convertible Fashion by Hussein Chalayan [source: Wordpress.com]

As Zaha Hadid said :

> *" Both architecture and fashion are based on structure and shape and turning basic necessities (like clothing and shelter) into art) "* [Farahat, 2014]..

While the realization of form in both Fashion and Architecture emerges as a culmination of Art, Science and Technology, in this Thesis we focus on the Art and Aesthetics aspect.

> '*Art is a human activity consisting in this, that one man consciously, by means of certain external signs, hands on to others feelings he has lived through, and that other people are infected by these feelings and also experience them'.* [Tolstoy, 1995]

These created forms, buildings or clothing, thus communicate emotionally with the user and the viewer, influencing reactions. The visual perception of the form thus influences reaction to the creation

Interdependency: **Fig 53a:** Zaha Hadid Fashion Inspired Building: ThyssenKrupp-building [source: Researchgate]

Fig 53b: Notre Dame Inspired Fashion : Dolce & Gabbana Dress [source: Mymodernmet.com]

The following section enlists, as derived from the previous study, the areas where the two domains overlap or digress from each other yet continue to influence form generation in similar manner.

a) Convergent areas –

1. Satisfy purpose w.r.t human body and movement
2. Exploration of space, volume
3. Symbolic of social practices and changes
4. Aesthetic pleasure

b) Divergent areas –

1. Materials and structure
2. Size and scale
3. Lifespan
4. Technology and effects

The above will be elaborated in the discussions in subsequent Chapters

2.5.3 Gap identification on conventional Form development within Design domains - Architecture and Fashion

Design and its fields generate forms which are strikingly similar in visual and structural characteristics. In the selected domains of Design – Architecture and Fashion – we come across forms which remain strikingly similar visually in outline shapes and its process of shaping up. However, there is very little study available on the understanding of generation of these forms, and the process of form generation, although the methodology, elements and structure remains strikingly similar.

Architecture and Fashion has influenced each other, by giving and taking from each other as stated above by Abloh, often cross pollinating either way in history or through art movements and in cultures. The previous literature studies reveal the inherent characteristic of Geometry that holds strong in visualization and realization of form, in very similar ways in both domains, yet has not been probed enough to identify the basic parameters that guide the design development activity.

Whereas Architecture deals with space for the human body and its activities, Fashion revolves around the space that is the Human body.. What emerges is the 3 dimensional form in the physical space w.r.t. surroundings in the macro perspective, or restricting to the micro expression containing the human body measures. From the parameters derived earlier, it is quite established that Geometry remains the key factor in form development and is pivotal to perception of the form, may it be Architecture or Fashion. However a deeper look into the parameters is essential to understand the interdependency, overlap and digression, and the relevance of Geometry behind form generation.

2.6 Summary of parameterization

Further deliberation is essential with surveys and case studies to validate the findings towards a rational and real understanding on appreciation of Geometry through visual perception in Design which is to be taken up in the following chapter 3. All the parameters arrived at under each section has generated broad spectrum parameters and sub-parameters of significance. These are to be assimilated into a comprehensive understanding towards the next stage of inquiry on the thesis. The questions on the surveys to be conducted will be generated based on these emerging parameters only – towards quantification of a qualitative study conducted so far.

2.7 Inference & Direction

The Literature survey in Stage 2 [ref fig 4] can now be synced with the correlation of Architecture and Fashion, both for convergence and divergence of Design thinking, and the gap areas identified. towards the follow up action required and to be considered in the following chapters of the thesis.

The roadmap is illustrated as below :

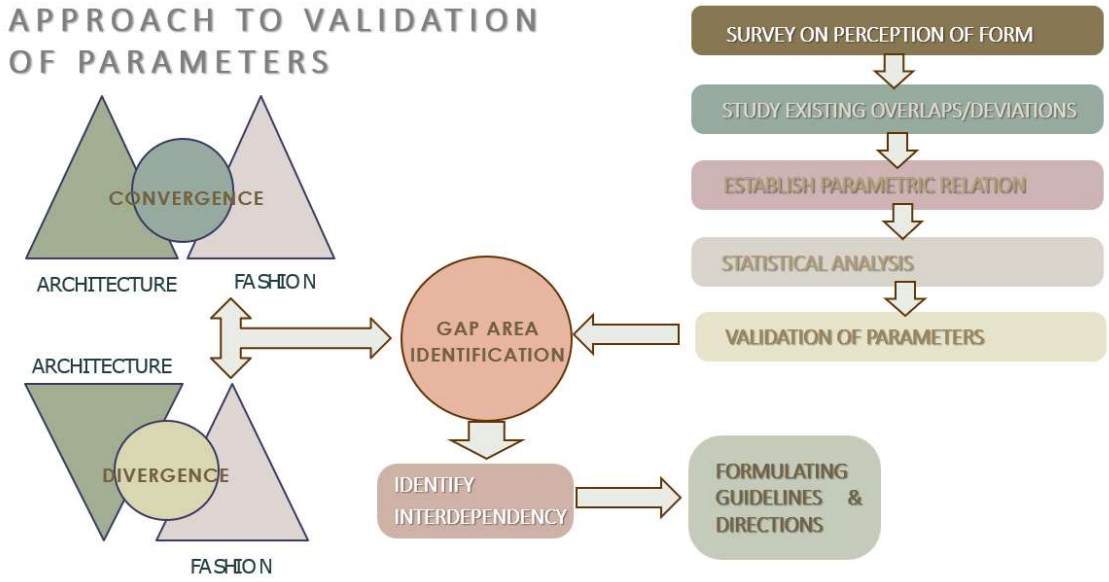


Fig 54: Structure of action plan towards validation of Parameters [pc: Author]

CHAPTER 3

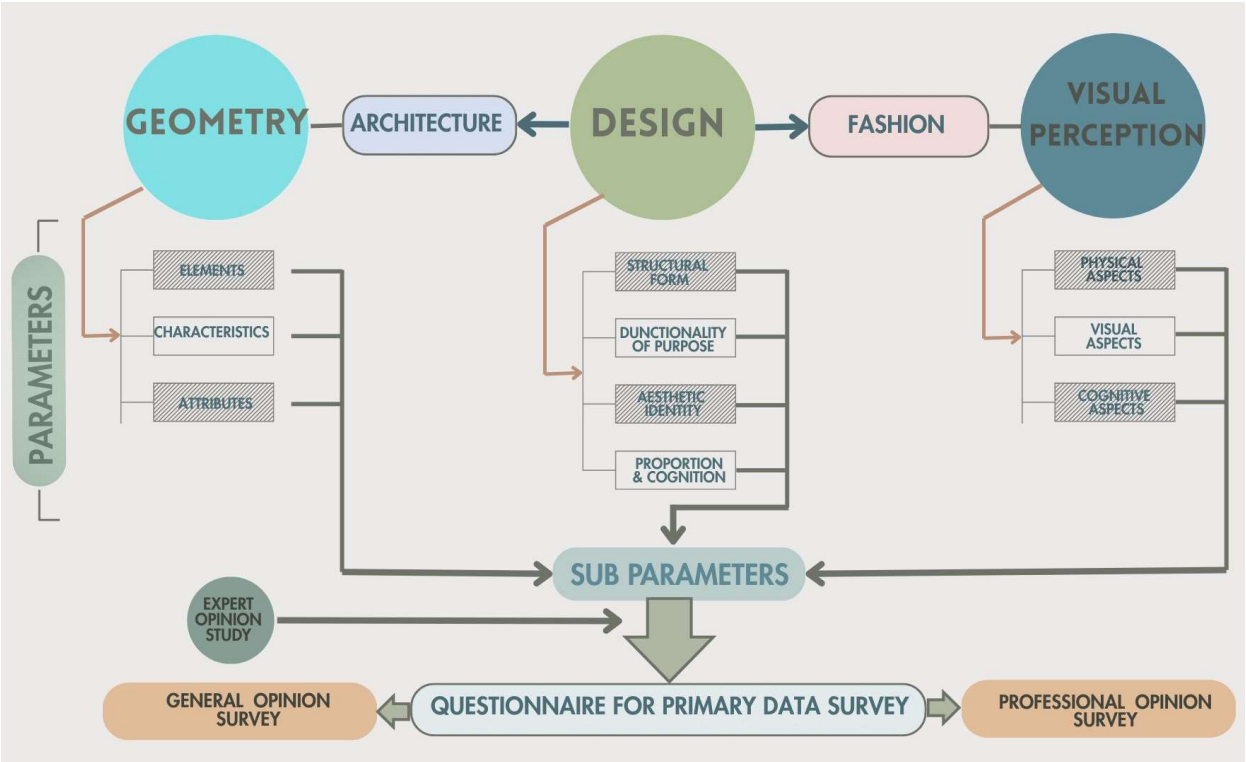
METHODOLOGY & ITS APPLICATION

3.1 Framework for implementation of Methodology

The literature survey explored in major directions w.r.t. the 5 basic keywords - from which emerged the respective sets of parameters and relevant sub-parameters. This now requires a structured methodology for executing the 'interpretation' stage of the thesis [ref fig 4]. The methodology to be framed now towards validation of parameters and analysis of findings, require to be linked to the literature survey to determine the subsequent steps to formulate directions that will eventually pin-point to specific factors emerging out of the research. The objective remains as to find guidelines that lead to form generation in design, in the context of Architecture and Fashion.

This chapter would introduce a methodology for classifying the parameters and validating them through levels of analysis, to be conducted through primary data collection. To formulate this strategy, it is essential to understand how to prepare for the data collection, developing relevant methods, based on the literature survey. Hence, understanding the parameters generated is essential to formulation of questionnaire , which requires to be based on the sample of survey selected and their understanding, opinions and activities for determining responses. These surveys will, in turn, bring out the important parameters , through quantified data generated through responses.

The framework of formulating the methodology is illustrated below :



Approach to formulating Methodology: Fig. 55: Parameters to survey and classifications [pc: Author]

3.2 The Objective leading to analysis

A broad perspective study emerged, based on the vast set of parameters identified in the previous chapter, during the process of exploring the basis of perception and correlation of form generation in Architecture and Fashion, and investigating the relevance of Geometry as the underlying principle guiding the actions. This chapter categorically synchronises the approach towards the analysis in the following pathway –

- Segregation and Identification of parameters
- Tools & Methods for Validation of the parameters
- Establishing the inter-relationship of the parameters
- Measuring dependency w,r,t the selected domains of design

3.3 Identification and Segregation of parameters

3.3.1 Identifying parameters

A detailed review of the above tables of parameters, arising out of the sub-categories of the previous chapter, interestingly summarize into a common set of key factors determining perception of objects. With limited digression, much of the literature survey illustrates the authors' observations pointing towards specific criteria w.r.t. Geometry– thus making it more evident that the ideal pre-existence of Geometry controls and guides perception of Design. The key aspects identified thus, indicates segregation into larger sets with sub sets.

The key aspects can be segregated broadly under –

1. ***Natural Objects –*** *inherent geometry in growth pattern*
2. ***Man-made Objects*** *– absolute geometry in ideation and realization*

Nature has created with Geometry way before human existence and it has remained the permanent basis of all objects of natural origin from time immemorial. Human activities have interpreted and applied the mathematics of geometry in their creation, consciously or subconsciously, and only later analysed the basis of its application in terms of mathematical and visual relations. While lines delineate the shapes, rectilinear or curvilinear outlines of the latter determine the attribute of static or dynamic motion in the form.

The end objective of Nature to imbibe Geometry or generate from it, appears to be for the purpose of creating and maintaining balance and order in environment. The science behind appears to instil an order in the growth of forms and sequence of actions, to predict natural evolution in a sequential manner. Such is the strength of these principles behind, that it has made the growth and visible form

of structures almost absolute in their characteristics. As Annie Dillard expresses her awe on natural Geometry in An American Childhood –

> *"Crystals grew inside rock like arithmetic flowers. They lengthened and spread, added plane to plane in an awed and perfect obedience to an absolute geometry that even stones – maybe only the stones – understood."* The growth sequence quantified into mathematical values, making it absolute in its application. [Dillard, 2013]

Hence, its predictable to understand how atoms look and generate the next set of structures that would shape an object, predict the fractals that multiply into the form, project the outlines and directions of the object at various stages of growth, towards generating a sensory experience or perception of what is termed as real physical world. The order thus maintained by virtue of the mathematical relation between the various elements and objects creates the balance so required for existence of life on earth, as also the order essential to the survival of the solar system as planetary relations and motions are as much guided by Geometry. Nature's art are frames that exhibit balance and proportion and generate harmony in abundant effects through limited elements and resources in homogeneous distribution, creating variety in symmetry and pre-determined asymmetry.

Horatio Greenough writes in – *The law of Adaptation*, 1852:

> *"In Nature and its birds or animals, it is variety as also the beauty. The components that make the body differ from species to species in accordance with their use.So, the neck of the swan differs from that of an Eagle, both being as charming on its own. The Law of Adaptation remains a Fundamental Law of nature in its structures. The form modifies by stretching / shrinking, lengthening / shortening etc as per the function that follows. A man-made object like a ship exhibits the same natural observation in time tested form generation. Beauty in an object lies in its promise of function. This is based on the laws of apportionment, distribution and connection."* [Gorman, 2003]

The above observations illustrate the visual structures and aesthetics in nature generating out of geometric sequence of growth. Human creations, inspired from nature, is bound to imbibe the intrinsic Geometry in all its forms. The human body, a composite of the Golden Section, as explained by Le Corbusier in his 'Modulor' scale, will naturally reflect the geometric structure in all man-made objects.

According to Kepler –

> *"Geometry has two great treasures: one is the theorem of Pythagoras, the other the division of a line into extreme and mean ratio. The first we may compare to a mass of gold, the second we may call a precious jewel"* indicating the significance of the Golden mean in design [Fink, 1903] He said in his Harmonice Mundi - *"Geometry is the archetype of the beauty of the world."* - following Pythagoras in his explanation of the *cosmos* through his wave theory of the string in a system known as *musica universalis* or *'the music of the spheres'-"There is geometry in the humming of the strings, there is music in the spacing of the spheres".*[Kepler,1619]

It is now evident that Geometry is inherent to all visual forms, whether natural or man-made. It is the basis of arranging the various elements and shapes that outline any object for visual perception and realization of physical form, whether in 2D or 3D. It manifests itself through its language

comprising of points, lines, shapes, surfaces, curves or solids etc. There is an inherent mathematics in the way these elements fit together. Wherever and whenever there is matter and form, Geometry is imperative in its outline. Geometry is essential to beauty of forms.

Quoting Newton-

> *"The description of right lines and circles, upon which geometry is founded, belongs to mechanics. Geometry does not teach us to draw these lines, but requires them to be drawn."* [Newton, 1687]

Aristotle said, in Metaphysica (350BCE, 3-1078b) –

> *"The mathematical sciences particularly exhibit order symmetry and limitations; and these are the greatest forms of the beautiful."* [Woodard, www.maths.tcd.ie]

This establishes the significance of Geometry in the visual characteristics of an object. Since this thesis focusses on Architecture and Fashion as the two directions of Design, the findings of the literature survey on Geometry will focus towards Man-made objects only and Natural objects as reference towards visualization of the former and /or influencing all creative outputs.

Design is manifestation of thinking through a visual process. Charles Eames speaks - *"What is design? A plan for arranging elements in such a way as to best accomplish a particular purpose."* [Faimon & Weigand, 2004]. These Elements are similar to the ingredients in a recipe, which when put together with dexterity, leads to creating effective visual communication. Visual design is associated with these design elements and principles, which are applied by the designers in the various design disciplines towards generating aesthetics, through an intuitive and subjective process. The language of visual design is creatively applied by designers and architects through the structure and composition and conveying information through visual design principles. In Design for the real World, Victor Papanek states -*"Design is the conscious effort to impose meaningful Order – mode of action by which Design fulfils purpose in through its function".* [Papanek, 1972]

Le Corbusier, 1923 – writes in 'Eyes which do not see'

> *"Human appreciation of aesthetics is based on the senses or maybe of an intellectual order . Harmony and Proportion incite these intellectual faculties . After consideration of the purpose of a space or object, the sensorial aspects absorb the shapes – that of cubes, spheres, cylinders, cones etc. – eventually achieving an order and organizing by virtue of measuring and arranging based on visual perception."* [Corbusier , 2008]

Arnheim states that

> *"... a well-organized line figure imposes itself upon all observers as basically the same shape... one could expect the same, at least in principle, with respect to people looking at the works of art. This trust in the objective validity of the artistic statement supplied a badly needed antidote to the nightmare of unbounded subjectivism and relativism"* [Arnheim, 1974]

Thus, from the view of the experts as stated, the factors that emerged are that aesthetics and beauty in objects designed are based upon visual appreciation which, in turn, is guided by–

a) ***Physical elements***
b) ***Perception elements***

These will be considered as the broad spectrum of the Parameters drawn towards analyzing the hypothesis in this research. These parameters will be elaborated as follows:

a) ***Physical Elements*** – Elements that delineate a design and are visible to human eye. These are static and cannot change their metrics

The sub -categories drawn from the studies can be as below –

ii) ***Basic****: Lines, straight and curved*

iii) ***Outline:*** *Shapes - Square, Triangle, Circle. Ellipse*

iv) ***Solid****: Form – Sphere, Cylinder, Cone*

v) ***Repeat****: Pattern, Motif, Rhythm, Texture*

vi) ***Measure****: Dimension, Direction, Golden mean, Fibonacci numbers*

b) ***Perception elements*** – Elements that make us see an object the way we see it. Its existence is partially real, partly psychological. They are dynamic and controlled by human emotions and moods to an extent.

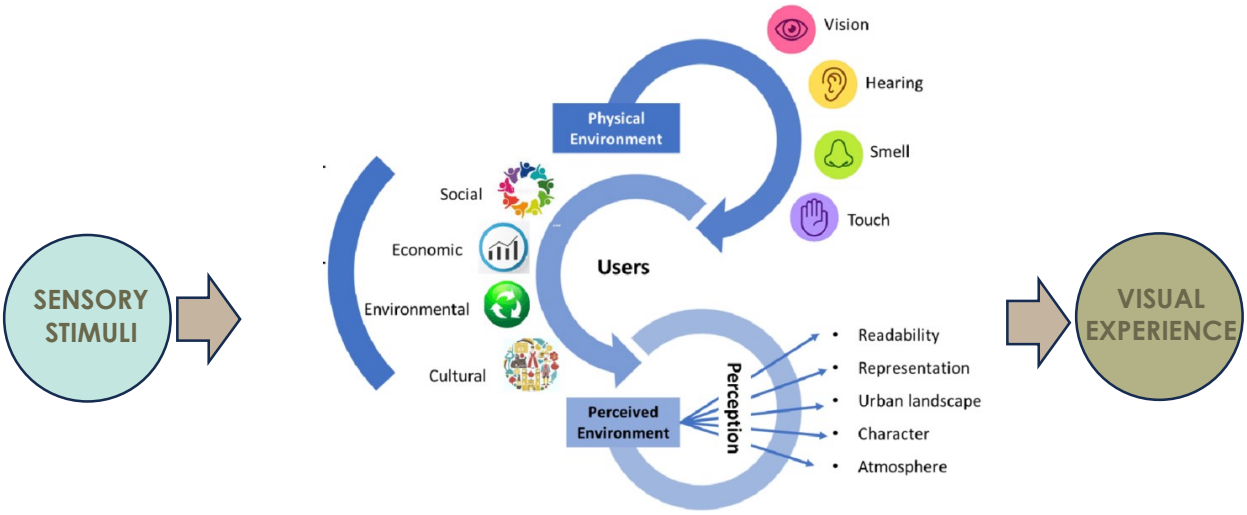
The sub-categories can be as below –

i) ***Balance****: Order, Symmetry, Harmony*

ii) ***Proportion****: scale, relative, sacred geometry*

iii) ***Perspective****: Viewpoint, distance*

The parameters summarised above, is explicitly illustrated in below on how a person interprets their visual environment based on the above elements -



Visual experience and interpretation: Fig. 56: Elements to Perception [source: Researchgate / Author]

To understand the process of this cognition integral with Geometry, Stephen Hawking says – *"Equations are just the boring part of mathematics. I attempt to see things in terms of geometry."* [Larsen, 2007].

This is reiterated in *"Geometry is the science of correct reasoning on incorrect figures."* [Polya, 1945] – Thus indicating the science of accurate figures read with the help of Geometry. This is achieved through the physical elements of Geometry, wherein the technicality is less significant w.r.t. its visual appearance.

Christopher Dresser, 1873, speaks in Principles of Decorative Design – *"An arc can vary from a simple mono centric line to the unique 3 center detail of the ellipse of the egg."* [Dresser, 1873]

According to him,

- *"Proportion. like the curve, must be of a subtle nature*
- *A principle of Order must prevail in every ornamental composition*
- *The orderly repetition of parts frequently aids in the production of ornamental effects"*

In the artificial world created by Man, all forms are centred on Geometry. Each element used to draw the outline, manifests itself through Geometry and geometric principles of relation of points, lines, angles, surfaces etc. Deriving from the proportions in nature, Man has aspired perfection through proportion and scale. The realization of proportion in the human body translated naturally in all that the hands shaped.

> *"In the pentagram, the Pythagoreans found all proportions well-known in antiquity: arithmetic, geometric, harmonic, and also the well-known golden proportion, or the golden ratio. ... Probably owing to the perfect form and the wealth of mathematical forms, the pentagram was chosen by the Pythagoreans as their secret symbol and a symbol of health".*
> - Alexander Voloshinov - as quoted by Alexey Stakhov [Stakhov, 2009]

A progress from the mundane physical surface and form into creating within a space unlimited, is the superiority of the human mind and its application of Geometry, within the sphere that contains. Arising from the first creations of the primitive man to modern superior designs, visual character of human designs have always been strictly based upon and expressed through Geometric elements and relations. Ethnic cultures and societies over ages have left behind images and examples of designs - in their spaces, clothes, artefacts – where the Geometry and its language emanates naturally and the same element creates separate identities across regional cultures.

In 1925 Helen Appleton Read says in The Exposition in Paris -

> *"As Cezanne said that all forms could be reduced to the cone, the cylinder and the cube – indicates that all geometric forms and intersections create beauty in terms of that seen in natural organic forms. From the Decorative ornamental forms emerges the beauty of geometric designs and elements."* [Gorman, 2003]

The basic shapes, such as squares, circles, polygons, continue to contain within boundaries or unbound into moving forms and actions. Many a time the shapes transcending physical forms into philosophical spaces and limits. What remains constant is the harmony and balance and order of the elements and the sequence in which repetition creates and enhances the form. All parameters need to direct towards a purposeful Design experience, in function and form.

3.3.2 Segregating parameters

Summing up the parameters elaborated so far leads to organization of various parameters of Geometry in relation to Design-

i) The first set of parameters contain the ***Physical elements***, segregated based on the ones which are primarily perceived visually. Further, within the group of Physical elements as parameters, classifications are made between the ones which are strictly ***elements*** and are necessary to make objects visible, and the others being those based on the ***principles*** which arrange the elements to create the desired effect of vision.

ii) The second set of parameters related to the ***Perception elements*** are dependent on the interpretation of the human mind and generates out of the physical elements or are perceived from them, though it can be generalised across different emotional states of perceiving design.

iii) Together, the Physical and the Perception elements are considered as ***Primary Parameter*** for this thesis.

iv) Apart from the primary parameters, the other aspects essential to guiding our perception of visual forms, are segregated into a set of ***Secondary parameters***, essential to aesthetic experience, but not entirely necessary in a direct way, to perceive visually. These are derivatives of the other sets, but influence visual experience in terms of creation and /or appreciation.

v) It is difficult to quantify the exact impact Secondary parameters have on perception, in an effort to establish direct interlinking with the Primary parameters. However, their influence is undeniable. In view of the paradigm of this thesis, the secondary parameters are not to be considered, and will remain as directions towards future research with further intrinsic study.

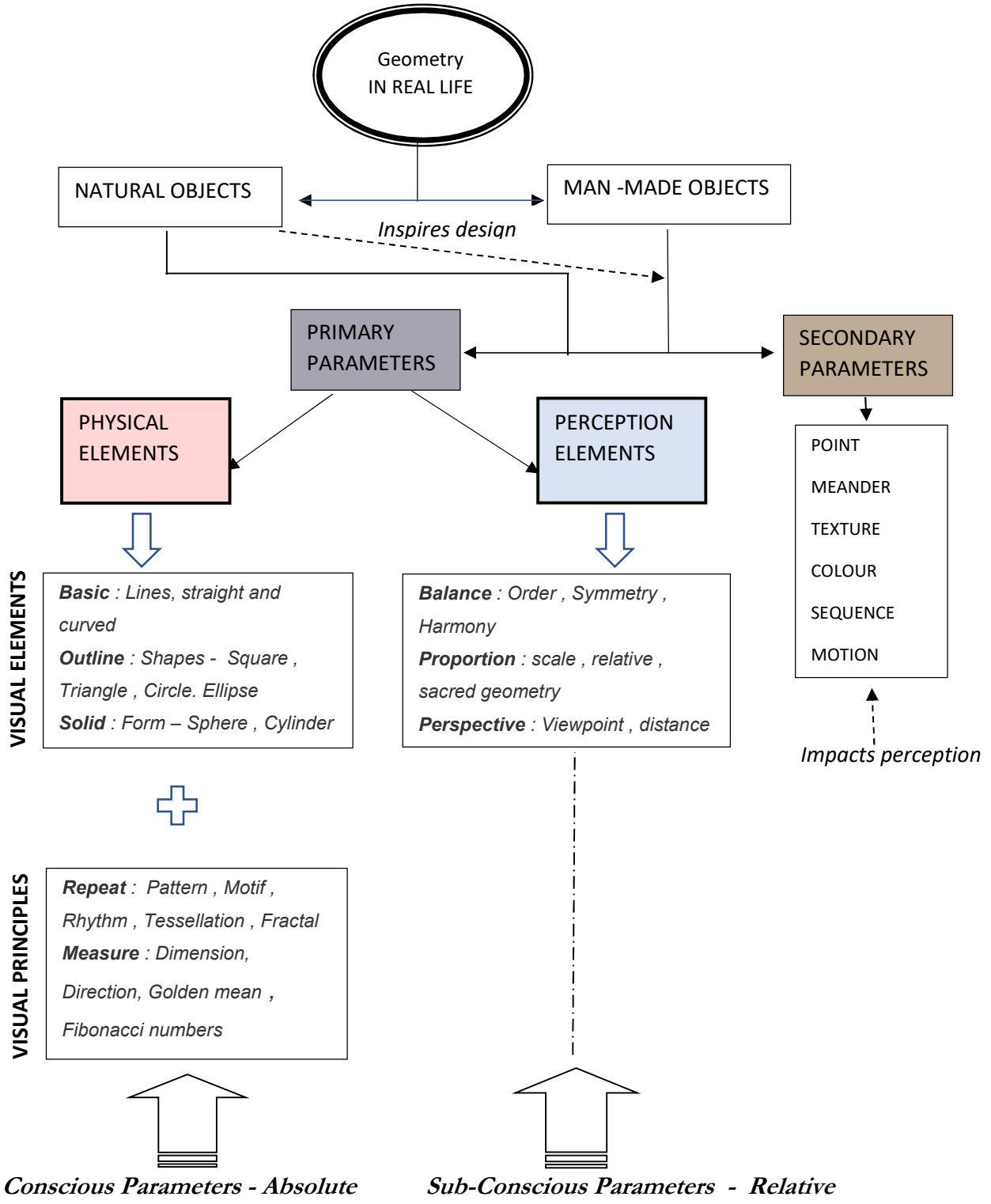
vi) The correlation and interdependence of the parameters together lead to the perception of forms and their aesthetic appreciation where the Primary parameters create the visual imagery and the Secondary parameters influence vision.

From the above segregation, the parameters are to be categorised now in the following way-

- In view of the parameters generated we need to look at the types of perception generated from the visual image created – '*explicit/conscious and implicit/subconscious perception*' – the former being subjective and guided by *'cognitive and linguistic filters of the information',* while the latter remains subjective and '*is sensory-based*'.
- The *Physical Elements* mentioned above may be thus considered as ***'Conscious Parameters'*** since they are physically visible and measurable, and thus **Absolute**.
- Other than the physical component, more often than not, the *Perception Elements* are a result of the sub-conscious mind trying to organise physical characters.
- These are thus termed ***'Sub-Conscious Parameters',*** since these are procedural and contextual, and thus **Relative**. [Olga Bogdashina, 2022]

The above sets and categories, along with the overall understanding as cited in this chapter as above, can be correlated and illustrated through the following figure which shows the inter-relation of the root areas and the parameters that arise from them –

3.3.3 Classifying parameters



Classification of Parameters: Fig. 57: Primary and Secondary Parameters [pc: Author]

3.4 Methodology of establishing inter-dependence of the identified Parameters

3.4.1 Understanding the Purpose-

3.4.1a) Background for methodology:

In the process of the research, it has emerged that there are hardly any information available on correlation of such parameters which leads to identifying the logic that triggers visual perception even though the chosen Design streams of Architecture and Fashion illustrate broad inter-dependency and inspiration from each other. It was necessary to extract and develop a method for quantification of the qualitative aspects arrived at from the literature survey and also generally understood with common observation by all and sundry.

3.4.1b) Experience in application of Geometry:

Having taught the subject of Geometry for nearly 29 years now to Design Aspirants – to-be Architects and Designers, I have seen how the subject is intrinsically embedded in design thinking and evolution of design, and how it is used in the design process to give shape to creative thoughts. On this premise, it has been keenly observed how it is applied in form development in conscious and sub-conscious manner and is mandatory in creation of form in 2-D and 3-D Design in both domains. This objective experience also guided the structuring of the methodology.

3.4.2 Tools of Information-

In order to derive a quantification of a qualitative perception, information assimilation was necessary. It was also essential to have a diverse set of data to analyse into different segments in which way the factors overlap or digress from each other to generate the visual experience related to Architecture or Fashion forms. 3 types of data aggregation were done as follows –

3.4.2a) Expert Opinion Study:

i. **Purpose:** During the discourse of Academic deliverance in both fields, it has emerged that Geometry remains pivotal to shaping of Design in various sub-directions within the Major domains selected, in practice, as professionals.

ii. **Action:** Hence, a short study was generated within 12 Experts, based in India and abroad - 6 from each domain - established and reputed in their fields, and working in various domains as Academicians, Professionals and Entrepreneurs.

iii. **Outcome:** The mix of Experts was chosen to get the varying perspective in thinking w.r.t application of Geometry in Design in Practice across Nations, Institutions and Organisations.

The purpose was to understand the similarity / dissimilarity in thinking on Geometry inherent to Design and perceiving it from the perspective of Architects/ Designers. The findings generated another table of parameters in consonance with the one arrived from the Literature survey.

3.4.2b) Primary data collection – General Opinion Survey:

i. **Purpose:** The opinion of a larger sample was required to establish the perception on Geometry in Design, based on the findings of the earlier two sets of Parameters arrived at through Literature Study and Expert Opinions.

ii. **Action:** Respondents were selected with generic understanding of Design but not structured in any specific direction / stream. This being necessary to express the perception towards Geometry through identification of attributes within visual fields. The above Expert Opinion study findings, along with Literature Survey and the parameters derived thus, acted as a base for preparing the questionnaire on understanding the perception of Geometry in Design and how relevant it is in untrained minds.

iii. **Outcome:** The survey generated a set of attributes that are essential to perceiving Design as a visual activity. It also helped establish a correlation between the parameters and segregated the previous findings into sets as per preference. The data, thus arrived at, generated a hierarchy of characteristics that a human mind responds to in terms of identification of visual forms, along with the range from the most preferred/noted to the least preferred/noted attributes that a human mind can gather from visual perception.

3.4.2c) Primary data collection – Professional Opinion Survey [Architects & Designers]:

i. **Purpose:** The sets of parameters thus arrived at from the earlier primary data collection required to be streamlined into specific Design directions – Architecture & Fashion – to substantiate the Hypothesis of this research

ii. **Action:** The set of correlations that emerged from the previous survey was generically translated into a questionnaire, partially broad-based, to cover the apparent aspects considered by the professional aspect of the 2 Design streams

iii. **Outcome:** The survey led to the validation of all the parametric considerations that generated from the earlier actions into establishing the similarity and dissimilarity of thinking for Architecture and Fashion, which expresses in the forms generated as Design and perceived by the observers as guided by the Design directions that emerge out of the thinking of the Designer, and intentionally for the purpose of creating visual cues.

3.5 Methodology of Application of Tool based study -

3.5.1 Validation of Identified Parameters

3.5.1a) Expert Study – Findings:

A seminar was conducted at the premier Institute on Fashion, NIFT, Kolkata on the topic '*Application of Geometry in Design – Perception and directions in Fashion, Architecture, Products and Spaces'* as a Lecture session on 16th Nov 2022. The purpose was to orient the new entrant students of Design - in their Foundation Programme - on the subject of Geometry which teaches them 2D – 3D visualization and form development in Design during the academic journey leading them to work across a range of products and spaces. Owing to the diverse location of the Experts, the sessions were online where 6 Architects and 6 Designers across countries, addressed the students. The narratives on different interesting avenues of thinking, as unfolded through the discourses, was based on the multidimensional domains of the Experts. The Expert details with profiles and experience were as follows-

Table 6: Profile of Experts in Architecture & Fashion: speaking on Geometry

A. ARCHITECT SPEAKERS				
SL. NO.	**NAME OF THE SPEAKER**	**CREDENTIAL**	**EXPERIENCE**	**LOCATION**
1.	**Prof. TAPAN Kr. CHAKRABARTY**	Urban Designer & Educator with leading Institutes in India	38 years	NEW DELHI, INDIA
2.	**Ar. MAHUA GHOSH**	Landscape Architect	30 years	KOLKATA, INDIA
3.	**Dr. ANIJO PUNNEN MATHEW**	Dean – Institute of Design, Illinois Institute of Technology	22 years	ILLINOIS, USA
4.	**Ar. TANAY KUMAR**	Co-Founder & Creative head of leading UI-UX company	22 years	MUMBAI, INDIA
5.	**Arr. KONADITYA BHATTACHARYA**	Planner & proprietor of Architectural Consultancy firm	21 years	KOLKATA, INDIA
6.	**Mr. RANIT MAITI**	Urban Designer and proprietor of Architectural Consultancy Firm	16 years	KOLKATA, INDIA
B. DESIGNER SPEAKERS				
1.	**Ms MAHUA LAHIRI**	Leather Designer and Craft revivalist	15 years	SHARJAH, UAE
2.	**Mr. CHIRAPRIYA MONDAL**	Textile Designer Design Specialist for healthcare & Filmmaker	14 years	NEW DELHI, INDIA
3.	**Dr. MOHAMMAD SHAHID**	Asstt. Prof – IIT Research domains in cultural heritage and cognitive aspects	14 years	HYDERABAD, INDIA
4.	**Mr. SHIVAJI DUTTA**	Leading Designer & Entrepreneur Design lead for renowned bra	14 years	DUBAI, UAE
5.	**Mr. SANDIPAN DAS**	Fashion & Product Designer Consultant for User Centric Design	9 years	PUNE, INDIA
6.	**Ms. ANTERLEENA MAITI**	Fashion Communication Designer & Design Innovation	5 years	BENGALURU, INDIA

The observations of the Experts, as presented through their topics, are broadly tabulated as follows:

Table 7: Opinions of Experts in Architecture & Fashion: speaking on Geometry

SPEAKER	TOPIC	OBSERVATIONS
Prof. TAPAN K. CHAKRABARTY	*Understanding application of Geometry in the identity of spaces over ~~time~~ periods*	Geometry from elements of nature, perception through visual elements and their relations, emotional aspect, organic forms and patterns, Geometry of ancient systems, grids and growth
Ar. MAHUA GHOSH	*Application of Geometry in Landscape designs and elements*	Organic shapes to rigid outlines, creating space and focal points, giving attributes with elements, formal informal spaces, physical and natural elements to segregate, defining boundaries
Dr. ANIJO PUNNEN MATHEW	*Application of Geometry in Design from Conceptualization to Form development*	Design to movements, shapes to perceptions, giving attributes and characters, experience space to form and prototypes, emotions and symbols, translating shapes to actions and meanings, communication with elements
Ar. TANAY KUMAR	*Application of Geometry in Experiential and Human-centric Design*	Identifying elements that communicate, proportion of visual field, placement of elements, scale of elements, symbols and perception, shapes to induce action, human activity to design elements and interaction
Ar. KONADITYA BHATTACHARYA	*Application of Geometry in Architectural spaces and Planning application of Geometry in Architectural spaces and Planning*	Transition of points, basic shapes defining activities, breaking into components, growth into complex shapes, generate volume, grids in space, golden mean and proportion in space design
Ar. RANIT MAITI	*Understanding application of Geometry in Architectural pavilions, pandals and interior spaces and the craft elements*	Understanding grammar of Geometry, minimum element to convey, aesthetics through form and function, exploration of lines and shapes, angles, curvatures, patterns, integrating modern elements in traditional spaces, scale of space
Ms. MAHUA LAHIRI	*Understanding of Geometry in Elements of Handicrafts, traditional textile motifs and their evolution*	Traditional motifs and geometric structure, crafts integrating geometry, exploration with geometry of patterns and repeats, shapes, tessellations, mandalas, ancient Indian Geometry in crafts, sacred geometry based design
Mr. CHIRAPRIYA MONDAL	*Understanding of Geometry in Ergonomics of Products*	User centric format for communication, use of space for maximum purpose, application of geometric correlation, Ergonomics, products, efficiency, geometry and purpose
Dr. MOHAMMAD SHAHID	*Understanding of Geometry in Design elements, Typography and others*	Basic Shapes and communication, Design movements and use of Geometry, typography and fonts, grids, scale, sacred geometry, ethnic symbols, repeats and tessellations
Mr. SHIVAJI DUTTA	*Application of Geometry in Fashion Design from Concept to Form*	Concept to Form, application in 2D – 3D, grid, position, scale, composition, products and purpose, segments and structure, space and volume, surface and repeats
Mr. SANDIPAN DAS	*Understanding and application of Geometry in Product Design*	Form generation repeat and pattern, geometry and aesthetics, geometry and function, design change on human perception, inspiration from nature, shapes, textures, tessellation, form exploration with geometry
Ms. ANTERLEENA MAITI	Application of Geometry in Visual Merchandising, Retail design and Graphics	Geometry in graphics, logo design, golden section, typography and perception, elements and signage, publication design, scale and proportion, grids and format

3.5.1b) Summary of Findings:

From the above observations, the parametric overviews can be summarized as –

1. **Geometry and ancient systems**
   - Ancient cultures and layouts based on basic shapes of square, triangle and circle
   - Mandalas, Vitruvian Man, Sacred geometry leads to patterns and growth of form
   - Nature inspired Design, interpreted through simple points lines and shapes, expressed in crafts and ethnic cultural symbols and motifs
2. **Geometric elements and form**
   - Form generates from lines to shapes and its various translations.
   - Points remain less significant only to mark position or focus
   - The 3 basic Shapes form core of form generation and disintegrate into components for growth and repeats leading to diverse form and pattern
   - Relative positions organize into composition where grids play a major role
3. **Geometry as language of design**
   - Symbolic meanings conveyed through elements
   - Universal perception in communication through Geometry across cultures and regional boundaries
   - Lines, angles direct in visual communication to convey the meaning
   - Organic forms guide geometry of man made designs w.r.t outlines, forms, additive motifs
4. **Geometry of aesthetics and purpose**
   - Human perception generated by geometric outlines
   - Beauty is less significant to balance in composition and shapes and forms easily identified than overall aesthetics
   - Geometric elements determine utility of design and fulfilling of purpose
   - Ergonomics and user centric design essential to purpose of creation where geometry is integral to attaining the objective
5. **Geometry and contemporary design**
   - Exploring spaces through grids and shapes as surfaces and volume
   - User centric designs with measures and proportion systems for generating both 2D and 3D experiences
   - Integrating modern elements with traditional design vocabulary
   - Symbolism in communication as in logos, signage and print publications as well as experiential design through geometric structures and medium
6. **Geometry and perception**
   - Human mind perceives form in relation to function
   - Geometry guides appreciation of visual attributes from the sub conscious
   - Visual elements and their correlation generate emotional response and reactions pertaining to purpose of design
   - Geometric attributes generate psychological impact on static or dynamic aspects in a composition or form

3.5.1c) Observations on Validating Parameters:

From the above summary drawn under the 6 broad heads of criteria derived out of the Experts' views, factors can be derived to validate the parameters arrived through the Literature survey. Summary of the above derivations validating the thus identified parameters can be listed in the following manner –

a) Physical elements within Primary parameters remain pivotal to perception of Design where Geometry and its integration is the fulcrum of Design
b) The visual elements, particularly shapes, remain absolute in identification of object and its objectivity
c) Visual principles manifest through the visual elements and remain secondary in perception of design
d) Nature remains inherent to design with most outlines inspired from Natural forms
e) Ancient cultures illustrate the geometry integral to day-to-day designs and practices generated from Sacred Geometry and Nature
f) Perception elements are related as a derivative to the physical elements but remain essential to absorbing the comprehensive visual aspect of design
g) The interdependency of the Physical and Perception elements generates the experience in observers wherein the mind coordinates the linking based on emotions the elements generate
h) It is apparent that the Secondary parameters are necessary as supportive elements, but not essential to visual experience and can be kept out of purview of this thesis

3.5.2 Preparation for Primary Data collection

3.5.2a) Action Plan

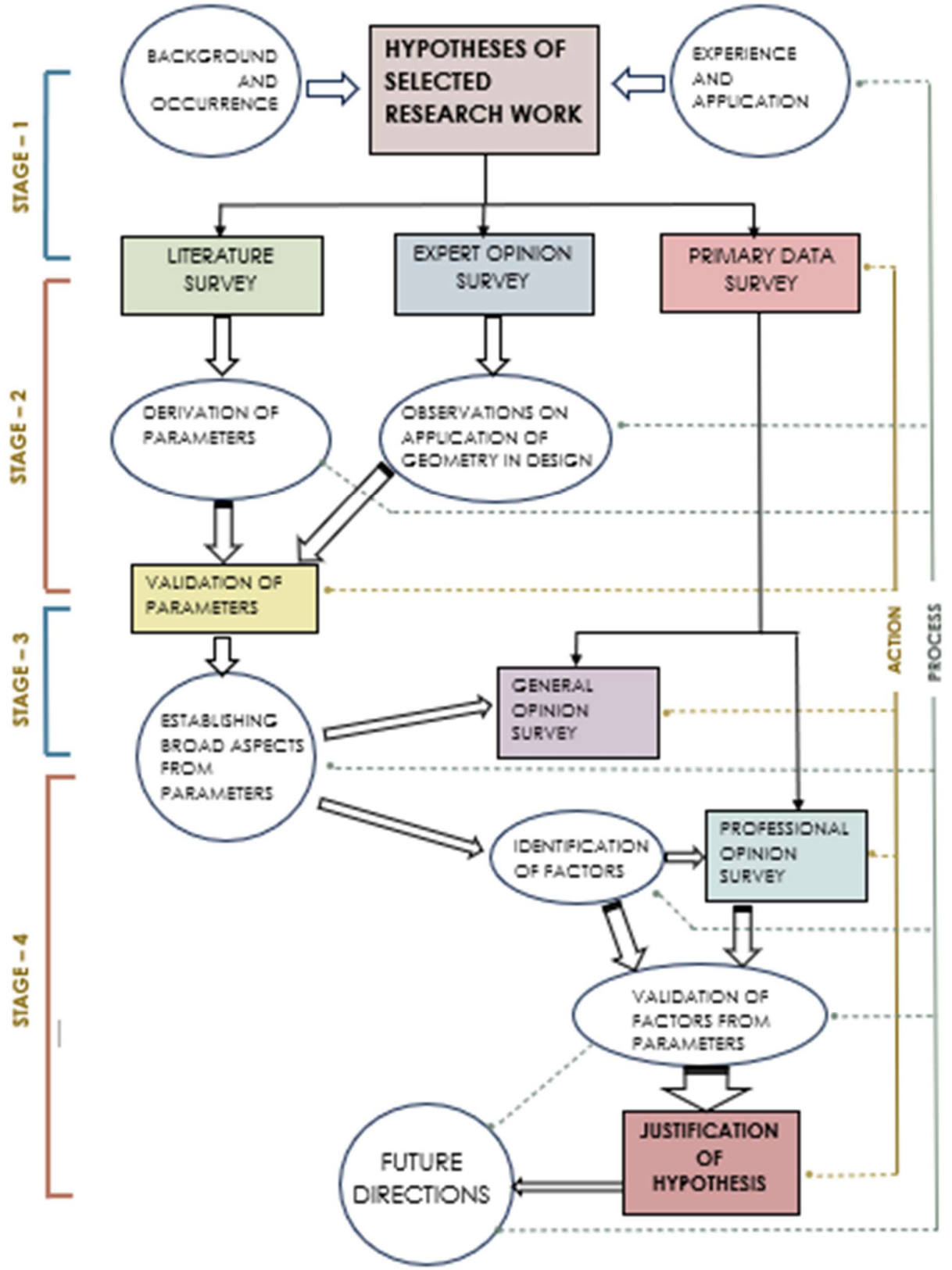
With the summary of the Expert opinions and the validation of the Parameters derived out of the Literature Survey, the research work is now taken to the next stage of attempting to establish the relation between Geometry and Visual Design manifested in Architecture and Fashion - through quantification of the qualitative aspects of perception.

The next stage of survey, as stated above under Primary data collection through General Opinion Survey under #3.3.2b, is now prepared for based on the qualitative conclusions on the parameters derived out of the earlier stages in the research. The questionnaire is prepared based on the observations found to be most relevant on the parameters derived on visual perception towards the two domains of Design. The questions are taken out of the parameters derived from Literature survey, validated through the expert opinions and the observations from own experience on application of Geometry in the discourses of Design. The scores to be generated through this survey is to be quantified to assign values to justify and establish a correlation between different factors that generate the visual experience and whether its emerges from the Geometry within,

3.5.2b) The Comprehensive Framework

The Methodology has 2 components of execution – ***Process*** & ***Action*** - Process determines the pathway and Action remains the direct outcome.

The various stages being executed in this research work, as elaborated until now, is illustrated below-



Stages of the Research: Fig. 58: Actions and Processes to be followed [pc: Author]

Methodology Chart above elucidates the progress of the research step by step as it segregates the exploration initiated in 4 stages of research –

a) **STAGE 1** – Formulation of the hypothesis based on the Background and real-life experience with Geometry in Design
b) **STAGE 2** – Data collection through various channels and from varying sources in the context of the research
c) **STAGE 3** – Validation of findings from analysis of data received for derivative factor generation
d) **STAGE 4** – Correlating the factors towards establishing the Hypothesis statement vis-à-vis generating future directions

The comprehensive course of research can be segregated under 2 heads of activity executed –

a) **ACTION** – initiated in the different stages such as:
    i) Literature Survey – Detailed in Chapter 2 with Parameters arrived at in conclusion
    ii) Expert Opinion Survey – Explained in Chapter 3 with observations to relate to the parameters
    iii) Validating Parameters – Analysed in Chapter 3 to prepare roadmap for further action
    iv) General Opinion Survey – Based on the findings of i) and ii) above - To be elaborated in Chapter 4 with intrinsic analysis of the various factors, quantifying the qualitative factors
    v) Professional Opinion Survey – Based on iii) above – To be explained in Chapter 4 to establish the perception of Geometry in Design and conclude the research
b) **PROCESS** – to relate the various Actions towards an answer to the Statement as follows:
    i) *Developing the Research Statement* – Elaborated in Chapter 1
    ii) *Deriving the parameters form the Literature survey* – Detailed out in Chapter 2
    iii) *Extracting observations from the Expert opinions* – Listed out in Chapter 3
    iv) *Establishing the broad aspects for further survey* – Concluded from Chapter 3
    v) *Quantifying findings of General Survey* – To be illustrated in Chapter 4
    vi) *Validation of findings and analysis through Professional Experts' views* – Concluding in Chapter 4
    vii) *Summarization in conclusion of research and directions for future* – Detailed in Chapter 5.

3.6 Summary

The findings in this chapter are qualitative and suggests the justification of the Statement of the Research. This is now to be followed with a detailed analysis of data from a broad-based survey in the following Chapter 4, which would help in establishing a quantified value to justify the qualitative aspects towards an understanding of the research and direct it towards its conclusion with future directions.

3.7 Inference & Direction

The Methodology adopted considers the findings from the Chapters 1-3 to conduct the primary Data Survey from 2 Sample Groups. These are to be used for analysing the findings that has emerged until now and through numerical data, attempt find the factors that guide perception of Visual Forms in Design.

The linking of the earlier chapters with the subsequent survey and analysis to be done in the following chapter 4 is cited to be as below :

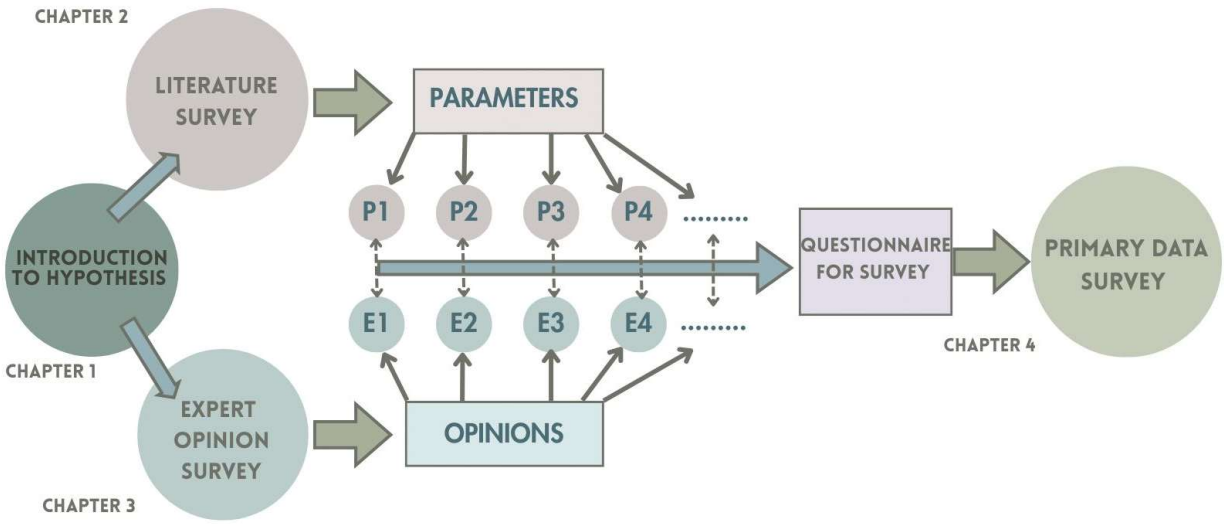


Fig 59: Course of action to be initiated on the findings of Chapters 1-3 [pc: Author]

CHAPTER 4

ANALYSIS OF DATA

4.1 Framework for Analysis of Data

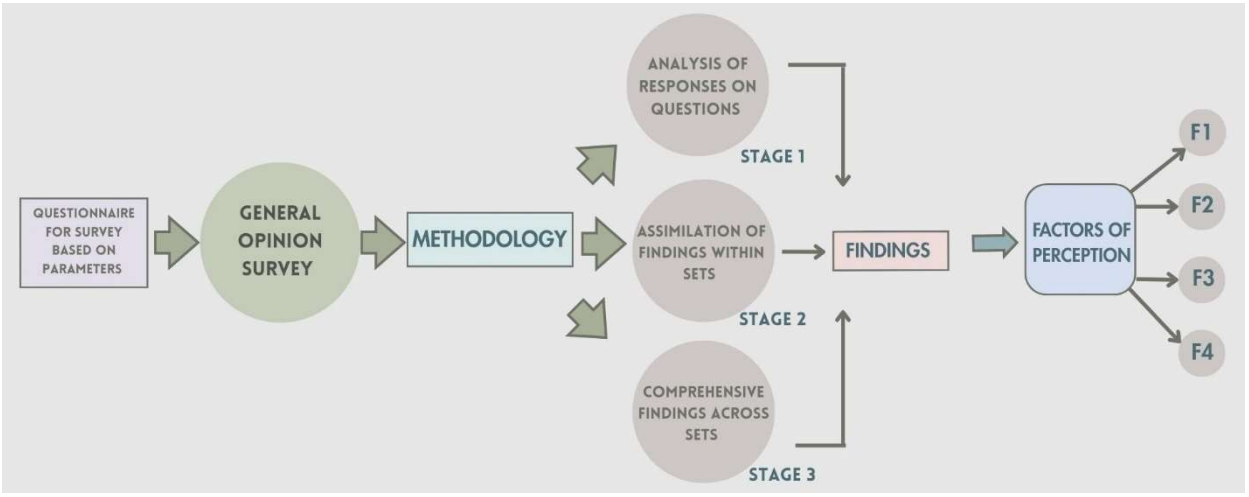
The Primary Data Survey to be conducted now is to generate quantified data to validate the parameters and findings of previous chapters 1-3 and generate a set of findings. These will be analysed sequentially based on each question of the survey. The framework to the process of analysing the survey responses was generated to validate the parameters of the hypothesis.

This chapter would introduce a methodology for classifying the parameters and validating them through levels of analysis, conducted through primary data collection. To formulate this strategy, it is essential to understand how to prepare for the data collection, developing relevant methods, based on the literature survey. Hence, understanding the parameters generated is essential to formulation of questionnaire, which requires to be based on the sample of survey selected and their understanding, opinions and activities for determining responses. These surveys will, in turn, bring out the important parameters, through quantified data generated through responses. To quantify a qualitative study, questionnaire appropriate to respondents is necessary for data to emerge relevant and logically framed towards the research. The survey was prepared based upon -

"The essence of designing a good questionnaire is that respondents must comprehend and understand all the questions and accompanying instructions in a uniform manner, as intended by the designer. Achieving this goal is possible through the combined effect of emotional and cognitive design…… With an infinite number of possible interpretations of any scene, we rely on our visual intelligence to organize it into elements that we understand and recognize." [Dillman, et al. 2005]

Although emotional design has a unique meaning its influence on responders is not independent from that of cognitive design. A good initial impression of a survey is born visually; hence the form should be guided towards higher usability by the responder with the correct visual tone. [Norman, 2004]. Following the Gestalt psychology in humans, according to the Law of Pragnanz, the simplest feasible figures from the scene under observation will be detected by the visual system- these are often the easiest to understand and recall. According to the Law of Common Region, humans understand small objects within larger areas as belonging together. [Palmer, 1999]

The framework of formulating the methodology is illustrated below:



Approach to Analysis of data: Fig. 60: Parameters to survey and classifications [pc: Author]

4.2 Analysis of the established parameters

The primary parameters arrived at based on Literature survey, finds resonance in the opinion of the Experts from both fields in the previous chapter. In this chapter, the parameters established by the Expert Opinions earlier are to be further investigated and analysed towards establishing the factors guiding perception in justification of the hypothesis. This has been done in the following sequence –

4.2.1 Primary Data collection –

a) ***General Opinion Survey*** [in Chapter 4]

b) ***Expert Opinion Survey – Architects & Designers*** [in Chapter 5]

4.2.2 The Technique of Analysis -

i) The data thus collected from the 2 surveys stated above was tabulated and segregated in various ways to arrive at the emergence of the parameters, in order to validate the parameters as finalized from the Literature survey and illustrated in the chart above.

ii) The general survey data was the major study which was segregated in various ways to arrive at the emerging preferences towards visual perception of Geometry in Design. to be used to analyze the inter-dependency of the parameters, relate it to the parameters identified previously and arrive at the most emerging factors that guide our visual thinking

iii) The data was necessary for quantification of visual thinking and perception. It was segregated into tables, bar charts, pie charts, statistics etc to arrive at different ways to identify the reasons behind human perception towards Geometric reasoning, not as a mathematical solution, but as a simple process for application, which has been in the sub conscious practice in Design all through.

iv) This was to be used towards establishing whether this remains the logic in thinking design by Architects and Designers by validation through existing works and by professionals with another survey on the findings. It was necessary to consolidate findings into simple narratives possible for application in design by human mind in general and towards logic of appreciating design in general.

v) From the expert study, data was tabulated to understand the common thread of thought and whether there is a convergence or divergence in the thinking and practice of Architects and Designers. The outcome was to understand the directions to be considered.

vi) In the process, to restrict the research to a specific focus, data assimilated on visual and pictorial observations were not considered and is left to be considered for future directions and research.

4.3 Primary Data collection- General Opinion Survey:

In order to arrive at a quantitative value on the parameters, a questionnaire based physical survey was conducted for **190 entrants to a Design Institute at under-graduate level.** It was necessary to select a definite set of respondents, in order to receive responses from a sample set with visual understanding towards Geometry. This was essential towards arriving at a valid set of responses to consider for decisive analysis. The selection was based on –

i) All the respondents were screened through a national entrance for entry to a Premier Design Institute in India. *This ensured the sample set to have a benchmark of aesthetic thinking towards further investing on Design studies and expectedly having a generic ability to understand visual fields and identify the components*

ii) The design aspirants were all from a formal academic learning, at the threshold of completing high school and entering their career pathway by choice, not out of compulsion, indicating an interest towards Design in general. The survey was conducted on their 1st day of inception into a Design Institute before any learning or tools would direct their thinking. *This was to ensure eager participation in the survey in order to generate conclusive and genuine results.*

iii) The sample set was a random mix of class XII pass outs who came from all the 3 streams of high school education in India – Science, Humanities and Commerce – having studied Geometry in short or longer stints in school. The age group being between 18-20 years. *This heterogeneity was essential to gather a wide range of perception towards Geometry and Design and the respondents belonging to Gen Z allowed responses pertaining to an age group who are young adults, fresh from school, tech savvy and connected beyond borders through social media, leading to open thinking with personal choices.*

iv) The respondents belonged to a hugely diverse set of social, cultural and economic background as the students came from all states of India and its corners, rural, semi-urban and urban areas. It was a uniform mix of genders as well – male, female and third gender. *This eliminated polarization of response towards visual appreciation which is largely influenced by socio-cultural-economic as well as gender oriented in terms of evolution of thinking and vision and introduced a variability in perception.*

v) The questionnaire was prepared on the basis of the core areas, objectives and directions seen emerging within my design education classroom experience of 25+ years followed by alumni responses of nearly 20 years, based on the pathway seen being adapted in shaping of Design into Form. *The questions, to be answered as per preferences specific to number, though apparently random and generic, were done to gather and maximise on quantification and based on the purpose of grouping together to extract the information into desired seta and purpose.*

vi) The 190 students were divided into groups of 2 each to physically answer the questionnaire - in a random mix of people completely new to each other as a team, and a mix of genders as well.

Thus the 95 response documents reflected a collective understanding of 190 respondents in an eclectic mix. From these, a final 60 questionnaires were selected based on proper and full completion of responses as also format of answering the questions. *This generated a set of 60 responses arising from 120 respondents to provide a valid and logical set of data that could be quantified.*

4.3.1 Findings:

The survey questionnaire had 15 questions, each having 4 options to be selected as per preference of highest to lowest from 1 – 4. The questions pertained to an understanding of Geometry in terms of different basic and generic aspects which could be responded, based on perception of simple geometry as learnt or experienced from regular visual experiences and memory. The interestingly homogeneous tendency in the emergence of the data is illustrated subsequently. [ANNEXURE 1& 2]

4.3.1a Categorizing responses:

The 15 questions with their respective options were segregated into 5 sets of 3. based on the context of the questions encompassing the broad aspects under this research, relevant to the parameters arrived at from the earlier study-

- *Meaning & Purpose of Geometry.*
- *Elements & Principle of Geometry,*
- *Geometry and Natural Objects,*
- *Geometry in Man-made objects,*
- *Shapes in Geometry.*

The set of questions are listed below.

Table 8: General Opinion Survey Questionnaire – set of questions:

SET A	W.R.T – MEANING AND PURPOSE OF GEOMETRY	**QUES # 1.'GEOMETRY' MEANS -**	**QUES # 5. GEOMETRY IS NECESSARY FOR -**	**QUES # 12. GEOMETRY IN DESIGN IS ESSENTIAL FOR -**
		i) OUTLINES AROUND US	i) ARTWORK	i) PURPOSE
		ii) MEASUREMENT OF OBJECTS	ii) SCULPTURE	ii) BEAUTY
		iii) CONSTRUCTION OF SHAPES	iii) PRODUCTS	iii) FORM DEVELOPMENT
		iv) CREATING PATTERNS	iv) PATTERNS	iv) SURFACE PATTERN
SET B	W.R.T – ELEMENTS AND PRINCIPLES OF GEOMETRY	**QUES # 2. APPLICATION OF**	**QUES # 3.GEOMETRY CONTAINS –**	**QUES # 4. GEOMETRY IS SEEN THROUGH –**
		i) DRAWING SHAPES	i) SCALE	i) DIMENSIONS
		ii) MEASURING AREA AND VOLUME	ii) PROPORTION	ii) ANGLES
		iii) TECHNICAL CONSTRUCTIONS	iii) BALANCE	iii) SHAPES
		iv) COMPOSING PATTERNS	iv) SYMMETRY	iv) PATTERNS
SET C	W.R.T – GEOMETRY AND NATURAL OBJECTS	**QUES # 6. IN NATURE WE SEE –**	**QUES # 7. NATURAL ENVIRONMENT HAS –**	**QUES # 8. SURFACE OF NATURAL OBJECTS SHOW -**
		i) POINTS	i) SYMMETRY	i) SHAPES
		ii) LINES	ii) RHYTHM	ii) REPEATS
		iii) SHAPES	iii) BALANCE	iii) TEXTURES
		iv) FORMS	iv) PROPORTION	iv) COMPOSITION
SET D	W.R.T – GEOMETRY AND MAN MADE OBJECTS	**QUES # 9. GEOMETRY OF MAN MADE DESIGN LIES IN –**	**QUES # 10. MAN MADE OBJECTS SHOW –**	**QUES # 11. MAN MADE DESIGNS DEPEND ON –**
		i) MOTIFS	i) SHAPES	i) DIMENSIONS
		ii) OUTLINES	ii) REPEATS	ii) ANGLES
		iii) REPEATS	iii) TEXTURES	iii) PROPORTION
		iv) PROPORTION	iv) COMPOSITION	iv) RLEATION OF SHAPES
SETE	W.R.T – SHAPES IN GEOMETRY	**QUES # 13. SHAPES SEEN MOSTLY AROUND US –**	**QUES # 14. TYPE OF TRIANGLE SEEN MOSTLY IN OBJECTS – NATURAL AND MAN MADE – –**	**QUES # 15. TYPE OF POLYGON SEEN MOSTLY IN OBJECTS – NATURAL AND MAN MADE –**
		i) TRIANGLE	i) EQUILATERAL TRIANGLE	i) RHOMBUS
		ii) SQUARE	ii) RIGHT ANGLED TRIANGLE	ii) PENTAGON
		iii) CIRCLE	iii) SCALENE TRIANGLE	iii) HEXAGON
		iv) POLYGON	iv) ISOCELES TRIANGLE	iv) OCTAGON

4.3.1b Analysis of responses – Methodology:

The data based on the responses received, [ANNEXURE 3a], was arranged through various statistical tools as per the sets in the above list. The objective was to find the trend based on overall responses, in terms of preferences 1- 4 for respective data within a question, followed by that within the set, and lastly in respect to overall data across 15 questions to arrive at the most preferred trends- the findings to be corelated to select the preferential combination of Parameters. [ANNEXURE 3b & 3c]

The methodology adopted for the analysis is as follows –

A. STAGE 1 -

a) QUANTIFICATION OF DATA – SETS OF 3 QUESTIONS

i) The preferential study is first done based on the designated set of 3 questions / set

ii) Within each set, every question is analysed statistically to arrive at the best possible or most probable parameters and combinations by determining the most preferred option as response

iii) For each question, choices are determined through numerical value and highest preferences identified

iv) For each criterion, data selected for analysis is done based on relative preference from highest to lowest choice corresponding to the remaining preferences

v) The primary preferential criteria based on number of responses is identified and correlated w.r.t. other preferences as secondary choice

DATA ANALYSIS OF INDIVIDUAL QUESTION [ANNEXURE 4a – 4c]

i) Preferred sets are identified within qualitative factors based on quantified value of responses

ii) For every attribute within a question, Preference 1 for each attribute is considered to determine in numbers the maximum value of corresponding preferences, correlating preferred combination of the attributes of each question

iii) Preferred sets are derived from overall data and Individual Oprion # 1 w.r.t other attributes

b) VALIDATION OF DATA – [USING CHAT GPT & STATISTICAL METHOD]

i) Relationship and Interdependence of the Factors under each question is done based on the aesthetic and construction aspects integrating to design – individually for each question

ii) Each set is then analysed based on choices 1 & 2 only, these being the most preferred choices – to arrive at the highest preferred attributes to identify the parameters perceived

iii) For validating data arrived at, Standard deviation and median value is considered to understand the range of preference with elimination of the least preferred option in number

c) OBSERVATION FROM FINDING – COMPARISON OF COMPREHENSIVE DATA

i) Preferred responses are segregated for all Set of 3 questions as per Options 1-4

ii) Highest preferences are arranged in sets of options between preference # 1 & 2 /3

iii) Least preferences are eliminated to arrive at highest preferred parameters

iv) Preliminary Observations are derived for overall responses and Emerging Observations arrived from Individual attribute preferences

B. STAGE 2 -

a) ASSIMILATION OF FINDINGS WITHIN SETS - [USING CHAT GPT]

i) Preferences are mapped based on the Primary and Secondary choices of Attributes for Each Set of 3 Questions – Option3 & 4 are neglected being the lesser preferences

ii) Emerging preferences are considered based on the quantified values

iii) The impact, application and directions of most preferred attributes w,r,t Design is identified

b) **CORRELATION OF ATTRIBUTES WITHIN EACH QUESTION / SET**

[ANNEXURE 4d]

i) Attributes of each question is graphically laid out as sequence of preference as Option 1 and then connected to the given sequence of the Attributes as per numerical relation

ii) Attributes with maximum preferences are identified from the 3 questions and within the Set

c) CONCLUDING OBSERVATION WITHIN THE SETS – A-E

i) From the above stages parameters of Visual Perception in Design is categorized from Primarily recognized to Least recognized attributes

ii) Inference is finally drawn for each Set and its objective of classification to arrive at the relevance of the Parameters of the Thesis emerging from the Attributes of the questions within

C. STAGE 3 -

a) MAPPING OF RESPONSES FOR ALL 15 QUESTIONS-

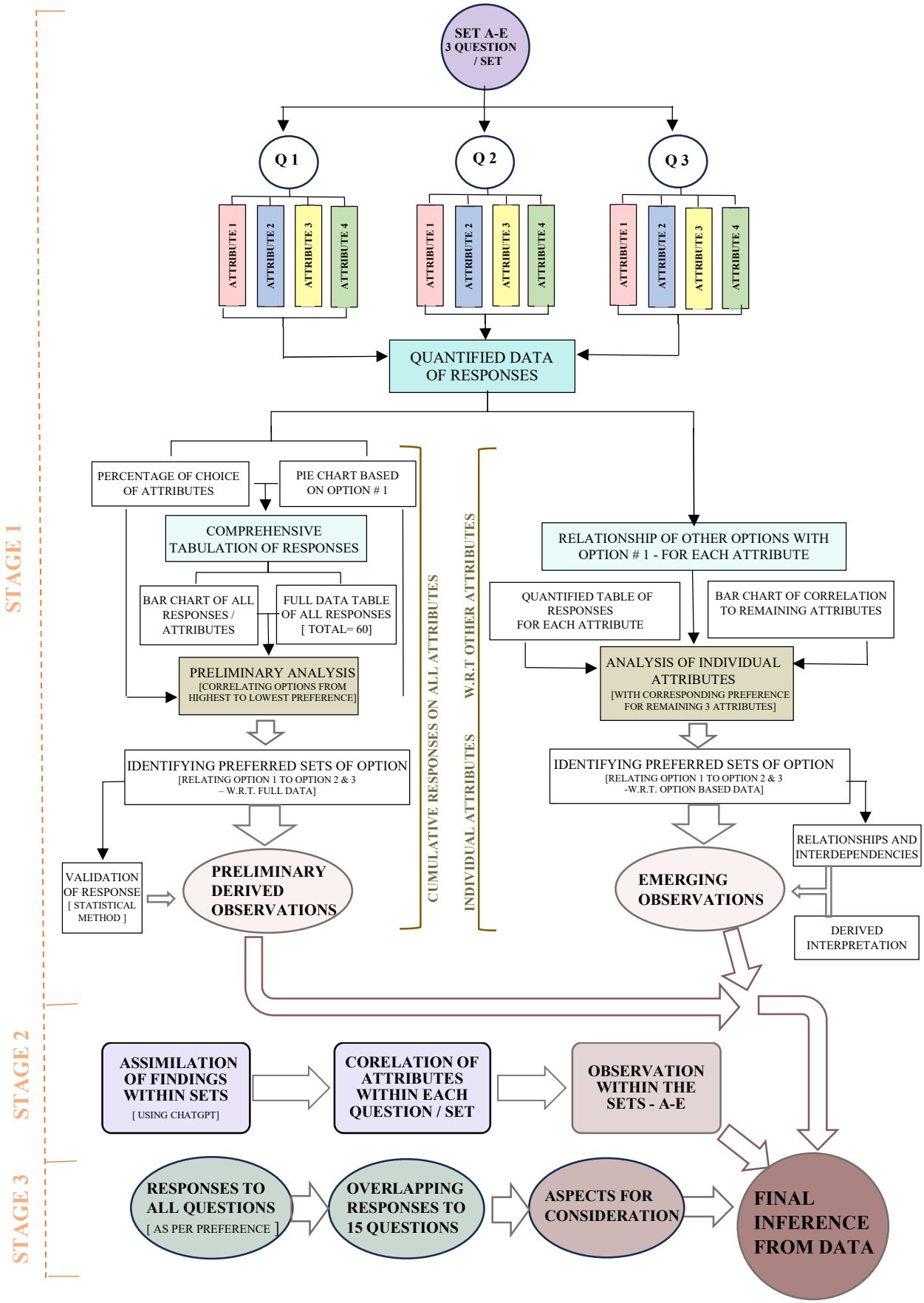
i) The responses to all the Questions are arranged in clustered column charts based on Options

ii) The graphs of all 4 options are overlapped to identify highest concentration of preferences

b) FINAL INFERENCE OF SURVEY

Based on the Observations arrived at in Stage 1 & 2 , and the study in Stage 3 , Final observation is identified as the concluding finding of the Preliminary survey towards the conclusion of the research.

4.3.1c The Methodology – at a glance



Analysis of data from General Opinion Survey: Fig. 61: Complete methodology for analysis [pc: Author]

4.3.1d Procedure – relating to the data

Since the procedure of analysis involves several stages and methods involving multiple data and action, the step-by-step illustration elaborating on the Table 4.3.1, will help explain w.r.t the subsequent tables and graphs enclosed and the method adopted for analysis- as per stages mentioned in above table:

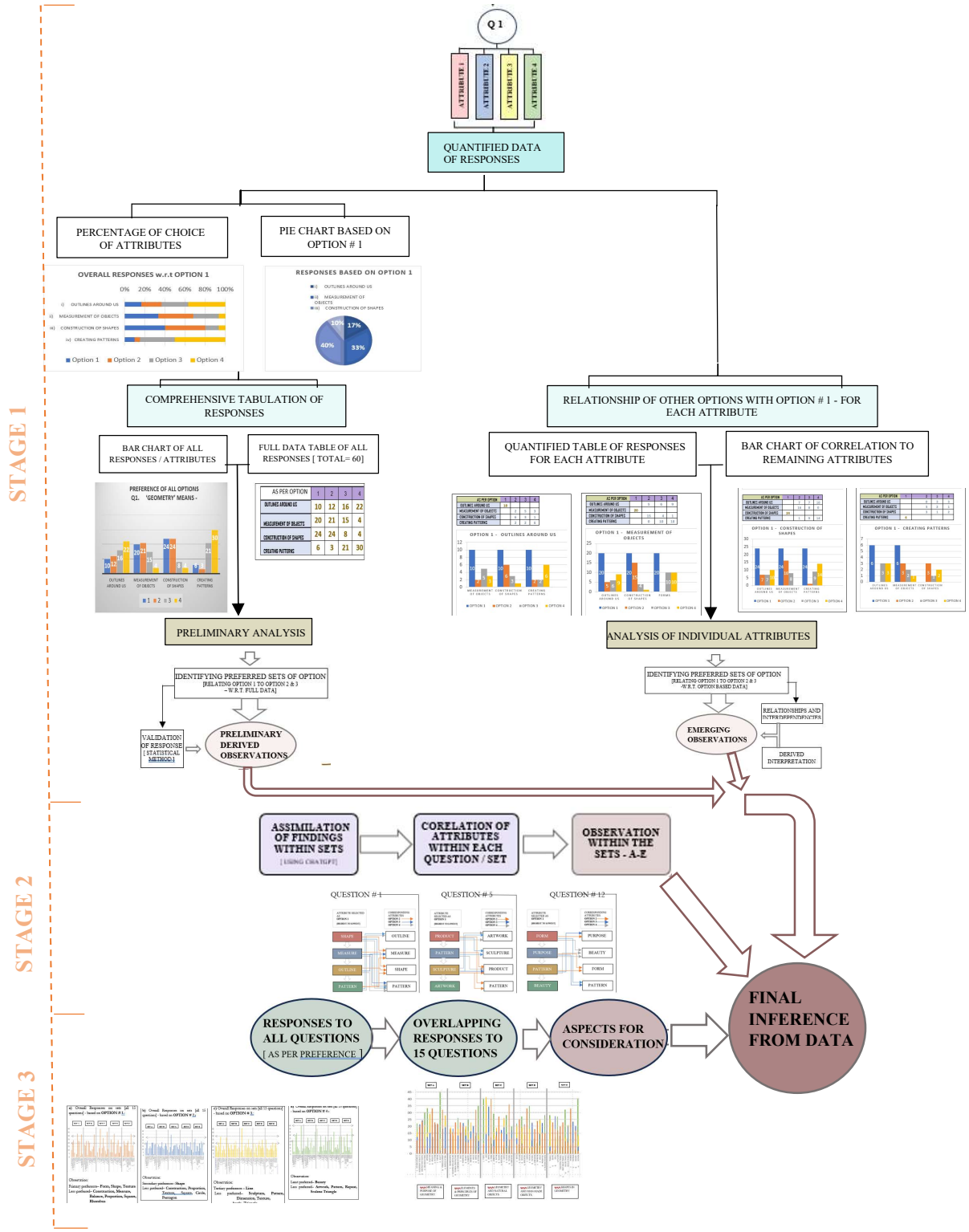


Illustration on the stages of analysis: Fig. 62: Elaborating stages of analysis w.r.t. data and method considered [pc: Author]

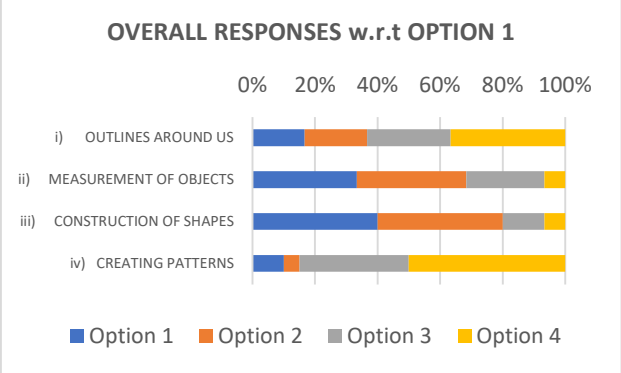
4.3.2 STAGE 1 : Analysis and Observations of responses -[ref. ANNEXURE 4b]

The detailed analysis and observations as per the identified sets in 4.2.1a is as below-

SET # A : Questions 1, 5, 12 – related to **MEANING AND PURPOSE OF GEOMETRY**

Q1. GEOMETRY MEANS: Attributes for selection according to preference being

a) Outlines around us [OA]
b) Measurement of objects [MO]
c) Construction of shapes [CS]
d) Creating Patterns [CrP]



QUES 1- Fig. 63a: OPTION 1 Bar Diagram

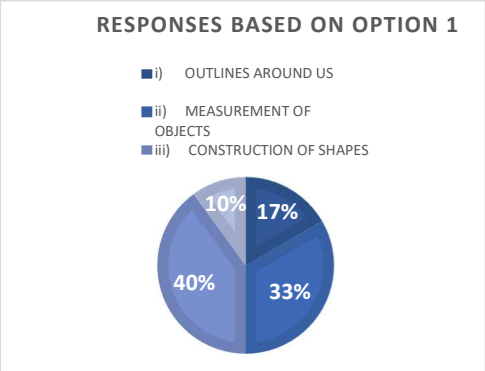
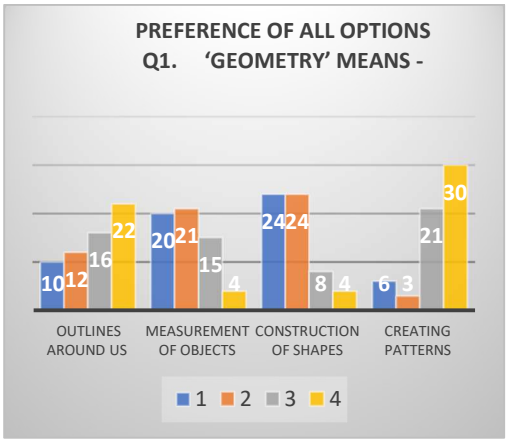


Fig. 63b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 40% respondents [24n] relate to CS, closely followed at 33% by MO [20 n] and only 17% to OA [10n], with least preference on CrP [6n]
2. For Option 2 & 3, all the attributes show similar choice for MO [21n], CS [24n] & CrP [21n]
3. In Option 4, 42% respondents [30n] relate to CrP as the least preferred option

COMPREHENSIVE TABULATION OF RESPONSES:



QUES 1- Fig. 63c: Overall responses

AS PER OPTION	1	2	3	4
OUTLINES AROUND US	10	12	16	22
MEASUREMENT OF OBJECTS	20	21	15	4
CONSTRUCTION OF SHAPES	24	24	8	4
CREATING PATTERNS	6	3	21	30

Table 9: QUES 1- ALL RESPONSES [pc: Author]

PREFERRED SETS:

1. CS–MO - 24:21, CS–OA-24:12 [16 n as OPTION 3]
2. MO–CS– 20:24, MO–OA [16n As OPTION 3] – 20:12
3. OA WITH 10n is low preference, hence only 2 attributes are considered

DERIVED OBSERVATION –

In understanding meaning of Geometry, respondents relate to CONSTRUCTION of SHAPES and MEASUREMENTS, and give lesser value to OUTLINES and least significance to PATTERNS.

VALIDATION BY DATA BASED RESPONSE -

For the given set , the standard deviation of the given set of numbers is approximately 8.5, measuring the spread or dispersion of the numbers around their median value of 15.5 - which eliminates the least values and syncs with the preferential choice of the larger sample. This validates the higher range of the sets above.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

[Respondents selection of an Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

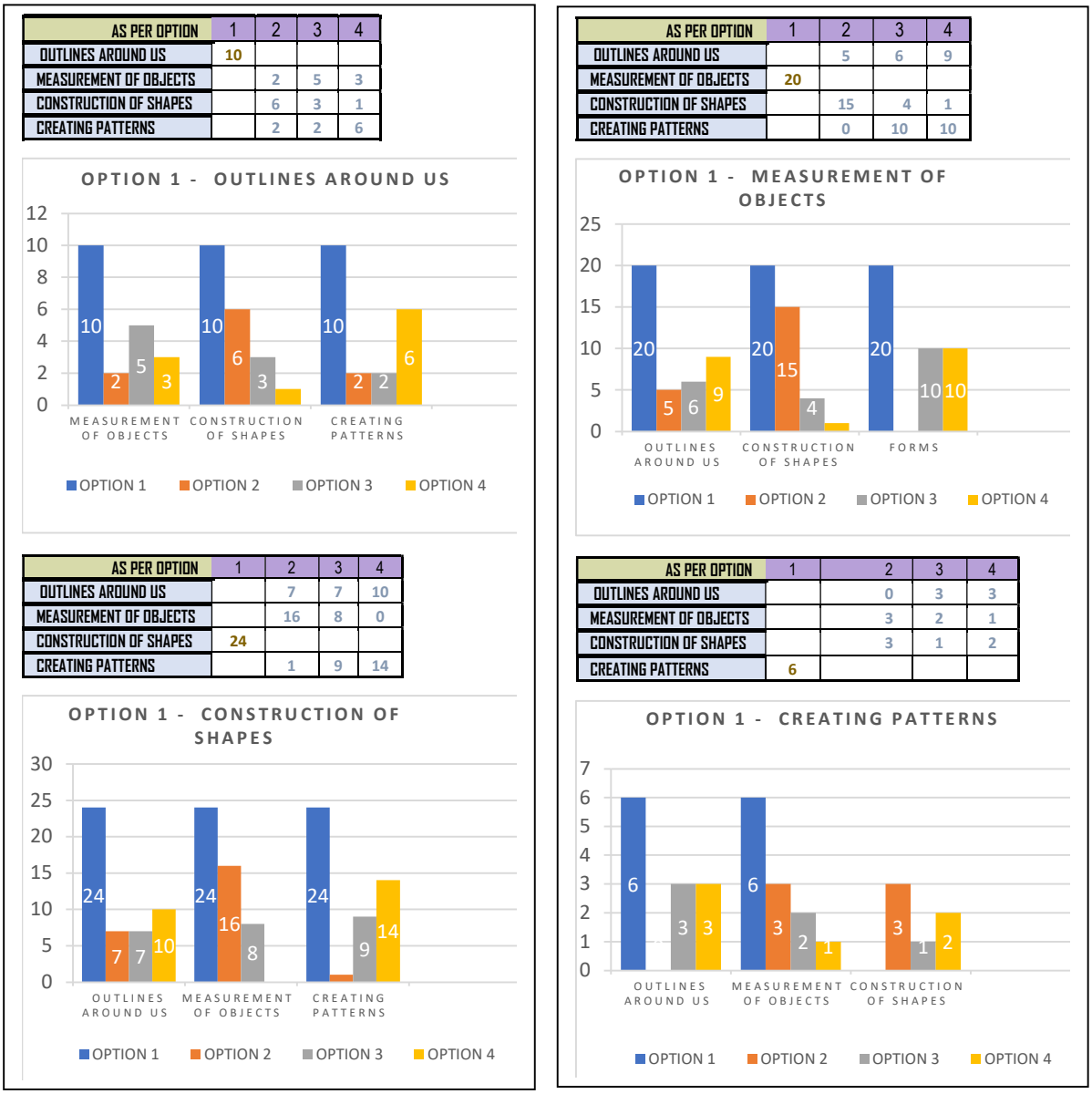


Fig.63d: QUES 1 - OPTION 1 - w.r.t. other Options [pc: Author] [Derived from ANNEXURE 4c]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Measurement and Construction**:
  - Option 2 (Measurement of Objects) and Option 3 (Construction of Shapes) both involve practical applications of geometry in creating and quantifying geometric forms and structures.
- **Visual and Creative Aspects**:
  - Option 1 (Outlines Around Us) and Option 4 (Creating Patterns) focus more on the visual and creative interpretations of geometry, where geometry is seen in the visual contours of objects and in the artistic creation of patterns.

DERIVED INTERPRETATION**:**

The data illustrates different interpretations or meanings associated with geometry—ranging from visual outlines and measurements to construction and creative pattern-making. Each option highlights a distinct perspective on how geometry is perceived and applied, whether through measurement, construction, visual observation, or creative expression. Understanding these interpretations provides insight into the diverse facets and applications of geometry in various contexts.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

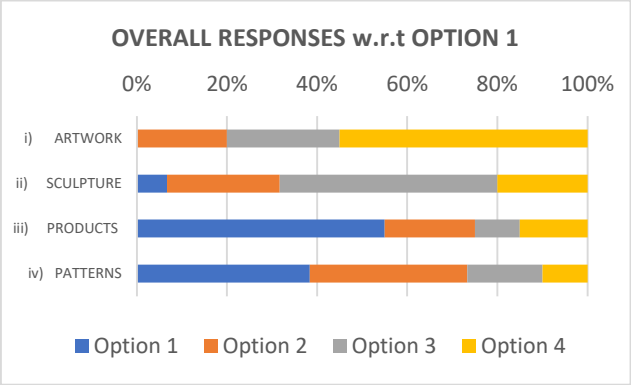
A. **Option 1 – Attribute # 1**: OUTLINES AROUND US
   Preference with choice #2: OA-CS [10:6]
   Preference with choice #3: data is negligible
B. **Option 1 – Attribute # 2:** MEASUREMENT OF OBJECTS
   Preference with choice #2: MO-CS [20:15]
   Preference with choice #3: data is negligible
C. **Option 1 – Attribute # 3:** CONSTRUCTION OF SHAPES
   Preference with choice #2: CS -MO [24:16]
   Preference with choice #3: data is negligible
D. **Option 1 – Attribute # 4**: CREATING PATTERNS
   With only 10% respondents, the data is negligible for consideration

EMERGING OBSERVATIONS –

1. MO and CS show highest preference as either being Option 1 or 2 and vice versa
   - Indicates mutual perception on Measurements and Construction of Shapes being strongest in human mind
2. OA has very few respondents with their Option 2 being related to Construction of Shapes
   - Illustrates Outlines are related to Constructions and perceptible with Shapes
3. CrP has the lowest preference as Option 1
   - This shows people do not connect Measures or Constructions in Creating Patterns
4. There emerges a strong relation of measures and shapes. However, the outlines become only relevant to Shapes , although shapes donot get noted in the context of pattern creation. Low range of data provides limited scope with validation with preference for only 2 attributes..

Q5. GEOMETRY IS NECESSARY FOR: Attributes for selection according to preference being–

a) Artwork [AR]
b) Sculpture [SC]
c) Products [PR]
d) Patterns [PA]



QUES 5- Fig. 64a: OPTION 1 Bar Diagram

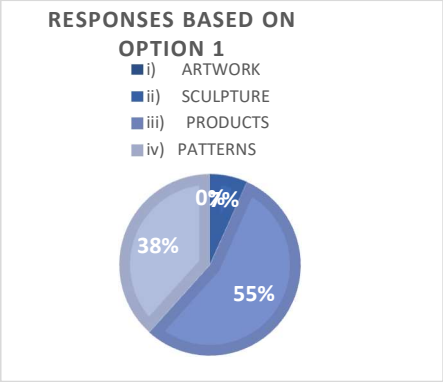
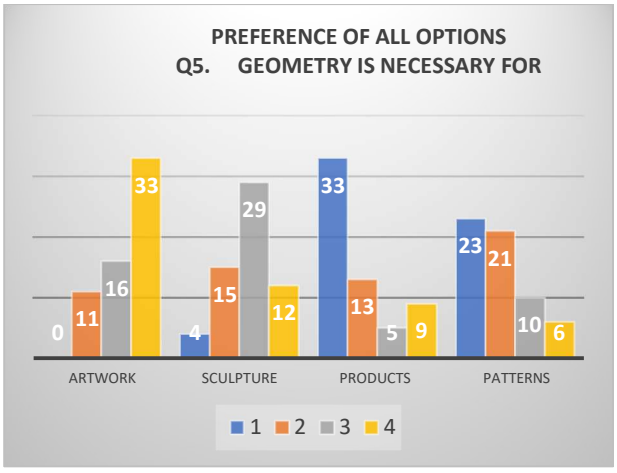


Fig. 64b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 55% respondents [33n] relate to PR, followed by 38% to PA [23n] and with least preference on SC and nil for AR
2. For Option 2, 34% [21n] prefer PA, while other options are uniformly opted by average 23% [11-15n] preferring the 3 attributes
3. As Option 3, SC shows preference at 49% [29n]
4. In Option 4, 55% respondents [33n] show their last preference to AR

COMPREHENSIVE TABULATION OF RESPONSES:



QUES 5- Fig. 64c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
ARTWORK	0	11	16	33
SCULPTURE	4	15	29	12
PRODUCTS	33	13	5	9
PATTERNS	23	21	10	6

Table 10: QUES 5- ALL RESPONSES [pc: Author]

PREFERRED SETS:

1. PR–PA- 33: 21, PR-SC- 33:15 [29 as Option 3]
2. PA–SC– 15:18, PA–AR– 23:11
3. Remaining options show very little data to consider

DERIVED OBSERVATION –

In Application of Geometry, respondents donot give cognizance to Geometry w.r.t. ARTWORK in their best preference. PATTERNS are preferred to ARTWORK, though both having little significance in selection

VALIDATION BY DATA BASED RESPONSE -

For the given set , the standard deviation of the given set of numbers is approximately 10.2, measuring the spread or dispersion of the numbers around their median value of 12.5 – with values ranging from nil to extremely high preference for some, the average preferences lie within a range that is visible in the above sets.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

[Respondents selection of AN Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

Fig. 64d: QUES 5 - OPTION 1 - w.r.t. other Options [pc: Author] [Derived from ANNEXURE 4c]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Functional vs. Aesthetic Applications**:
    - Option 3 (Products) emphasizes the functional necessity of geometry in designing and manufacturing products, where precise measurements and structural integrity are critical.
    - Option 4 (Patterns) underscores the aesthetic and decorative applications of geometry, particularly in creating visually appealing patterns and designs.
- **Artistic vs. Practical Considerations**:
    - Options 1 (Artwork) and 2 (Sculpture) show varying degrees of necessity for geometry in artistic expressions, with sculpture requiring more structural considerations compared to artwork, where geometry's role may be less defined or necessary.

DERIVED INTERPRETATION**:**

The data provides insights into the diverse applications of geometry across different domains—ranging from artistic expression to product design and decorative patterns. Understanding the necessity of geometry in these contexts highlights its versatile role in both functional and aesthetic aspects of creation and design.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

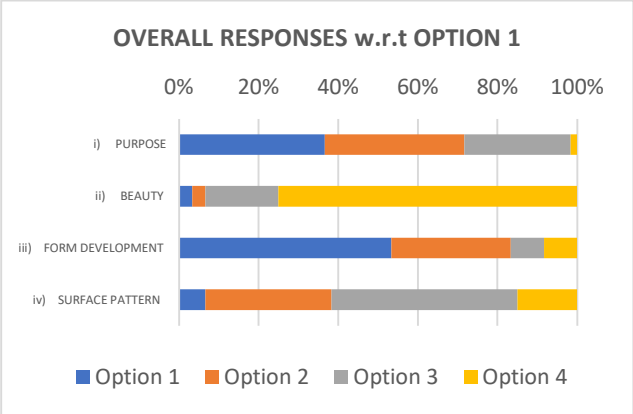
A. **Option 1 – Attribute # 1**: ARTWORK
   Nil preference as option 1
   Preference with choice #4: showing least preferred attribute
B. **Option 1 – Attribute # 2**: SCULPTURE
   Negligible number for consideration of preferred set
C. **Option 1 – Attribute # 3**: PRODUCTS
   Preference with choice #2: PR-PA [33:19], PR-SC [33:11]
   Preference with choice #3: PR-SC [33:16]
D. **Option 1 – Attribute # 4**: PATTERNS
   Preference with choice #2: PA-PR [23:11]
   Preference With Choice #3: PA-SC [23:13]

EMERGING OBSERVATION –

1. Artwork is not perceived as an expression of Geometry
   - It generates strong response as the last choice, possibly being organic in character
2. Majority of respondents identify Geometry in Products followed by Patterns
   - This illustrates perception in terms of specific lines, shapes and forms
3. Patterns become significant in this set where major question areas lead to artistry instead of design
   - Relative to organic and free flowing outlines, repeats into patterns become identifiable as a Geometric process
4. Due to nil or low data value, Artwork and Sculpture can be ignored
   - The 2 characteristics are perceived in the context of derivatives of the other

Q12. GEOMETRY IN DESIGN IS ESSENTIAL FOR: Attributes for selection according to preference being

a) Purpose [PU]
b) Beauty [BE]
c) Form Development [FD]
d) Surface Pattern [SP]



QUES 12- Fig 65a: OPTION 1 Bar Diagram

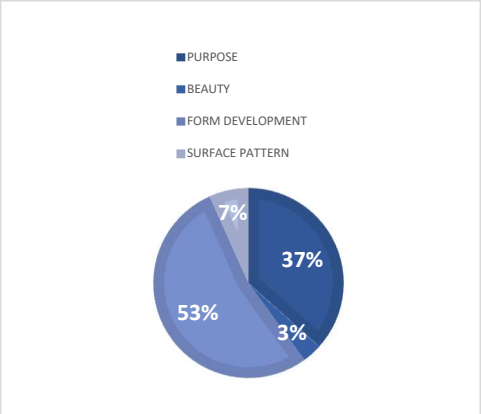
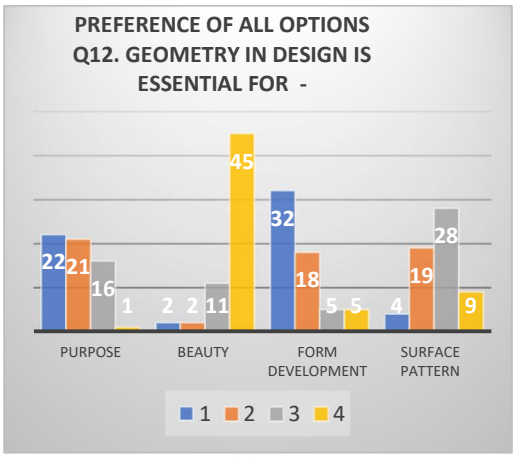


Fig. 65b: OPTION 1 Pie chart [pc: Author]

ANALYSIS :

1. Based on Option 1, 53% respondents [32n] relate to FD, followed by 37% for Pu [22n] and the remaining ones RE insignificant
2. For Option 2, it is similar for PU [21n] at 35%, SP [19n] at 32%, FD [18n] at 30%
3. For Option 3, 48% [28n] choose SP, with 26% [16n] preferring PU
4. In Option 4, 75% respondents [45n] relate to BE as the least preferred option

COMPREHENSIVE TABULATION OF RESPONSES :



QUES 12- Fig. 65c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
PURPOSE	22	21	16	1
BEAUTY	2	2	11	45
FORM DEVELOPMENT	32	18	5	5
SURFACE PATTERN	4	19	28	9

Table 11: QUES 12- ALL RESPONSES [pc: Author]

PREFERRED SETS:

1. FD–PU- 32:21, FD-SP – 32:19
2. PU–SP – 22:19, PU–FD – 22: 18
3. There are least preferences for Be or SP as Option 1

DERIVED OBSERVATION –

In Geometry in Design, respondents relate to FORM and PURPOSE, while PATTERNS are related in context of FORM or PURPOSE only. BEAUTY has least relevance to respondents give while PATTERNS have less value independently

VALIDATION BY DATA BASED RESPONSE -

For the given set, the standard deviation of the given set of numbers is approximately 12.58, measuring the spread or dispersion of the numbers around their median value of 13.5 - this justifies the preferential choice of the larger sample and the selection of the sets above. The lowest ranges to be ignored on insufficiency.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

[Respondents selection of an Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

Fig. 65d: QUES 12- OPTION 1 - w.r.t. other Options [pc: Author] [Derived from ANNEXURE 4c]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Functional vs. Aesthetic Considerations**:
    - Option 1 (Purpose) and Option 3 (Form Development) emphasize the functional necessity of geometry in design, focusing on achieving specific objectives and developing coherent forms.
    - Option 2 (Beauty) and Option 4 (Surface Pattern) highlight the aesthetic applications of geometry, where it contributes to enhancing beauty through patterns and visual appeal.
- **Comprehensive Design Integration**:
    - Geometry integrates into design across multiple dimensions, from fulfilling functional purposes and developing forms to enhancing beauty through intricate patterns and textures.

DERIVED INTERPRETATION**:**

The data underscores the multifaceted role of geometry in design, encompassing both functional and aesthetic dimensions. Understanding the necessity of geometry in different aspects—purpose, beauty, form development, and surface pattern—provides insights into its essential contributions to creating meaningful and visually appealing designs.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

A. **Option 1 – Attribute # 1: PURPOSE**
   Preference with choice #2: PU-FD [22:15]
   Preference with choice #3: almost all attributes have low data, hence ignored
B. **Option 1 – Attribute # 2: BEAUTY**
   With less than 1% respondents, the data is negligible for consideration
C. **Option 1 – Attribute # 3: FORM DEVELOPMENT**
   Preference with choice #2: FD-PU [32:19]
   Preference with choice #3: FD -SP [32-17]
D. **Option 1 – Attribute # 4: SURFACE PATTERNS**
   With less than 1% respondents, the data is negligible for consideration

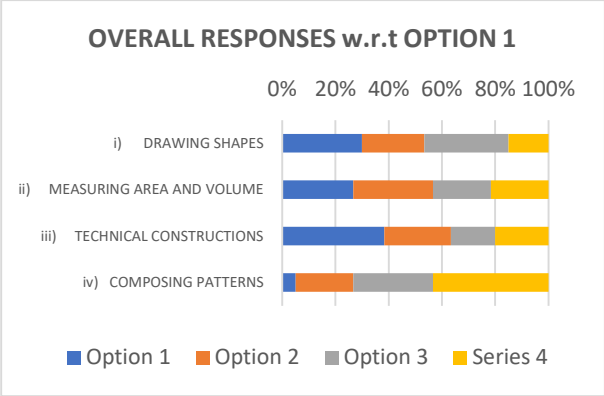
EMERGING OBSERVATION –

1. FD with PU has highest preference as either being Option 1 & 2 and vice versa.
   - It shows that majority of respondents associate Purpose with Form
2. FD and SP show a marginal relation where Surface Patterns are related with Form
   - Illustrates Form is perceived with its Surface Pattern
3. While there is a strong association between Form and its Surface in terms of Pattern, independently Pattern is not in cognition as preference.
   - This shows people connect cannot interpret Patterns except in relative context.
4. Beauty is considered completely away from Geometric perception
   - A major observation which illustrates that aesthetics is not primary as what looks good, but other factors play determinant to perceiving visual appeal

SET # B: Questions 2, 3, 4 – questions related to ELEMENTS AND PRINCIPLES OF GEOMETRY

Q2. APPLICATION OF GEOMETRY: Attributes for selection according to preference being

a) Drawing Shapes [DS]
b) Measuring Area and Volume [MAV]
c) Technical Constructions [TC]
d) Composing Patterns [CP]



QUES 2- Fig. 66a: OPTION 1 Bar Diagram

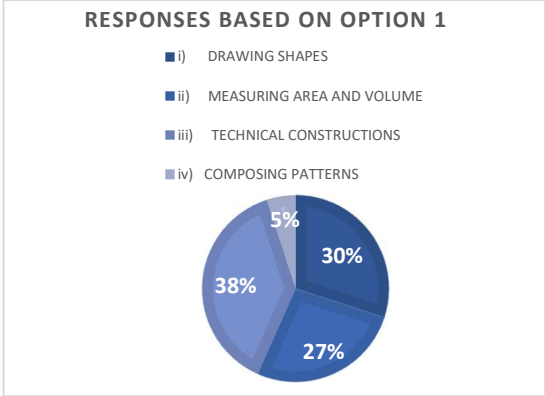
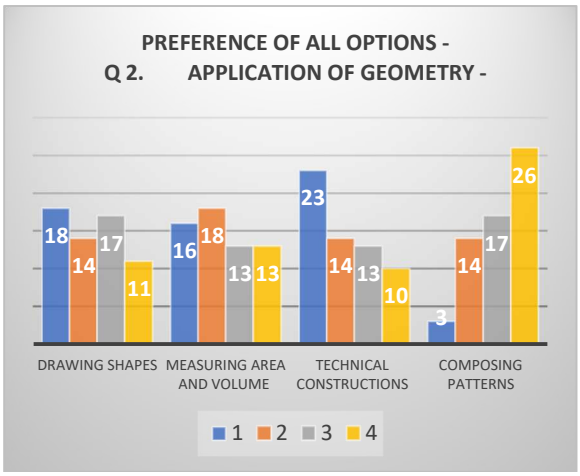


Fig. 66b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 38% respondents [23n] relate to TC , closely followed by 30% to DS [18n] and 27% to MAV [16n], with least preference on CP
2. For Option 2 & 3, all the attributes show similar number of respondents
3. In Option 4, 42% respondents [26n] relate to CP as the least preferred option

COMPREHENSIVE TABULATION OF RESPONSES-



QUES 2- Fig. 66c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
DRAWING SHAPES	18	14	17	11
MEASURING AREA AND VOLUME	16	18	13	13
TECHNICAL CONSTRUCTIONS	23	14	13	10
COMPOSING PATTERNS	3	14	17	26

Table 12: QUES 2- ALL RESPONSES [pc: Author]

PREFERRED SETS :

1. TC–MAV - 23:18, TC–DS [17N as OPTION 3] – 23:14
2. DS–MAV – 18:18 , DS–CP [17N as OPTION 3] –18:14
3. MAV–DS – 16:14 , MAV-CP –16:14 [17N as OPTION 3]

DERIVED OBSERVATION –

In Application of Geometry, respondents relate to SHAPES and MEASUREMENTS, relating both to CONSTRUCTION, and give least significance to PATTERNS over other choices

VALIDATION BY DATA BASED RESPONSE -

For the given set, the standard deviation of the given set of numbers is approximately 5.24, measuring the spread or dispersion of the numbers around their mean value of 14 - which eliminates the extremes of the least preferred options and the preferential choice of the larger sample justifies the selection of the sets above.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

[Respondents selection of an Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

Fig. 66d: QUES 2- OPTION 1 - w.r.t. other Options [pc: Author] [Derived from ANNEXURE 4c]

RELATIONSHIPS AND INTERDEPENDENCIES

- **Skill Diversity**
  - Each option requires a distinct set of skills and attributes w.r.t. geometry. Option 1 (drawing shapes) focus on precision and spatial awareness, while Option 3 (technical constructions) emphasize structural analysis and problem-solving
- **Complementary Skills**:
  - There may be overlaps in skills and attributes across options- creativity in Option 4 (composing patterns) and Option 1 (drawing shapes), or mathematical proficiency in Option 2 (measuring area and volume) and Option 3 (technical constructions)
- **Specialization**:
  - Option 3 (technical constructions) requiring specialized technical knowledge, Option 2 (measuring area and volume) requires strong mathematical and analytical skills.

DERIVED INTERPRETATION**:**

The data provided illustrates the diverse applications of geometry and the corresponding attributes or skills required for each option. Understanding these attributes helps in identifying the specific competencies and interdependencies between different types of geometric applications, highlighting the varied skill sets needed across domains such as visual representation, measurement, technical analysis, and creative design.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

A. Option 1 – Attribute # 1: DRAWING SHAPES
Preference with choice #2: DS-MAV, DS-CP [18:7]
Preference with choice #3: DS-TC [18:8], DS-MAV [18:7]

B. Option 1 – Attribute # 2 : MEASURING AREA AND VOLUME
Preference with choice #2: MAV-TC [16:9], MAV -DS [16:7]
Preference with choice #3: MAV-DS [16:7], MAV -CP [16:6]

C. Option 1 – Attribute # 3 : TECHNICAL CONSTRUCTIONS
Preference with choice #2: TC-MAV [23:10], TC- DS [23 :7]
Preference with choice #3: TC-DS [23:8], TC-CP [23:7]

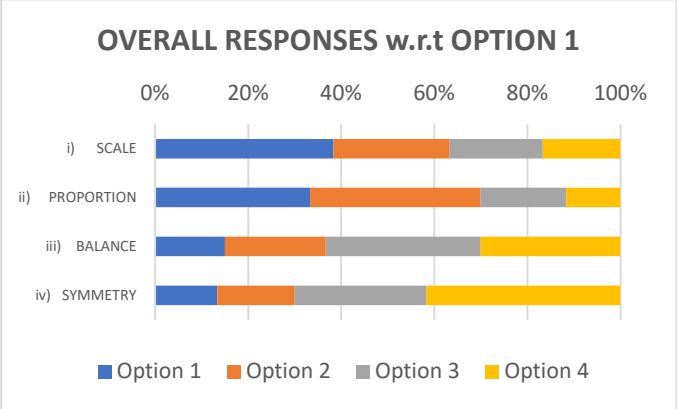
D. Option 1 – Attribute # 4: COMPOSING PATTERNS
With only 5% respondents, the data is negligible for consideration

EMERGING OBSERVATION –

1. MAV and DS show highest preference as either being Option 1 or 2 and vice versa and recurrence also as Option 3
   - Indicates perception of Measures in Shapes being strongest in human mind
2. DS and TC show second highest preference as either being Option 1 or 2 and vice versa and recurrence also as Option 3
   - Illustrates Shapes are directly perceived to Constructions
3. MAV and TC show third highest preference of either being Option 1 or 2
   - This shows people connect Measures to Constructions
4. Although there emerges a relation of all three attributes to creating patterns, the absence of data on CP as Option 1 limits the preference validation and is eliminated as a choice.

Q3. GEOMETRY CONTAINS: Attributes for selection according to preference being–

a) Scale [SC]
b) Proportion [PR]
c) Balance [BA]
d) Symmetry [SY]



QUES 3- Fig. 67a: OPTION 1 Bar Diagram

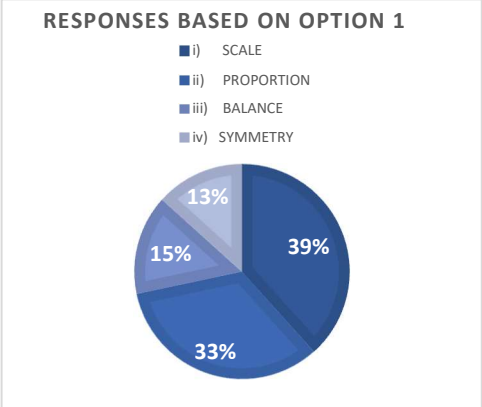
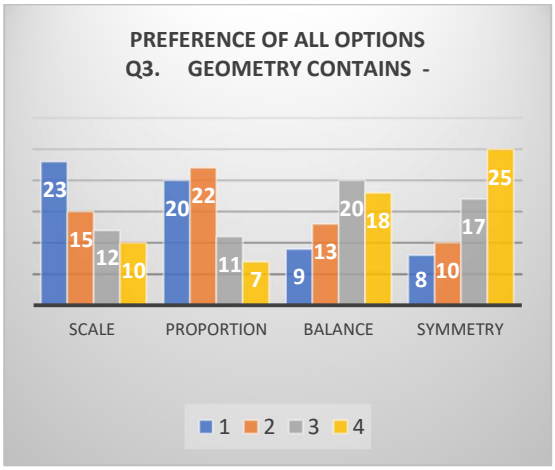


Fig. 67b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 39% respondents [23 n] relate to SC, followed by 33% to PR [20 n] and with least preference on BA or SY
2. For Option 2, 36% [22n] prefer PR, closely followed by 33% [20n] preferring BA
3. As Option 3, similar preferences show for BA [20n] and SY [17n]
4. In Option 4, 40% respondents [25n] relate to SY and 30% [18n] to BA, as the least preferred option

COMPREHENSIVE TABULATION OF RESPONSES-



QUES 3- 67c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
SCALE	23	15	12	10
PROPORTION	20	22	11	7
BALANCE	9	13	20	18
SYMMETRY	8	10	17	25

Table 13: QUES 3- ALL RESPONSES [pc: Author]

PREFERRED SETS:

1. SC–PR - 23:22, SC–BA – 23:13
2. PR–SC – 20:15, PR–BA – 20:13
3. SC –SY– 23:17, PR-BA – 20: 20 [As OPTION 3]

DERIVED OBSERVATION –

In understanding what Geometry contains, respondents relate to SCALE and PROPORTION, relating both to BALANCE, and give least significance to SYMMETRY over other choices

VALIDATION BY DATA BASED RESPONSE -

For the given set , the standard deviation of the given set of numbers is approximately 5.52, measuring the spread or dispersion of the numbers around their mean value of 15 - which eliminates the least preferred options and the preferential choice of the larger sample justifies the observations on selected sets above.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

[Respondents selection of an Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

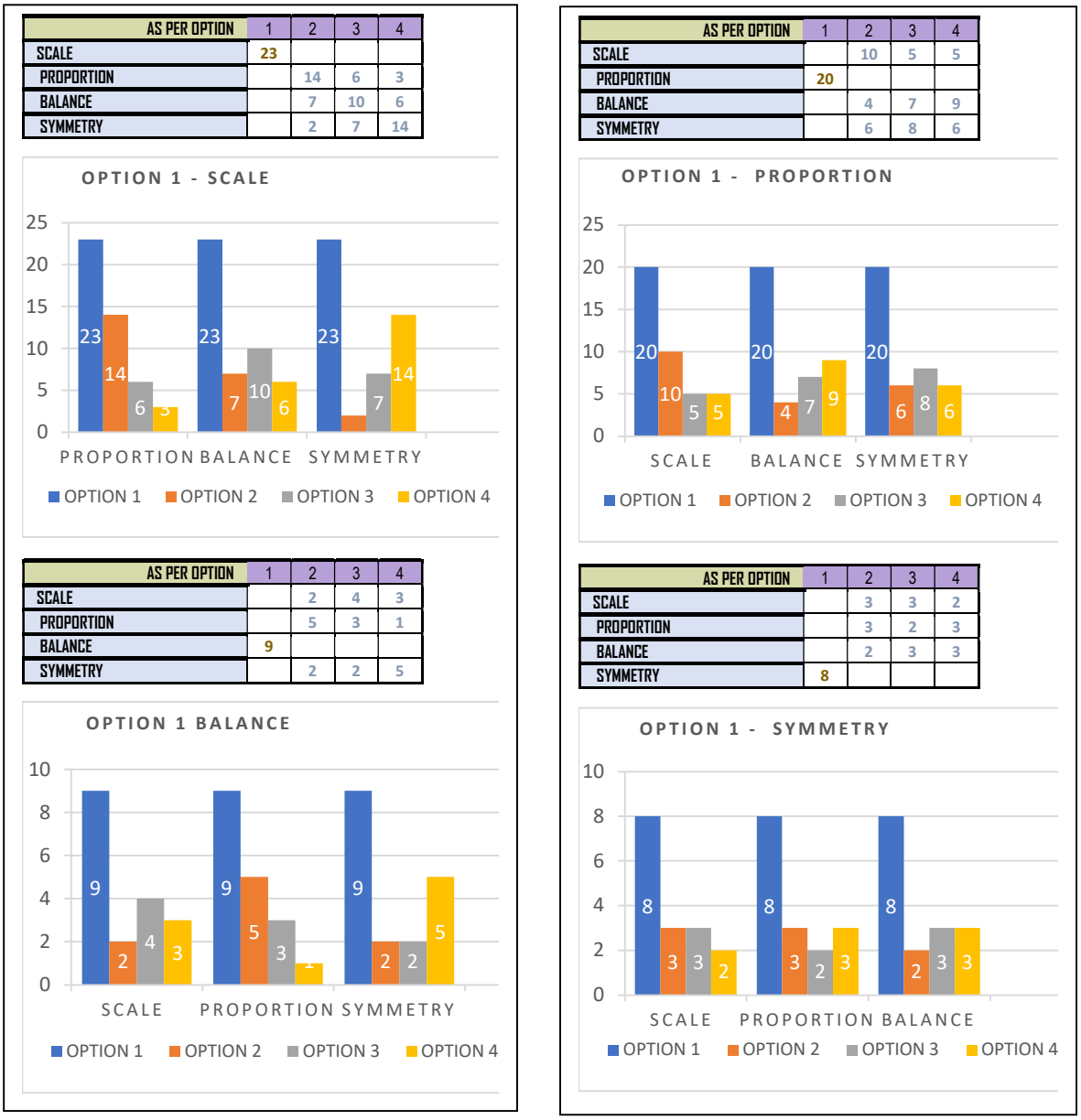


Fig. 67d: QUES 3- OPTION 1 - w.r.t. other Options [pc: Author]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Proportion and Balance**:
    - Option 2 (Proportion) and Option 3 (Balance) are closely related, as they both deal with the visual harmony and proportionate relationships within geometric designs. Achieving balance often involves maintaining proportional relationships among different elements.
- **Symmetry and Scale**:
    - Option 1 (Scale) and Option 4 (Symmetry) can be related in terms of how size and measurement (scale) affect the perception and application of symmetry in geometric forms. Larger or smaller scales can influence how symmetry is perceived or achieved in designs.
- **Comprehensive View**:
    - Together, these options provide a comprehensive view of essential aspects within geometry. Scale sets the size and measurement standards, Proportion ensures balanced relationships, Balance maintains visual harmony, and Symmetry adds aesthetic appeal through mirrored repetition.

DERIVED INTERPRETATION**:**

The data demonstrates the diverse aspects encompassed within geometry—Scale, Proportion, Balance, and Symmetry—each playing a crucial role in understanding and creating geometric compositions. Understanding these relationships helps in appreciating the fundamental principles and aesthetic considerations involved in geometric designs and structures.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

A. Option 1 – Attribute # 1: SCALE
Preference with choice #2: SC-PR [23:14]
Preference with choice #3: SC-BA [23:10]

B. Option 1 – Attribute # 2: PROPORTION
Preference with choice #2: PR-SC [20:10]
Preference with choice #3: PR-SY [20:8], PR - BA [20:7]

C. Option 1 – Attribute # 3: BALANCE
Preference with choice #2: BA-PR [9:5]
Preference with choice #3: - data is beyond deviation range

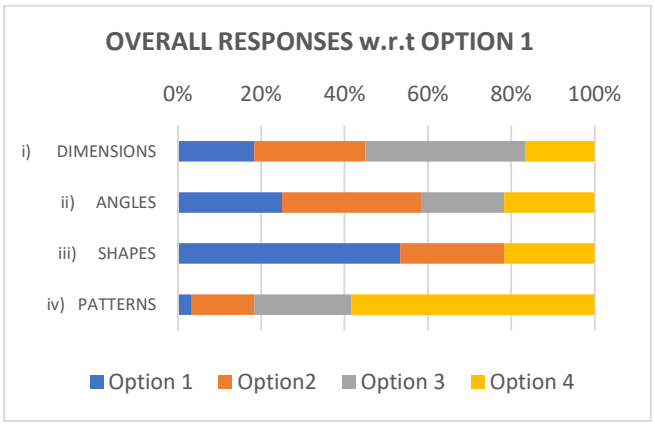
D. Option 1 – Attribute # 4: SYMMETRY
With only 5% respondents, the data is negligible for consideration

EMERGING OBSERVATION –

1. SC and PR show highest preference as either being Option 1 or 2 and vice versa
    - Indicates perception of relative dimension and size being strongest in human mind
2. BA show second highest preference and recurrence as Option 3 only
    - This illustrates consideration of visual balance less significant to relative proportion
3. SY is considered relevant only to PR and BA
    - The option remains least preferred indicating symmetry in visual composition less desired

Q4. GEOMETRY IS SEEN THROUGH: Attributes for selection according to preference being

a) Dimensions [DI]
b) Angles [AN]
c) Shapes [SH]
d) Patterns [PA]



QUES 4- Fig. 68a: OPTION 1 Bar Diagram

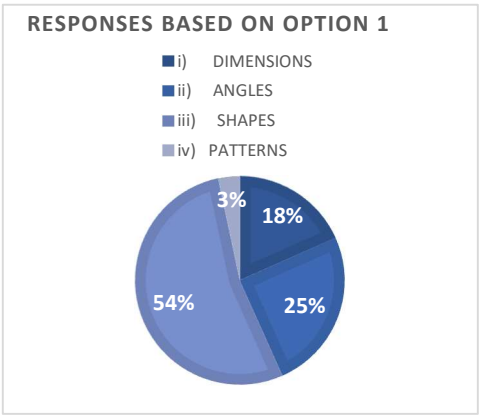
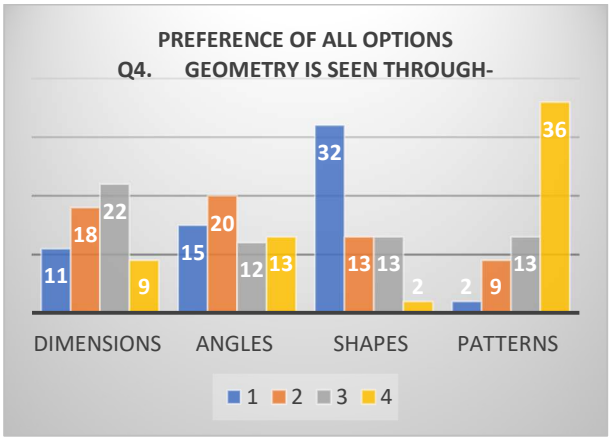


Fig. 68b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 54% respondents [32n] relate to SH, followed by 25% for AN [15 n] and 18% on DI [11 n], with least preference on Pa
2. For Option 2, 33% [20n] choose AN, 30% [18n] choose DI, 21% [13n] prefer SH
3. For Option 3, 37% [22n] choose DI
4. In Option 4, 60% respondents [36n] relate to PA as the least preferred option

COMPREHENSIVE TABULATION OF RESPONSES-



QUES 4- Fig. 68c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
DIMENSIONS	11	18	22	9
ANGLES	15	20	12	13
SHAPES	32	13	13	2
PATTERNS	2	9	13	36

Table 14: QUES 4- ALL RESPONSES [pc: Author]

PREFERRED SETS :

1. SH–AN- 32:20
2. AN–DI– 15:18, DI–AN –11:20
3. AN–DI– 20:22, [Between 2 & 3], AN-PA– 20: 13 [36n As OPTION 4]

DERIVED OBSERVATION –

In Application of Geometry, respondents relate to SHAPES and ANGLES, while ANGLES are related to all attributes in mid-range data, while respondents give least significance to PATTERNS over other choices

VALIDATION BY DATA BASED RESPONSE –

For the given set , the standard deviation of the given set of numbers is approximately 8.83, measuring the spread or dispersion of the numbers around their mean value of 15 – this eliminates the extremes of the least preferred options and the preferential choice of the larger sample justifies the selection of the sets above, with the exception of the highest preference which also remains singular in identity.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

[Respondents selection of AN Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

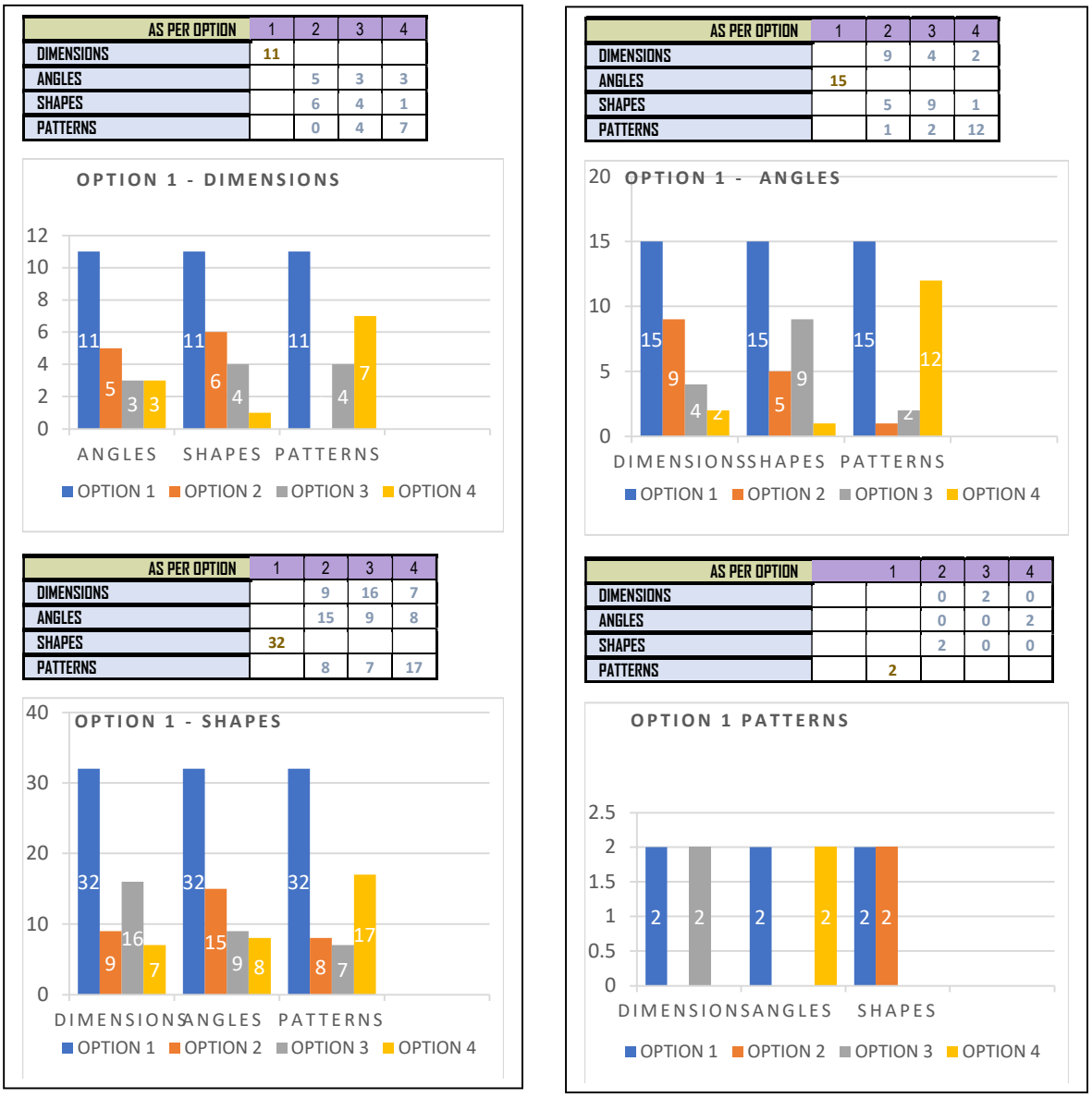


Fig. 68d: QUES 4- OPTION 1 - w.r.t. other Options [pc: Author] [Derived from ANNEXURE 4c]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Shapes and Patterns**:
  - Option 3 (Shapes) and Option 4 (Patterns) both emphasize fundamental aspects of geometric representation. Shapes provide the foundational forms, while patterns explore their repetitive and decorative arrangements.
- **Angles and Dimensions**:
  - Option 1 (Dimensions) and Option 2 (Angles) are closely related as they both deal with measurements and spatial relationships within geometry. Understanding dimensions helps in defining angles, and vice versa.
- **Comprehensive View**:
  - Together, these options provide a comprehensive view of how geometry is perceived and understood. Dimensions set the scale, angles define spatial relationships, shapes represent the forms, and patterns illustrate the repetitive nature or decorative elements within geometric contexts.

DERIVED INTERPRETATION**:**

The data illustrates various aspects through which geometry is perceived—Dimensions, Angles, Shapes, and Patterns—each contributing uniquely to our understanding and representation of geometric concepts. Understanding these relationships helps in appreciating the diverse facets of geometry, from fundamental measurements to intricate patterns and forms.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

A. Option 1 – Attribute # 1: DIMENSIONS
Preference with choice #2: DI-SH [11:7], Di- AN [11:5]
Preference with choice #3: almost all attributes have low data, hence ignored

B. Option 1 – Attribute # 2: ANGLES
Preference with choice #2: AN – DI [15:9]
Preference with choice #3: AN- SH [15:9]

C. Option 1 – Attribute # 3: SHAPES
Preference with choice #2: SH-AN [32:15]
Preference with choice #3: SH-DI [32-16]

D. Option 1 – Attribute # 4: PATTERNS
With less than 1% respondents, the data is negligible for consideration

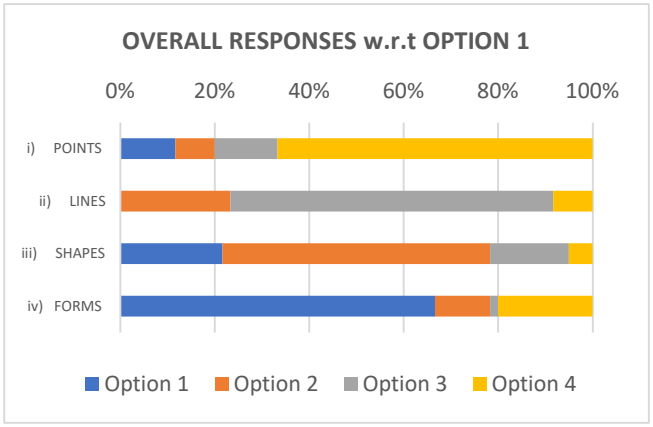
EMERGING OBSERVATION –

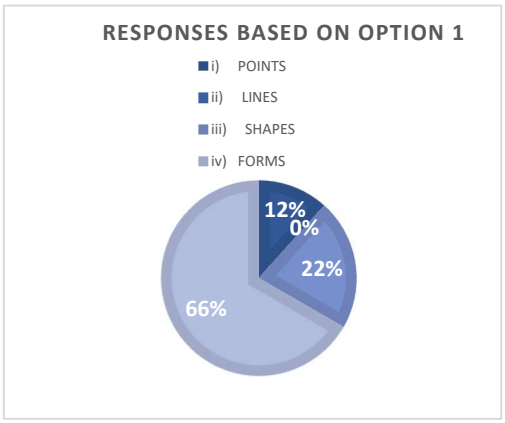
1. SH with DI has highest preference as either being Option 1 & 2 and vice versa and recurrence also as Option 3. SH and AN have highest preference as Option 1 & 2 , and recurrence in Option 3
   - Indicates perception of Shapes being strongest in human mind and relates to Dimensions followed by Angles
2. AN and DI show second highest preference as either being Option 1 or 2 and vice versa and have similar range of preference
   - Illustrates Angles are directly aligned with Dimensions
3. The absence of data on Pattern as Option 1 limits the preference and eliminates the option. -This shows people connect Shapes in isolation , relate Angles and Dimensions similarly, but cannot interpret the same in terms of Patterns

SET # C: Questions 6, 7, 8 – questions related to GEOMETRY AND NATURAL OBJECTS

Q6. IN NATURE WE SEE: Attributes for selection according to preference being

a) Points [PO]
b) Lines [LI]
c) Shapes [SH]
d) Forms [FO]



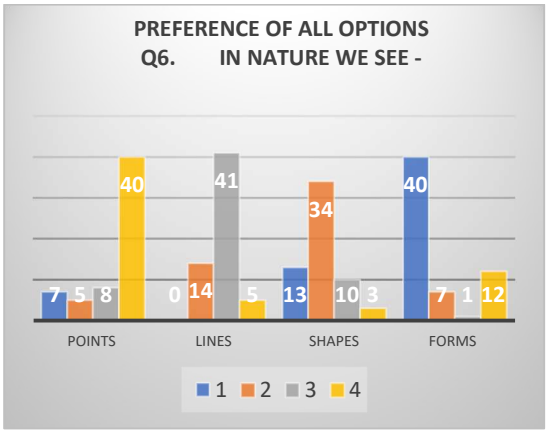


QUES 6- Fig.69a: OPTION 1 Bar Diagram **Fig. 69b:** OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 66% respondents [40n] relate to FO, with least choice on others
2. For Option 2 & 3, preference shows 52% [34n] for SH and 67% [41n] for LI
3. In Option 4, 67% respondents [41n] relate to PO as the least preferred option

COMPREHENSIVE TABULATION OF RESPONSES-



AS PER OPTION	1	2	3	4
POINTS	7	5	8	40
LINES	0	14	41	5
SHAPES	13	34	10	3
FORMS	40	7	1	12

QUES 6- Fig. 69c: OPTION 1 Bar Diagram **Table 15: QUES 6- ALL RESPONSES** [pc: Author]

PREFERRED SETS:

1. FO–SH- 40:34, FO– LI [Option 2]– 40:41
2. SH–LI– 13:14 & 13:41 [As OPTION 3]
3. Po is least selected with maximum [40n] selecting as Option 4 only

DERIVED OBSERVATION –

In respect of Natural objects, respondents relate Geometry predominantly to FORMS and SHAPES, relating both to LINES, and give least significance to POINTS over other choices

VALIDATION BY DATA BASED RESPONSE -

For the given set, the standard deviation of the given set of numbers is approximately 14.76, measuring the spread or dispersion of the numbers around their mean value of 15 eliminating the extremes of the least preferred options and justifying the preferential choices of the majority of respondents in the sets above.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

[Respondents selection of AN Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

Fig. 69d: QUES 6- OPTION 1 - w.r.t. other Options [pc: Author] [Derived from ANNEXURE 4c]

RELATIONSHIPS AND INTERDEPENDENCIES

- **Hierarchy of Observation**:
  - Option 4 (Forms) stands out with the highest score, indicating that overall forms or structures are most prominently observed in nature, encompassing a wide range of natural phenomena.
  - Option 2 (Lines) and Option 3 (Shapes) also score significantly, suggesting that linear features and distinct shapes play prominent roles in natural patterns and compositions.
- **Interconnectedness**:
  - Points (Option 1) contribute to the formation of lines, shapes, and forms in nature, highlighting their foundational role in natural geometry.

DERIVED INTERPRETATION**:**

The data underscores the rich presence of geometric elements in nature, demonstrating how points, lines, shapes, and overall forms contribute to the diversity and beauty of natural landscapes and structures. Understanding these elements helps in appreciating the underlying geometry inherent in natural patterns and forms.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

A. Option 1 – Attribute # 1: POINTS
Preference with choice #2: PO-LI [7:6]
Preference with choice #3: PO-SH [7:6]

B. Option 1 – Attribute # 2: LINES
No respondent has selected LI as Option 1

C. Option 1 – Attribute # 3: SHAPES
Preference with choice #2: SH-FO [13:7] SH-LI [13:5]
Preference with choice #3: SH-LI [13:7], SH-PO [13:5]

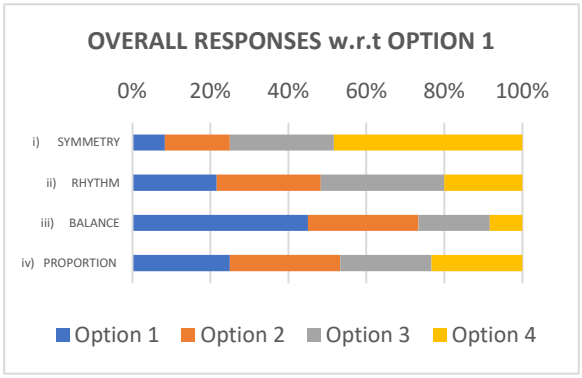
D. Option 1 – Attribute # 4: FORMS
Most preferred option having equal preference for other attributes
Preference with choice #2: FO-SH [40:33]
Preference with choice #3: FO-LI & choice #4: FO-PO show equal preference [40:33]

EMERGING OBSERVATION –

1. FO shows highest preference as either being Option 1 and with dominance over others
   - Indicates perception of overall form being primary in human interpretation
2. SH is second highest preference as either being Option 1 or 2
   - Illustrates Shapes are directly perceived in Forms
3. Li and PO show least as primary consideration in perceiving natural objects, though LI stands out as the nest preferred option to SH
   - This shows people find points or lines within forms less significant for cognition
4. Although there emerges a relation of FO with SH, the absence of data on LI as Option 1 limits the preference validation and is eliminated as a choice or merged within outline of FO.

Q7. NATURAL ENVIRONMENT HAS: Attributes for selection according to preference being–

a) Symmetry [SY]
b) Rhythm [RH]
c) Balance [BA]
d) Proportion [PR]



QUES 7- Fig. 70a: OPTION 1 Bar Diagram

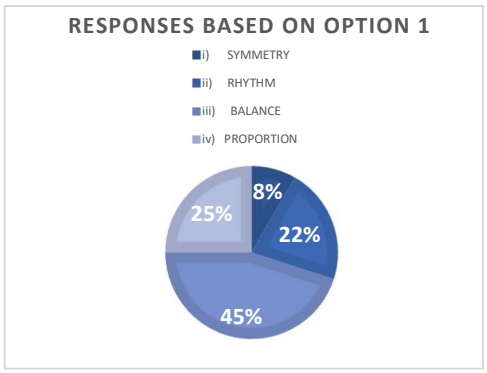
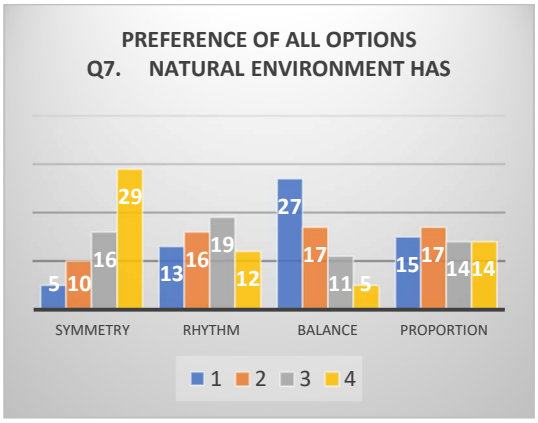


Fig. 70b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 45% respondents [27n] relate to BA, followed by 25% to PR [15n] and 22% to RH [13n] with least preference for Sy
2. For Option, BA & PR [17n] show equal preference at 27%, closely followed at 26% [16n] preferring RH
3. As Option 3, RH [19n] at 32% is followed by similar preferences for SY [16n] at 26% and PR [14] at 24%
4. As Option 4, SY [29n] at 49% is followed by preference for PR [14n] at 23% and RH [12n] at 20%

COMPREHENSIVE TABULATION OF RESPONSES-



QUES 7- Fig. 70c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
SYMMETRY	5	10	16	29
RHYTHM	13	16	19	12
BALANCE	27	17	11	5
PROPORTION	15	17	14	14

Table 16: QUES 7- ALL RESPONSES [pc: Author]

PREFERRED SETS:

1. BA–PR - 27:17, BA–RH – 27:16 and BA – RH- 27-19 [as Option 3]
2. PR–BA –15:17, PR–RH – 15:16, PR–RH - 15-19 [as Option 3]
3. SY appears to be the least choice for respondents

DERIVED OBSERVATION –

In respect of understanding Geometry in natural environment, respondents can majorly perceive BALANCE, relating it to PROPORTION, with emphasis w.r.t RHYTHM, and SYMMETRY appears to be of least significance over other attributes

VALIDATION BY DATA BASED RESPONSE -

The standard deviation of the given set of numbers is approximately 8.79, around a mean value of 15 - which shows the higher incidence of numbers and a preferential choice of the larger sample on higher end while a limited low value on the other, based on the observations on selected sets above.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES
[Respondents selection of an Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

Fig. 70d: QUES 7- OPTION 1 - w.r.t. other Options [pc: Author]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Interconnected Characteristics**:
  - Symmetry (Option 1) and Balance (Option 3) both involve the concept of equilibrium and structured organization in natural environments, albeit with different emphases.
  - Rhythm (Option 2) and Proportion (Option 4) focus on the repetitive patterns and proportional relationships observed in natural phenomena, contributing to the overall harmony and coherence.
- **Perceptual Variations**:
  - The varying scores across Symmetry, Rhythm, Balance, and Proportion suggest different levels of emphasis or observation in how these characteristics manifest in the natural world.

DERIVED INTERPRETATION**:**

The data illustrates the nuanced characteristics observed in natural environments, highlighting how symmetry, rhythm, balance, and proportion contribute to the overall structure and beauty of the natural world - from balanced structures and rhythmic patterns to proportional relationships and occasional symmetrical forms. These elements help in the appreciation of underlying principles of harmony and order that govern natural systems.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

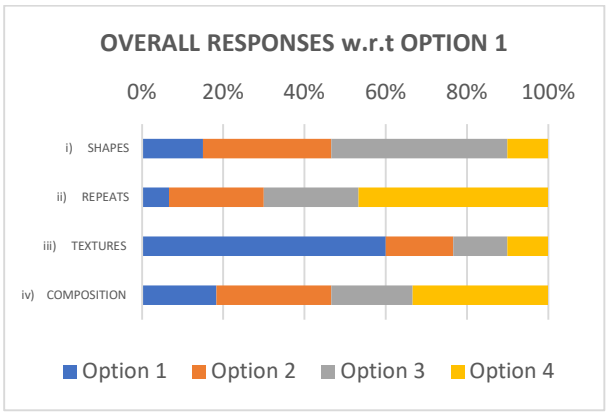
A. **Option 1 – Attribute # 1: SYMMETRY**
   Only 8% respondents make the attribute least significant for consideration
B. **Option 1 – Attribute # 2: RHYTHM**
   Preference with choice #2: RH-PR [13:7]
   Low incidence of selection of Option makes it less preferred as choice based on perception
C. **Option 1 – Attribute # 3: BALANCE**
   Most preferred option having marginal choice for Rhythm
   Preference with choice #2: BA-RH [27:12]
   Other attributes are insignificant
D. **Option 1 – Attribute # 4: PROPORTION**
   Preference with choice #2: PR-BA [15:10]
   The secondary choice for respondents and relatable to primary option Balance

EMERGING OBSERVATION –

1. BA has highest preference as either being Option 1 or 2
   - Indicates human perception can perceive visual balance in human mind
2. PR shows second highest preference and recurrence as Option 3 as well
   - This indicates consideration of geometric proportion relative to visual balance
3. RH is considered with relation to BA and PR
   - The option remains least preferred indicating symmetry in visual composition less desired
4. SY is not instantly perceived by human mind or remains insignificant for cognizance

Q8. SURFACE OF NATURAL OBJECTS SHOW: Attributes for selection according to preference being

a) Shapes [SH]
b) Repeats [RE]
c) Textures [TE]
d) Composition [CO]



QUES 8- Fig. 71a: OPTION 1 Bar Diagram

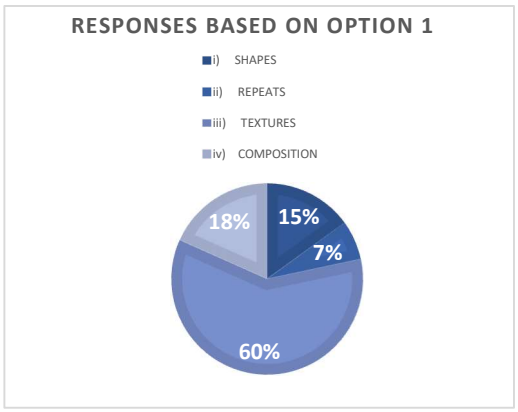
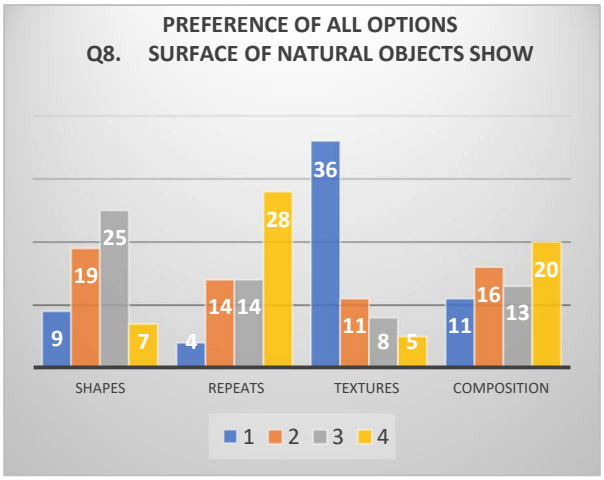


Fig. 71b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 60% respondents [36n] relate to TE, followed by only 18% for CO [11n]
2. For Option 2, 32% [19n] choose SH, followed by 27% [16n] who choose Co, 21% [14n] preferring RE
3. For Option 3, 42% [25n] choose SH
4. In Option 4, 47% respondents [28n] relate to RE as the least preferred option

COMPREHENSIVE TABULATION OF RESPONSES-



QUES 8- Fig. 71c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
SHAPES	9	19	25	7
REPEATS	4	14	14	28
TEXTURES	36	11	8	5
COMPOSITION	11	16	13	20

Table 17: QUES 8- ALL RESPONSES [pc: Author]

PREFERRED SETS:

1. TE–SH- 36:19 & TE-SH – 36:25 [as Option 2]
2. SH–RE–19:14, CO–SH - 16:25 [Between 2 & 3],
3. TE-RE– 36:28 & TE-CO-36:20 [showing primarily least choices in Option 4]

DERIVED OBSERVATION –

In the Surface of Natural Objects, respondents perceive TEXTURE easily, with SHAPES remaining the next most preferred visual perception. Although REPEAT and COMPOSITION are observed in the context of SHAPE, they remain least significant as independent characteristics

VALIDATION BY DATA BASED RESPONSE -

For the given set, the standard deviation of the given set of numbers is approximately 8.83, measuring the spread or dispersion of the numbers around their mean value of 15 - this eliminates the extremes of the least preferred options and the preferential choice of the larger sample justifies the selection of the sets above, with the exception of the highest preference which also remains singular in identity.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

[Respondents selection of AN Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

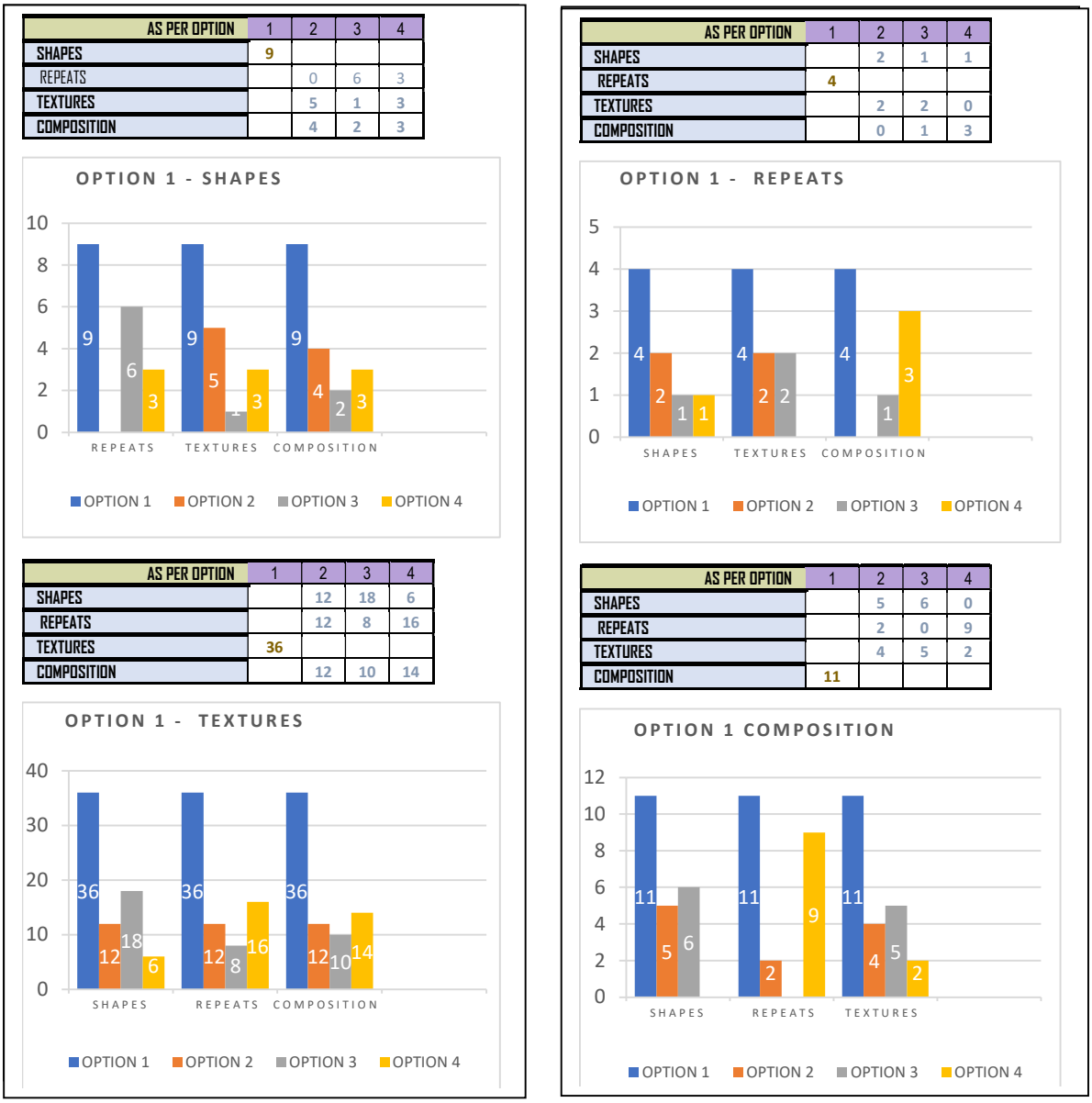


Fig. 71d: QUES 8- OPTION 1 - w.r.t. other Options [pc: Author] [Derived from ANNEXURE 4c]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Interconnected Surface Features**:
  - Shapes (Option 1) and Repeats (Option 2) both contribute to the visual patterns and forms observed on natural surfaces, with shapes defining the primary forms and repeats indicating their recurring nature.
- **Tactile and Visual Aspects**:
  - Textures (Option 3) and Composition (Option 4) emphasize the tactile qualities and organizational structure of surface elements, providing insights into both visual aesthetics and functional attributes of natural objects.
- **Perceptual Observations**:
  - The scores reflect varying levels of emphasis or observation of these surface characteristics, suggesting different perspectives or priorities in how these features are perceived or studied in natural contexts.

DERIVED INTERPRETATION**:**

The data highlights the intricate surface characteristics observed in natural objects, underscoring how shapes, repeats, textures, and composition contribute to the visual appeal and structural integrity of natural forms. These elements not only enrich our understanding of natural aesthetics but also provide insights into ecological functions and evolutionary adaptations in natural systems.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

A. Option 1 – Attribute # 1: SHAPES
Preference with choice #2: SH-TE [9:5], SH- CO [9:4]
Preference with choice #3: SH–RE [9:6], while none chose RE in Option 2

B. Option 1 – Attribute # 2: REPEATS
Too few respondents in selecting this option – hence data is ignored

C. Option 1 – Attribute # 3: TEXTURES
Preference with choice #2: TE–SH, TE– RE, TE–CO [36 :12 each]
Preference with choice #3: TE-SH [36:18]

D. Option 1 – Attribute # 4: COMPOSITION
Preference with choice #2: CO-SH [11:5]
Preference with choice #4: CO–RE [11:9] – shows RE are least selected w.r.t. CO

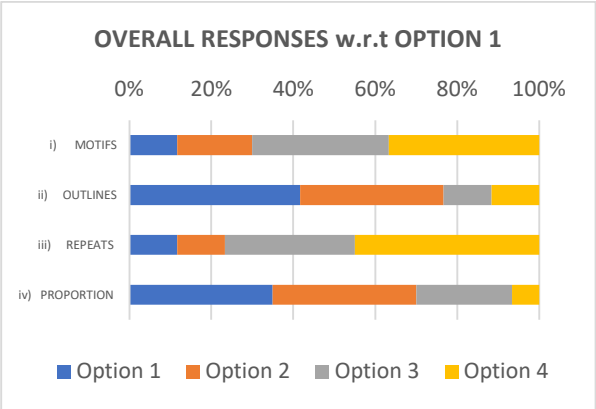
EMERGING OBSERVATION –

1. TE has highest preference as Option 1 having equal preference for the remaining 3
   – showing other attributes can be read w.r.t. TE, with high number of respondents choosing TE as Option # 1
2. SH has maximum preference as the next choice w.r.t to all attributes and vice versa and recurrence also as Option 3
   – perception of Shapes being strongest in human mind and related to Composition followed by Repeats
3. There is a relation of all three attributes equally to TE.
   –This establishes that while Texture has equal interdependency on perception with other choices, Repeats are less cognizable and remain the least preference, while Composition is also hard to interpret.

SET # D: Questions 9, 10, 11– questions related to GEOMETRY AND MAN-MADE OBJECTS

Q9. GEOMETRY OF MAN-MADE DESIGN LIES IN: Attributes for selection according to preference being

a) Motifs [MO]
b) Outlines [OU]
c) Repeats [RE]
d) Proportion [PR]



QUES 9- Fig. 72a: OPTION 1 Bar Diagram

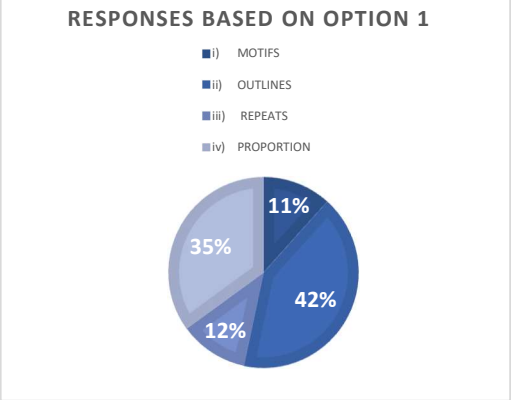
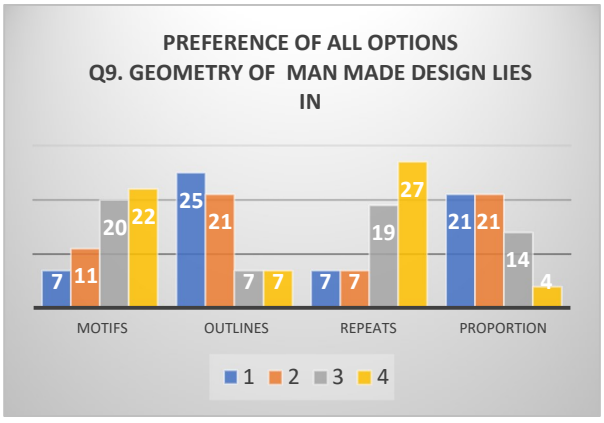


Fig. 72b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 42% respondents [25n] relate to OU, followed with 35% for PR [21n]
2. For Option 2, 35% [21n] choose either OU or PR,
3. For Option 3, 34% [20n] choose MO, closely followed at 33% [19n] for RE
4. In Option 4, 45% respondents [27n] relate to RE as the least preferred option, with 37% [22n] finding MO as the lowest option

COMPREHENSIVE TABULATION OF RESPONSES-



QUES 9- Fig. 72c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
MOTIFS	7	11	20	22
OUTLINES	25	21	7	7
REPEATS	7	7	19	27
PROPORTION	21	21	14	4

Table 18: QUES 9- ALL RESPONSES [pc: Author]

PREFERRED SETS :

1. Ou–PR - 25:21 & PR-OU– 21:21 [in Option 2]
2. Ou–MO – 25:20, OU–RE - 25:19 [as Option 3],
3. PR-MO – 21:20 & PR-RE- 21:19 [being the next preferred in Option 3]

DERIVED OBSERVATION –

Interpreting Geometry in MAN made Objects, respondents perceive OUTLINE easily, relate with PROPORTION, and vice versa, making this mutual choice for visual perception. MOTIF and REPEAT are observed only in respect of OUTLINE, but also remain least significant as independent characteristics

VALIDATION BY DATA BASED RESPONSE -

In this given set, the standard deviation of the given set of numbers is approximately 7.75, with the spread or dispersion of the numbers in both extremes around their mean value of 16 -concentration of numbers on the higher periphery eliminates the least preferred options and the preferential choice of the larger sample concentrates on the selection of the sets above, with the balance on the highest value of responses

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

[Respondents selection of an Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

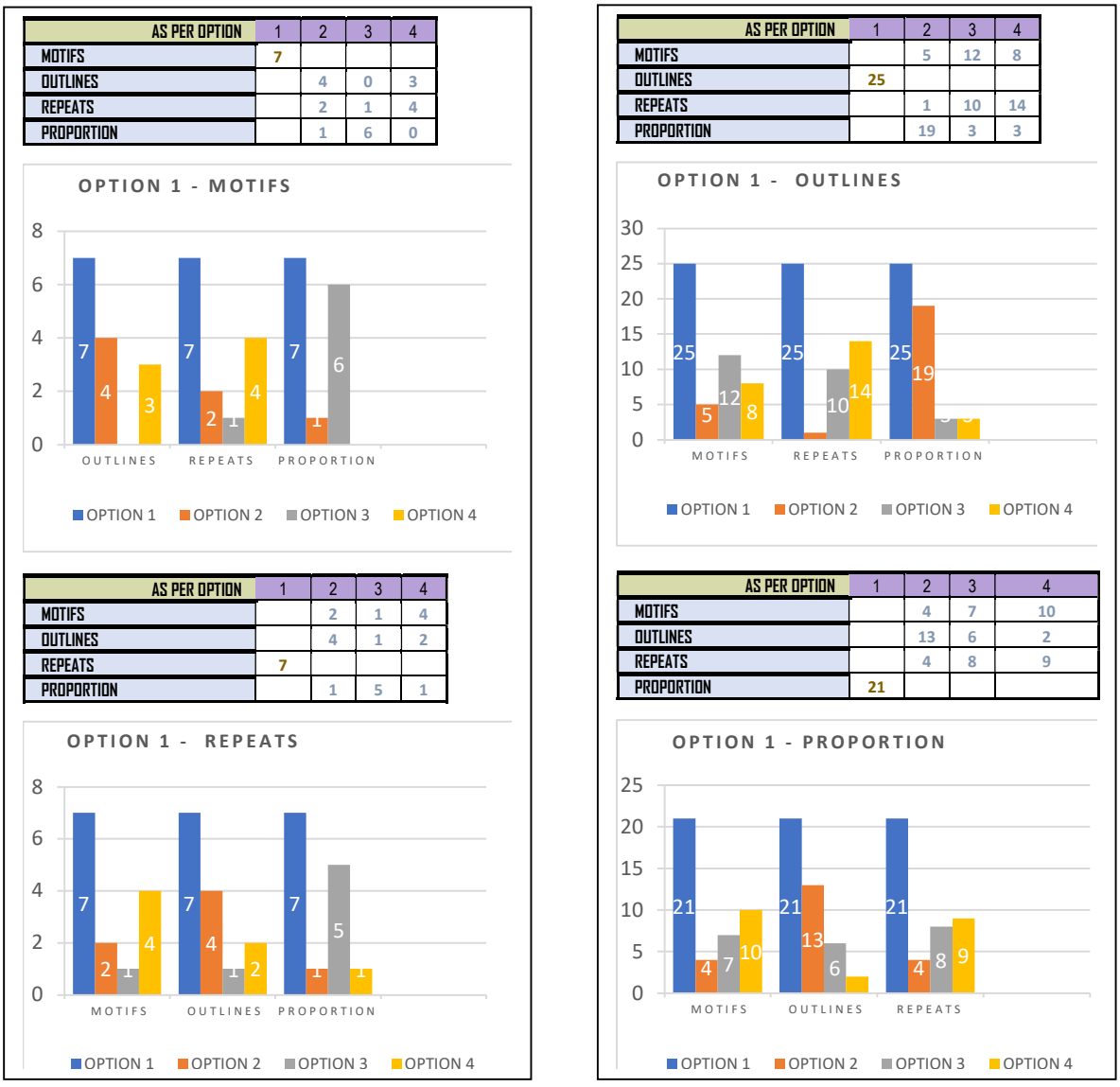


Fig 72d: QUES 9- OPTION 1 - w.r.t. other Options [pc: Author]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Structural vs. Aesthetic Elements**:
  - Option 2 (Outlines) and Option 4 (Proportion) emphasize structural aspects, with outlines defining shapes and proportion governing spatial relationships.
  - Option 3 (Repeats) contributes to both structural coherence and aesthetic appeal through repetitive patterns.
  - Option 1 (Motifs) suggests a more decorative or thematic role in enhancing design rather than defining its geometric structure.
- **Comprehensive Design Integration**:
  - Together, these options provide a comprehensive view of how geometric principles—outlined shapes, proportional relationships, repetitive patterns, and thematic motifs—contribute to the geometry and visual impact of man-made designs.

DERIVED INTERPRETATION**:**

The data underscores the multifaceted nature of geometry in man-made designs, where outlines, proportion, repeats, and motifs each play distinct roles in defining structure, rhythm, coherence, and thematic richness. Understanding these elements helps in appreciating the underlying geometric principles that govern effective design in various contexts. However, the interrelation of Outlines and Proportion is stronger in human mind than deciphering Motifs and Repeats in man-made objects.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1:

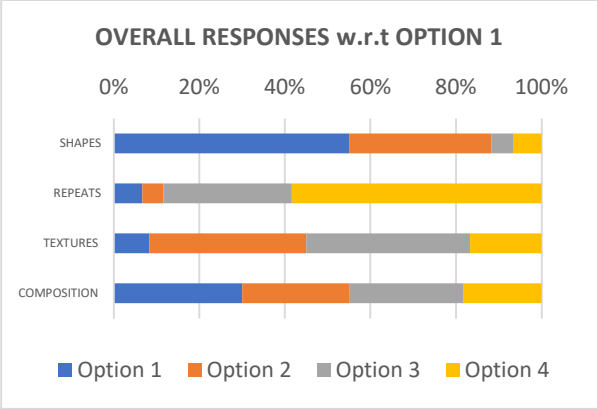
A. **Option 1 – Attribute # 1: MOTIFS**
   Preference with choice #2: MO-OU [7:4]
   Preference with choice #3: MO–PR [7:6], while other options negligible
B. **Option 1 – Attribute # 2: OUTLINES**
   Preference with choice #2: OU-PR [25:19]
   Preference with choice #3: OU–MO [25:12], and OU-RE [25:10]
C. **Option 1 – Attribute # 3: REPEATS**
   Preference with choice #2: RE-OU [7:4]
   Preference with choice #3: RE-PR [7:5]
D. **Option 1 – Attribute # 4: PROPORTION**
   Preference with choice #2: PR-OU [21:13]
   Other preferences have low value w.r.t Option #1 for any consideration

EMERGING OBSERVATION –

1. Ou has highest preference as Option 1, followed closely by PR, mutually having same dependency being options # 2 and #3 as well
   – other attributes can be marginally read w.r.t. OU or PR, but not independently. While OU and PR are mutually dependent as related attributes, which human mind takes cognizance subconsciously
2. MO and RE are found secondarily to OU and in relation to PR
   – showing MO and RE relate to OU but stand out as least choices too

Q10. MAN MADE OBJECTS SHOW: Attributes for selection according to preference being

a) Shapes [SH]
b) Repeats [RE]
c) Textures [TE]
d) Composition [CO]



QUES 10- Fig. 73a: OPTION 1 Bar Diagram

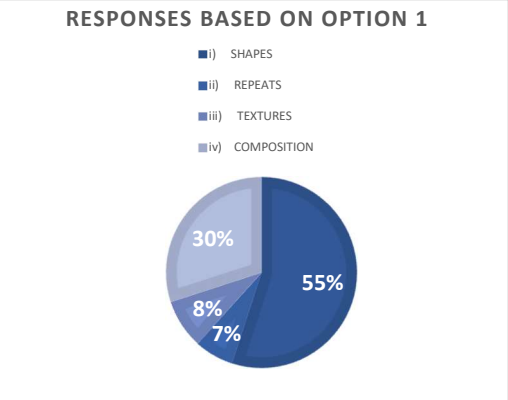
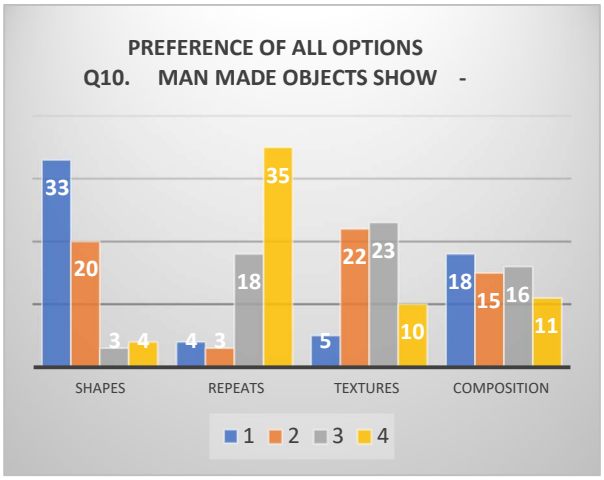


Fig. 73b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 42% respondents [25n] relate to OU followed with 35% for PR [21n]
2. For Option 2, 35% [21n] choose either OU or PR,
3. For Option 3, 34% [20n] choose MO, closely followed at 33% [19n] for RE
4. In Option 4, 45% respondents [27n] relate to RE as the least preferred option, with 37% [22n] finding MO as the lowest option

COMPREHENSIVE TABULATION OF RESPONSES -



QUES 10- Fig. 73c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
SHAPES	33	20	3	4
REPEATS	4	3	18	35
TEXTURES	5	22	23	10
COMPOSITION	18	15	16	11

Table 19: QUES 10- ALL RESPONSES [pc: Author]

PREFERRED SETS:

1. SH–TE - 33:22, SH-CO – 33:15 [in Option 2]
2. SH–TE – 33:23, SH–RE- 33:18 [as Option 3],
3. CO-TE – 18:22 & CO - SH- 18:20 [being the next preferred in Option 2]

DERIVED OBSERVATION –

In MAN made Objects, human eyes perceive SHAPES predominantly, can relate with TEXTURES mainly, and makes it a choice for COMPOSITION, which is secondary to Shapes in cognizance. REPEATS are observed least in significance, but also remain least significant as independent characteristics

VALIDATION BY DATA BASED RESPONSE -

In this given data, the standard deviation of the given set of numbers is approximately 10.17, which indicates the dispersion of the numbers in the higher range with mean value of 15 – larger value of numbers on the higher end eliminates the less preferred options and the preferential choice of the sample is determined on the basis of the higher preferred options.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

[Respondents selection of an Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

Fig. 73d: QUES 10- OPTION 1 - w.r.t. other Options [pc: Author] [Derived from ANNEXURE 4c]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Diversity of Characteristics**:
  - Shapes (Option 1) stand out with the highest score, indicating their prominent role in defining the visual identity and structural integrity of man-made objects.
  - Textures (Option 3) and Composition (Option 4) also score notably, highlighting their contributions to the sensory experience and organizational clarity of man-made designs.
- **Visual vs. Functional Considerations**:
  - While Shapes and Textures emphasize visual and tactile aspects, Composition focuses more on the structural and organizational aspects of man-made objects.
  - Repeats (Option 2) suggests a moderate presence of repetitive patterns, contributing to visual rhythm or thematic consistency in designs.

DERIVED INTERPRETATION**:**

The data highlights shapes and composition while it underscores how textures and repetitive patterns contribute to the visual appeal, functional design, and overall aesthetic quality of man-made objects. These elements not only define their physical appearance but also influence how they are perceived, used, and appreciated in various contexts.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

A. Option 1 – Attribute # 1: SHAPES

Preference with choice #2: SH-TE [33:20]

Preference with choice #3: SH–CO [33:13]

B. Option 1 – Attribute # 2: REPEATS

Too few responses to consider- negligible data

C. Option 1 – Attribute # 3: TEXTURE

Too few responses to consider- negligible data

D. Option 1 – Attribute # 4: COMPOSITION

Preference with choice #2: CO-SH [18:15]

Preference with choice #3: CO–TE [18:10]

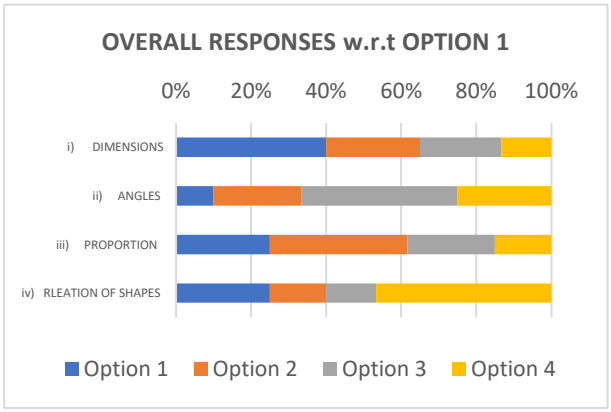
Other preferences have low value w.r.t Option #1 for any consideration

EMERGING OBSERVATION –

1. SH is most preferred as Option 1, followed distantly by CO. As most respondents choose shapes, remaining data falls in significance.
   – It is understood that TE can be interpreted largely by SH, and RE and CO are in cognizance at a later stage.
2. Re and TE generated least response
   – indicates that in visual perception repeats and textures are not primarily focussed
3. CO, though not with a large response, remains linked with SH
   – It can be interpreted that CO is understood through SH and remains dependent for cognizance

Q11. MAN MADE DESIGNS DEPEND ON: Attributes for selection according to preference being

a) Dimensions [DI]
b) Angles [AN]
c) Proportion [PR]
d) Relation of Shapes [RoS]



QUES 11- Fig. 74a: OPTION 1 Bar Diagram

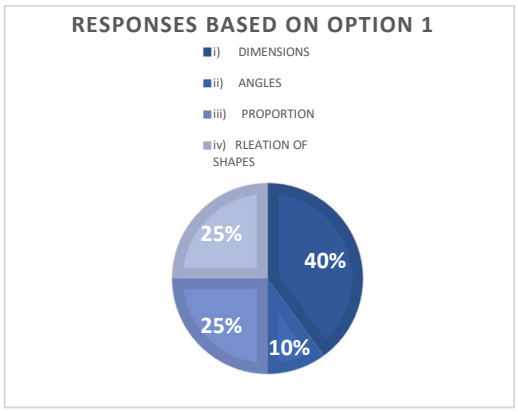
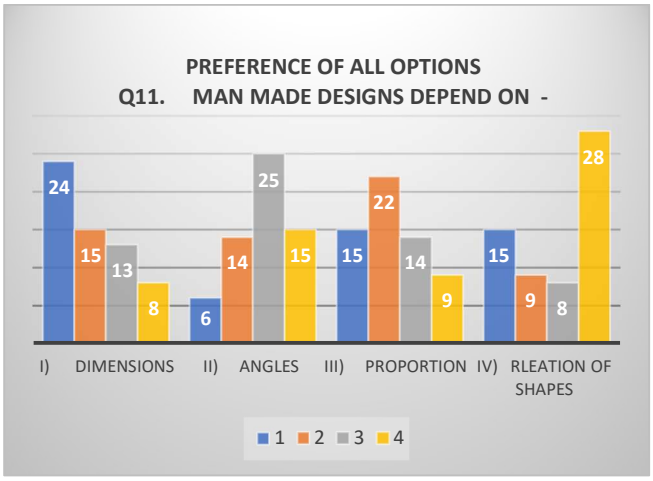


Fig. 74b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 40% respondents [24n] relate to DI, followed by 25% [15n] for both PR & ROS
2. For Option 2, 40% [24n] choose PR
3. For Option 3, 42% [25n] choose AN
4. In Option 4, 48% respondents [28n] select ROS as the least preferred option

COMPREHENSIVE TABULATION OF RESPONSES –



QUES 11- Fig. 74c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
DIMENSIONS	24	15	13	8
ANGLES	6	14	25	15
PROPORTION	15	24	12	9
RELATION OF SHAPES	15	7	10	28

Table 20: QUES 11- ALL RESPONSES [pc: Author]

PREFERRED SETS:

1. DI–PR - 24:24 & PR-DI– 15:15 [in Option 2]
2. DI–AN – 25: 25 [as Option 3],
3. PR - AN – 15: 25 [being the next preferred in Option 3]

DERIVED OBSERVATION –

For respondents, MAN made Design Depends On primarily DIMENSIONS, with secondary selection of PROPORTION, and vice versa with equal number of respondents' selection, with RELATION OF SHAPES being a less recognized choice. ANGLES remain the least significant for determining man-made objects.

VALIDATION BY DATA BASED RESPONSE -

The standard deviation of the given set of numbers is approximately 6.83, with the dispersion of the numbers mostly uniform at both extremes with mean value of 15 - concentration of numbers on the extreme periphery not being very high both ways, it results in preferential choice of the larger sample concentrating on the selection of the sets above, with the balance mostly around the median.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

Respondents' selection of AN Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

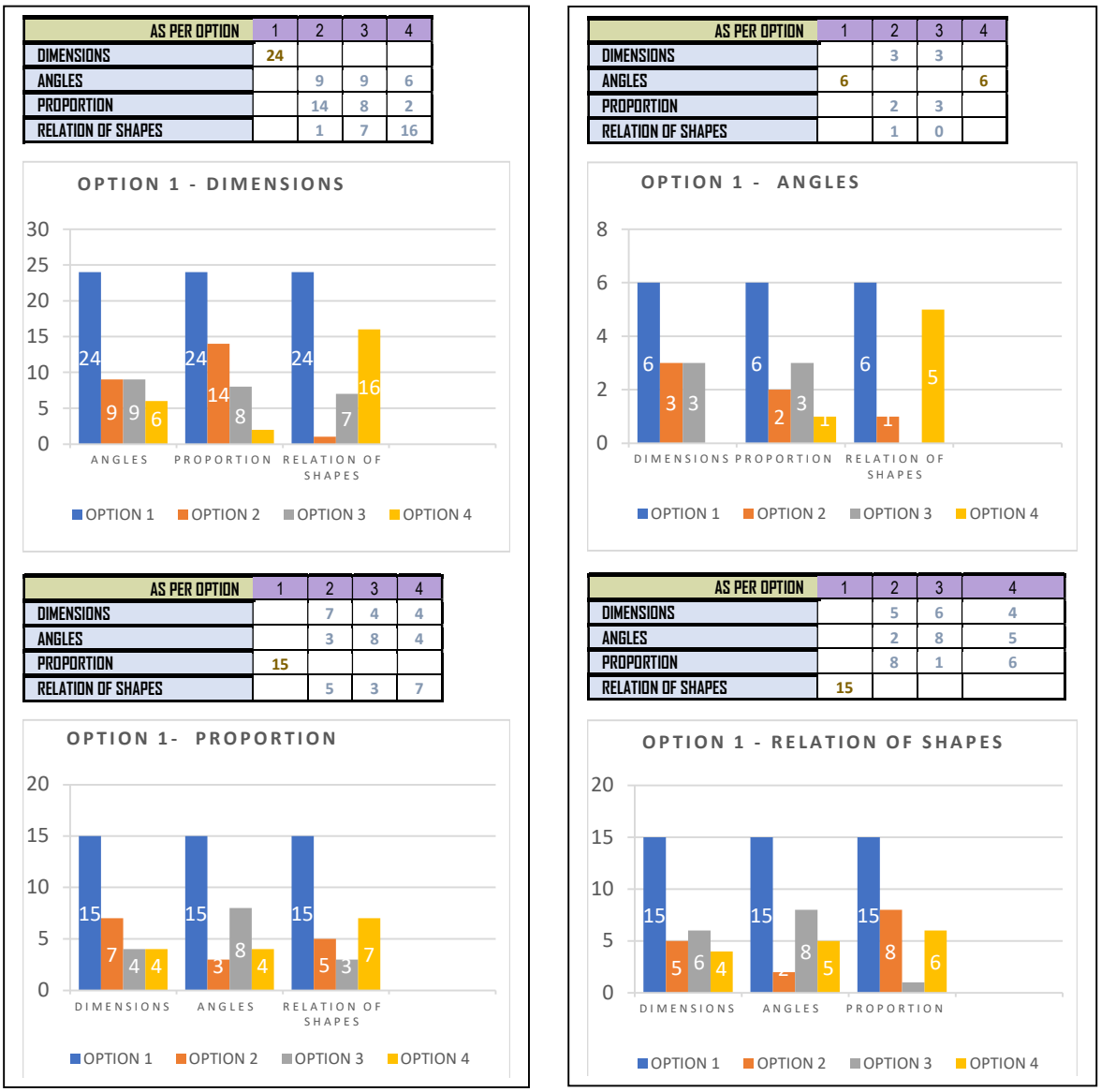


Fig. 74d: QUES 11- OPTION 1 - w.r.t. other Options [pc: Author]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Spatial and Structural Elements**:
  - Dimensions (Option 1) and Angles (Option 2) both contribute to the spatial definition and geometric precision of man-made designs, ensuring functional integrity and aesthetic appeal.
- **Design Composition**:
  - Proportion (Option 3) and Relation of Shapes (Option 4) focus on the harmonious arrangement and interconnectedness of elements, enhancing the overall composition and visual unity of designs.
- **Integrated Design Principles**:
  - Together, these options illustrate how dimensions, angles, proportion, and the relationship of shapes collectively influence the creation, structure, and aesthetic qualities of man-made designs, reflecting a holistic approach to design.

DERIVED INTERPRETATION**:**

The data highlights the fundamental design principles that underpin man-made creations, emphasizing the critical roles of dimensions, angles, proportion, and the relationships between shapes in defining their spatial, structural, and visual attributes. These elements collectively contribute to the efficacy, beauty, and harmony of designed objects and environments in various contexts.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

A. Option 1 – Attribute # 1: DIMENSIONS
Preference with choice #2: DI-PR [24:14]
Preference with choice #3: DI–AN [24:9], while other options even lesser

B. Option 1 – Attribute # 2: ANGLES
Too few respondents having selected as Option # 1, makes it a very insignificant attribute

C. Option 1 – Attribute # 3: PROPORTION
Preference with choice #2: PR-DI [15:7]
Preference with choice #3: PR-AN [15:8]

D. Option 1 – Attribute # 4: RELATION OF SHAPES
Preference with choice #2: ROS-PR [15:8]
Preference with choice #3 ROS-AN [15:]

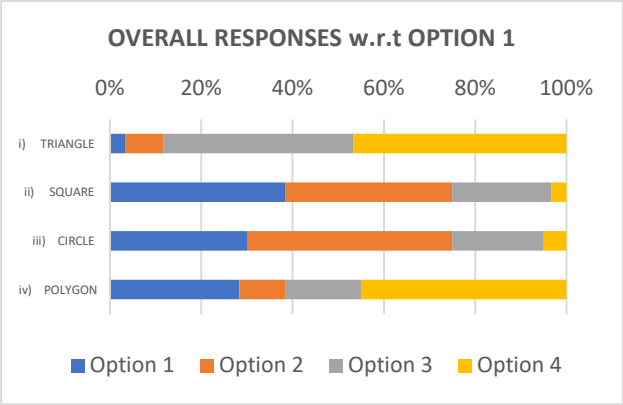
EMERGING OBSERVATION –

1. DI has highest preference as Option 1, followed at a lower value by PR, mutually having same dependency being options #2, and by ROS, which has more value to PR in Option 2
   – Dimensions appear more relatable in man-made objects by the human eye
2. PR and ROS are equally but secondarily observed as Option 1
   – While Dimensions is relatable to proportion, these attributes find association to angles
3. AN finds least significance
   – Human observation do not focus on angular aspects, however the relevance of this attribute is seen w.r.t Proportion as well as Shapes subsequently

SET # E: Questions 13, 14, 15 – questions related to SHAPES IN GEOMETRY

Q13. SHAPES SEEN MOSTLY AROUND US: Attributes for selection according to preference being

a) Triangle [TR]
b) Square [SQ]
c) Circle [CI]
d) Polygon [PO]



QUES 13- Fig. 75a: OPTION 1 Bar Diagram

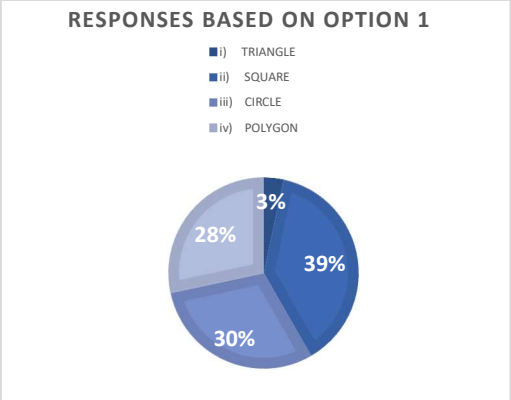
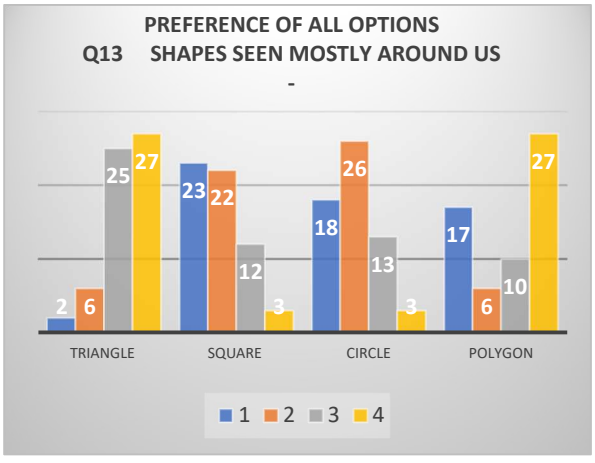


Fig. 75b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 39% respondents [23n] relate to SQ, followed closely by 30% [18n] for CI and 28% [17n] by PO
2. For Option 2, 44% [26n] choose CI
3. For Option 3, 42% [25n] choose TR
4. In Option 4, 47% respondents [27n] select both TR and PO as the least preferred option

COMPREHENSIVE TABULATION OF RESPONSES –



QUES 13- Fig. 75c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
TRIANGLE	2	6	25	27
SQUARE	23	22	12	3
CIRCLE	18	26	13	3
POLYGON	17	6	10	27

Table 21: QUES 13- ALL RESPONSES [pc: Author]

PREFERRED SETS:

1. SQ–CI - 23:26 & CI - SQ – 18:22, PO-CI-17:26 [in Option 2]
2. SQ–TR – 23:25 [as Option 3],
3. SQ-TR – 23:27, SQ-PO – 23:27 [being the next preferred in Option 3]

DERIVED OBSERVATION –

For most respondents, Shapes in Geometry primarily are recognized in SQUARE, with CIRCLE being the next recognized shape, followed by POLYGON, with RELATION OF SHAPES. TRANGLE remain the least noticed shape in objects around us.

VALIDATION BY DATA BASED RESPONSE -

The standard deviation of the given set of numbers is approximately 9.28, as the distribution of the numbers mostly remain towards the higher values, and a concentration in the mid-range maintaining the mean at 15 - concentration of numbers on the higher periphery results in preference of the larger sample resulting in the selection of the sets above, with a few very low numbers balancing the range around the mean value.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES
[Respondents selection of an Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

Fig. 75d: QUES 13- OPTION 1 - w.r.t. other Options [pc: Author] [Derived from ANNEXURE 4c]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Utility and Aesthetics**:
  - Squares (Option 2) and Circles (Option 3) are highly rated for their utility in man-made objects and natural forms, reflecting their functional and aesthetic significance.
  - Triangles (Option 3 and Option 4) and Polygons (Option 1 and Option 4) demonstrate their versatility in both natural and built environments, contributing to structural integrity and design diversity.
- **Observational Frequency**:
  - The scores suggest varying degrees of observation and application of these shapes in our surroundings, influenced by their inherent properties and cultural associations.

DERIVED INTERPRETATION**:**

The data underscores the diversity and ubiquity of geometric shapes in our everyday surroundings, highlighting their essential roles in architecture, design, and natural formations. Recognizing these shapes helps in appreciating their contributions to both functional utility and aesthetic appeal in diverse contexts. Understanding the prevalence and roles of different shapes—triangle, square, circle, and polygon—provides insights into their functional, aesthetic, and structural contributions to our built environment and natural surroundings. These shapes not only serve practical purposes but also contribute to visual harmony and design coherence.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1 :

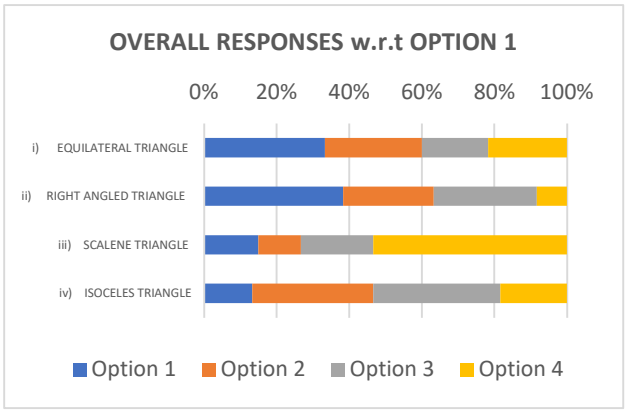
A. **Option 1 – Attribute # 1: TRIANGLE**
   Least number of respondents selecting as Option 1 makes it a redundant option for data
B. **Option 1 – Attribute # 2: SQUARE**
   Preference with choice #2: SQ-CI [23:20]
   Preference with choice #3: SQ-Tr [23:14]
C. **Option 1 – Attribute # 3: CIRCLE**
   Preference with choice #2: CI-SQ [18:11]
   Preference with choice #3: CI-TR [18 :9]
D. **Option 1 – Attribute # 4: POLYGON**
   Preference with choice #2: PO –SQ [17:11]
   Preference with choice #3: PO-CI [17:12]

EMERGING OBSERVATION –

1. SQ has highest preference as Option 1, followed by CI & PO, mutually having same dependency with SQ being options # 2
   – Squares are perceived most easily by the human eye followed by Circles and Polygons
2. CI and PO are equally but secondarily observed as Option 1
   – For perceiving objects, these attributes are significant to cognition in relation to SQ
3. TR find least significance independently
   – However, it is considered in conjunction with other attributes

Q14. TYPE OF TRIANGLE SEEN MOSTLY IN OBJECTS – NATURAL AND MAN MADE: Attributes for selection according to preference being

a) Equilateral Triangle [EQTR]
b) Right-angled Triangle [RATR]
c) Scalene Triangle [SCTR]
d) Isoceles Triangle [ISTR]



QUES 14- Fig. 76a: OPTION 1 Bar Diagram

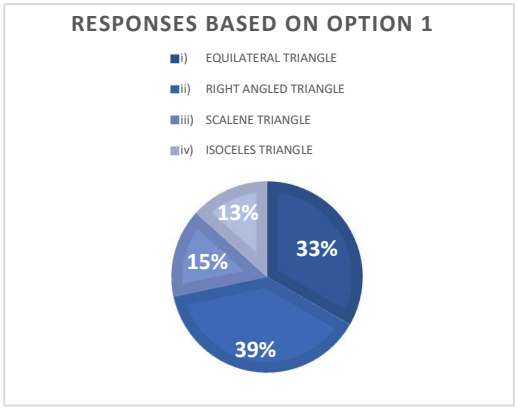
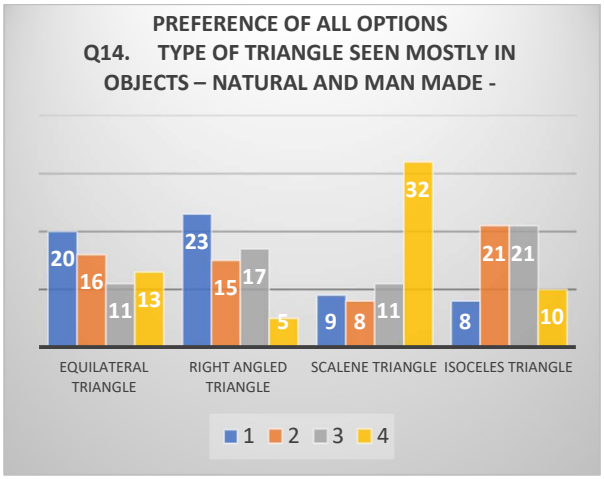


Fig. 76b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 39% respondents [23n] relate to RATR, followed closely by 33% [20 n] for EQTR
2. For Option 2, 35% [21n] choose ISTR
3. For Option 3, 35% [21n] choose ISTR
4. In Option 4, 51% respondents [32n] select SCTR as the least preference

COMPREHENSIVE TABULATION OF RESPONSES –



QUES 14- Fig. 76c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
EQUILATERAL TRIANGLE	20	16	11	13
RIGHT ANGLED TRIANGLE	23	15	17	5
SCALENE TRIANGLE	9	8	11	32
ISOCELES TRIANGLE	8	21	21	10

Table 22: QUES 14- ALL RESPONSES [pc: Author]

PREFERRED SETS:

1. RATR–ISTR - 23:21 & EQTR-ISTR – 20:21 [in Option 2]
2. RATR–ISTR – 23:21 [as Option 3]
3. EQTR–ISTR – 20:21 [being the next preferred in Option 3]

DERIVED OBSERVATION –

For most respondents, Triangles around us are recognized primarily in RIGHT ANGLED and EQUILATERAL TRIANGLE, followed by ISOCELES TRIANGLE as the secondary choice, with SCALENE TRIANGLE & ISOCELES TRIANGLE having the lowest preference as recognized shape based on cognition towards symmetric Geometry.

VALIDATION BY DATA BASED RESPONSE -

The standard deviation of the given set of numbers is approximately 7.07, and the distribution of the numbers remain uniform towards both ends with no extremes, and a concentration in the mid-range maintaining the mean at 15 – there being no extreme number, leading to balancing the range around the mean value, larger set of numbers in the mid-range results in preference of the sample.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES
[Respondents selection of AN Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

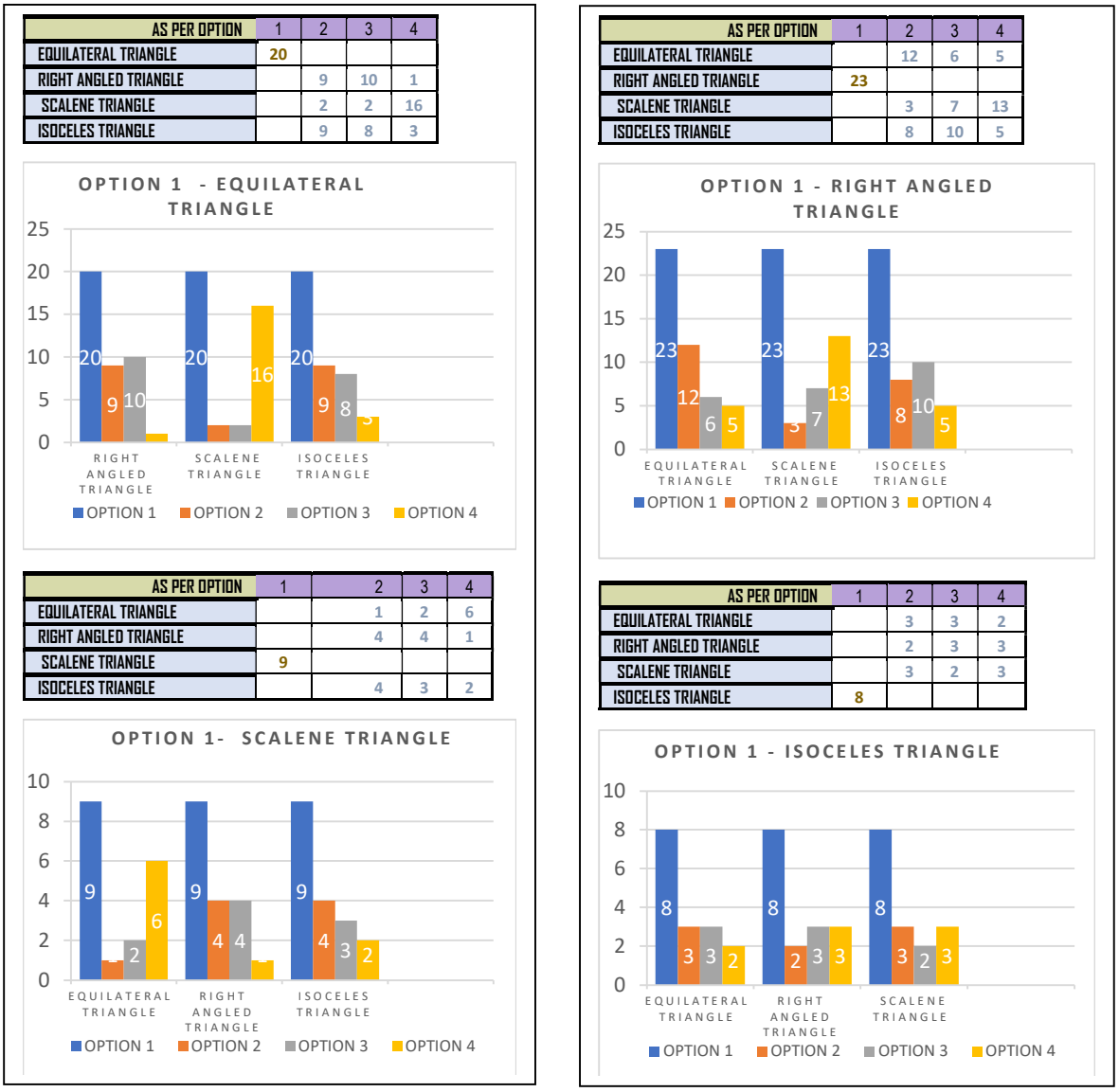


Fig. 76d: **QUES 14- OPTION 1 -** w.r.t. other Options [pc: Author] [Derived from ANNEXURE 4c]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Geometric Diversity**:
  - The scores reflect the diversity and utility of different triangle types in both natural formations and human creations, highlighting their structural and aesthetic roles in design and architecture.
- **Functional and Aesthetic Considerations**:
  - Equilateral and isosceles triangles are often chosen for their symmetry and stability in structural design.
  - Right-angled triangles are crucial for architectural support and angular calculations.
  - Scalene triangles provide flexibility in design and can be found in irregular natural formations.

DERIVED INTERPRETATION**:**

Recognizing the prevalence and roles of equilateral, right-angled, scalene, and isosceles triangles helps in understanding their contributions to structural stability, geometric harmony, and design versatility in both natural and man-made environments. The data highlights the significance of different triangle types—equilateral, right-angled, scalene, and isosceles—in various contexts, demonstrating how their unique properties contribute to the functionality, stability, and aesthetic appeal of objects and structures in our surroundings. Understanding these triangle types enhances our appreciation of geometric principles in design and nature.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1:

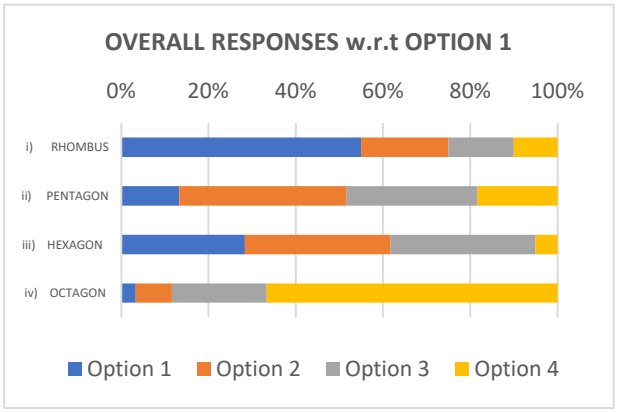
A. **Option 1 – Attribute # 1: EQUILATERAL TRIANGLE**
   Preference with choice #2: EQTR–RATR & EQTR–ISTR [20:9]
   Preference with choice #3: EQTR–RATR [20 :10]
B. **Option 1 – Attribute # 2: RIGHT-ANGLED TRIANGLE**
   Preference with choice #2: RATR-EQTR [23:12]
   Preference with choice #3: RATR- ISTR [23:10]
C. **Option 1 – Attribute # 3: SCALENE TRIANGLE**
   Preference with choice #2: SCTR – RATR & SCTR – ISTR [9:4]
   Other selections are too insignificant due to low number of responses
D. **Option 1 – Attribute # 4: ISOCELES TRIANGLE**
   Although it has a preference majorly as Secondary choice and similar to a Scalene Triangle as Option 1, the remaining selections as secondary choice is too insignificant as data

EMERGING OBSERVATION –

1. RATR has highest preference as Option 1, followed by EQTR, mutually each having same dependency as also with ISTR being Option # 2
   – It shows that cognition is towards strict geometric structures with defined angles
2. ISTR and SCTR has minimal selection as Option 1
   – Though slightly more recognized that ISTR, SCTR has least acceptance as subsequent option for any of the attributes
3. ISTR finds least significance as primary choice, but is a preference in secondary choices
   Once again establishes that human mind is aligned to interpretive angular structures

Q15. TYPE OF POLYGONS SEEN MOSTLY IN OBJECTS – NATURAL AND MAN MADE: Attributes for selection according to preference being

a) Rhombus [RHO]
b) Pentagon [PEN]
c) Hexagon [HEX]
d) Octagon [OCT]



QUES 15- Fig. 77a: OPTION 1 Bar Diagram

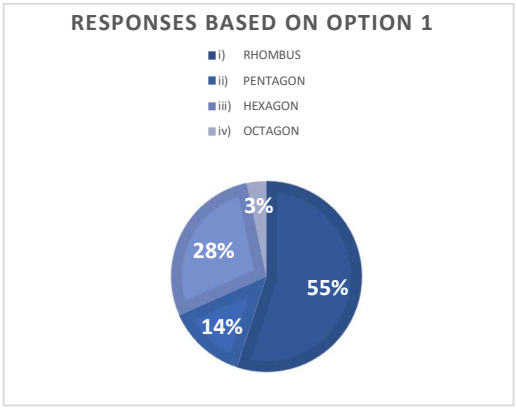
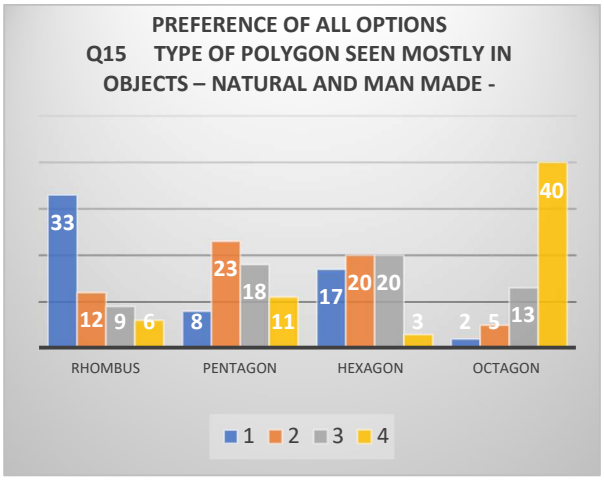


Fig. 77b: OPTION 1 Pie chart [pc: Author]

ANALYSIS:

1. Based on Option 1, 55% respondents [33n] relate to RHO, followed much less by 28% [17n] for HEX
2. For Option 2, 35% [23n] choose PEN followed closely by 32% [20n] by HEX
3. For Option 3, 32% [20n] choose HEX
4. In Option 4, 67% respondents [40n] select OCT as the lowest preference

COMPREHENSIVE TABULATION OF RESPONSES –



QUES 15- Fig. 77c: OPTION 1 Bar Diagram

AS PER OPTION	1	2	3	4
RHOMBUS	33	12	9	6
PENTAGON	8	23	18	11
HEXAGON	17	20	20	3
OCTAGON	2	5	13	40

Table 23: QUES 15- ALL RESPONSES [pc: Author]

PREFERRED SETS:

1. RHO–PEN - 33: 23 & RHO–HEX - 33:20, and HEX-PEN- 17:23 [in Option 2]
2. RHO–HEX - 33:20 [as Option 3]
3. RHO–PEN - 33:20 [being the next preferred in Option 3]

DERIVED OBSERVATION –

Majority respondents recognize primarily a RHOMBUS and, followed much less by HEX AGON as the secondary choice, followed by PENTAGON and OCTAGON having a nearly nil preference illustrating human mind recognizing simpler Geometric structures

VALIDATION BY DATA BASED RESPONSE -

For the given set of numbers, the standard deviation is approximately 10.59, with extreme values at both ends and distribution of the numbers remain in mid-range, leading to the mean at 15, with majority of weightage on higher values predominantly. Having only few numbers in the lower range has made the dispersion of data towards higher values.

ANALYSIS OF INDIVIDUAL ATTRIBUTES AND CORRESPONDING PREFERENCES

[Respondents selection of an Attribute as Option #1 w.r.t their Options #2-4 in for other Attributes]

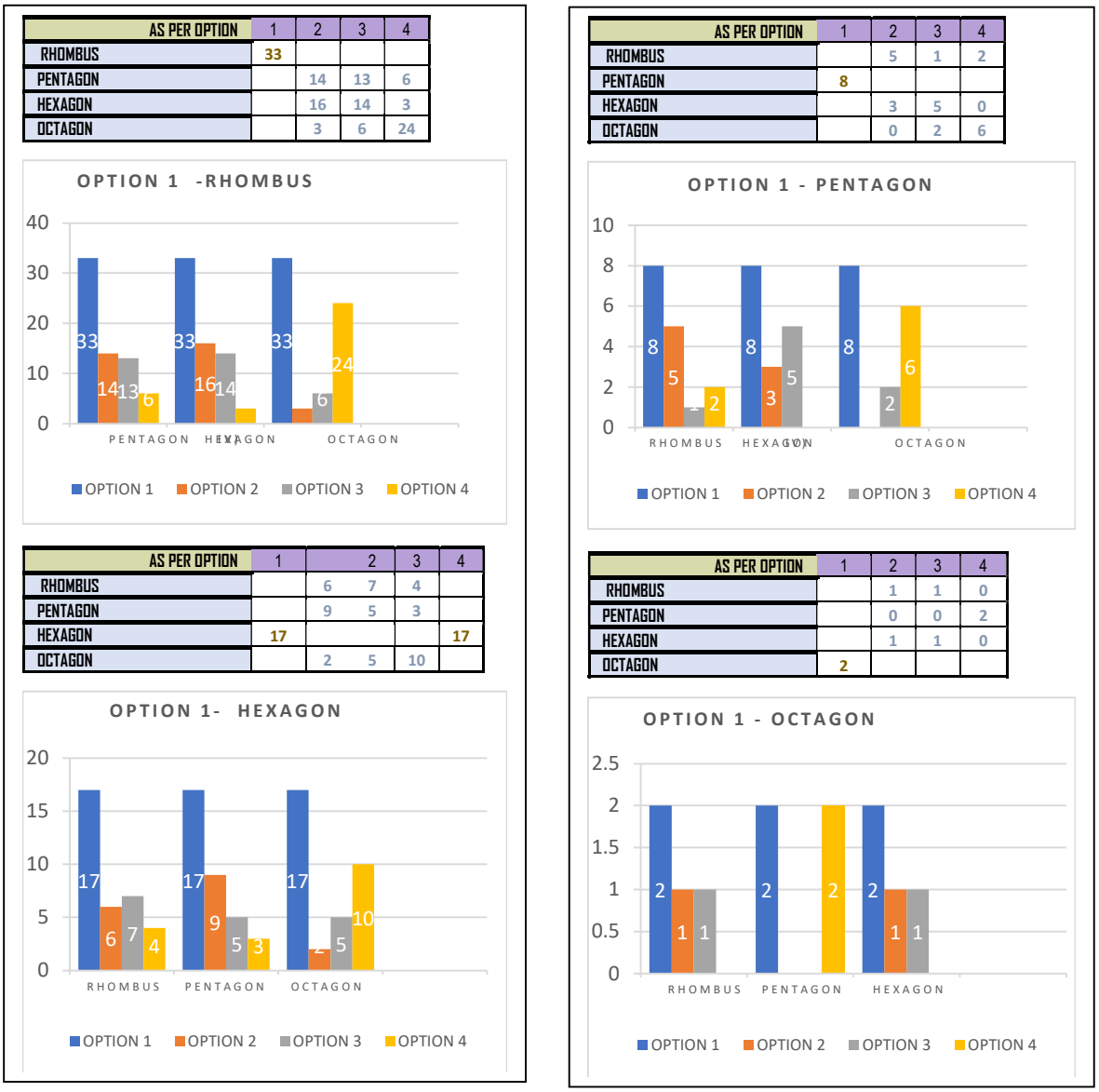


Fig. 77d: QUES 15- OPTION 1 - w.r.t. other Options [pc: Author] [Derived from ANNEXURE 4c]

RELATIONSHIPS AND INTERDEPENDENCIES:

- **Versatility in Design and Nature**:
  - The scores reflect the diverse applications of these polygons in both natural and human-made environments, showcasing their structural integrity, aesthetic appeal, and functional roles.
- **Geometric Patterns and Efficiency**:
  - Hexagons and octagons are notable for their efficiency in packing and structural strength, making them ideal choices for architectural and industrial applications.

DERIVED INTERPRETATION**:**

These polygons contribute to structural stability, visual appeal, and functional efficiency in diverse environments. Understanding the roles of rhombuses, pentagons, HEX agons, and octagons in various contexts enhances our appreciation of geometric principles in design, architecture, and natural formations. Recognizing their prevalence and applications helps in understanding their contributions to design aesthetics, structural integrity, and spatial efficiency in both natural and man-made settings.

RELATION OF OTHER ATTRIBUTES W.R.T. ATTRIBUTE SELECTED AS OPTION 1:

A. Option 1 – Attribute # 1: RHOMBUS
Preference with choice #2: RHO–HEX [33:16], RHO–PEN [33:14]
Preference with choice #3: RHO–HEX [33:14], RHO–PEN [33:13]

B. Option 1 – Attribute # 2: PENTAGON
Preference with choice #2: PEN-RHO [8:5]
Preference with choice #3: PEN-HEX [8:5]

C. Option 1 – Attribute # 3: HEX AGON
Preference with choice #2: HEX -PEN [17:9]
Preference with choice #3: HEX-RHO [17:7]

D. Option 1 – Attribute # 4: OCTAGON
With an extremely low response, data is not considerable and remains the least option

EMERGING OBSERVATION –

1. RHO has highest preference as Option 1, followed in much lesser value by HEX and Pen, both the other attributes mutually having same dependency with RHO as Option # 2
   – It shows that human mind can recognize simple geometric structures with defined boundaries
2. HEX has secondary selection as Option 1 and is also preferred as Option 2, similar as PEN
   – This shows that regular symmetric shapes have better cognitive property
3. OCT has too little response and emerges as least preferred
   – Illustrates multiple elements are considered for cognition at a later stage

4.3.3 STAGE 2: Assimilation of findings within sets - [ref. ANNEXURE 5]

The findings within each set is now to be analysed on the basis of quantitative data on the Primary and Secondary Options selected by the respondents, using Chat GPT is as a tool to attain the observations. Since these are the most preferred choices to derive the parameters of visual perception that is recognized in the Geometry of natural and man-made objects around us.

The relation between the Attributes within a set is now mapped based on numerical values arrived from 60 responses- corelating Option 1 preference (sequenced from highest to lowest) with other options having maximum response as Options 2, 3 & 4. Observations to be derived upon from these.

This will eventually determine Design realization using recognized by human perception.

i) ANALYSING SET A - [w.r.t. MEANING AND PURPOSE OF GEOMETRY]

A. ANALYSIS ON PRIMARY OPTION # 1 & SECONDARY OPTION # 2 - [ref Chat GPT]

a) RESPONSES BASED ON **OPTION 1:**
Based on the scores provided:

- **Products** (33) and **Form Development** (32) emerge as the most important aspects, reflecting a strong emphasis on tangible outcomes and intentional form evolution.
- **Construction of Shapes** (24) follows closely, highlighting its significance in both practical and creative domains.
- **Functional Aspects** (Measurement of Objects and Construction of Shapes)
- **Aesthetic and Creative Aspects (**Outlines Around Us, Creating Patterns)
- **Purpose and Beauty**: (Purpose, Beauty, Form Development, Surface Pattern)

These sets of data are likely to represent and emphasize practical aspects of creating physical forms related to design, measurement, creativity, and aesthetic appreciation. They collectively reflect the diverse aspects involved in observing, creating, and appreciating design in various contexts.

b) RESPONSES BASED ON **OPTION 2:**
Based on the scores provided:

- **Construction of Shapes** (24), **Measurement of Objects** (21), **Purpose** (21), and **Surface Pattern** (19) emerge as the most important aspects.
- **Construction of Shapes** indicates a strong emphasis on creating and manipulating geometric forms.
- **Measurement of Objects** and **Purpose** underscore practical and functional aspects.
- **Surface Pattern** highlights aesthetic and design considerations.

These insights suggest that understanding and applying concepts related to constructing shapes, measuring objects, defining purpose, and considering surface patterns are crucial in various contexts, including design, architecture, and artistic creation, where these elements play fundamental roles in functionality, aesthetics, and conceptual clarity.

B. CORELATION OF ATTRIBUTES -

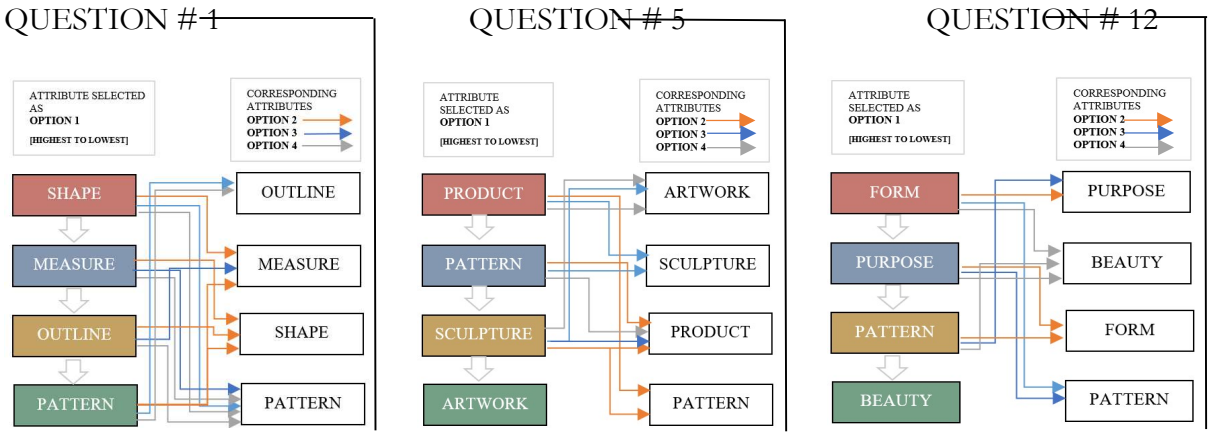


Fig. 78: Preference and relation of attributes within SET A [pc: Author]

C. DERIVED OBSERVATION -

Based on the responses from the attributes selected with Options # 1 & 2 being the predominant preferences, the Parameters established in understanding the Geometry in Design in above context emerges as –

a) **Primarily recognized** – 3D Forms followed by Shapes
b) **Secondarily recognized** – Shapes with Measurements, w.r.t Purpose, generating Patterns
c) **Tertiarily recognized** – Patterns w.r.t Outlines, in the context of Artwork
d) **Least recognized** – Artwork, Sculpture and Beauty have least cognizance in perception of Geometry

ii) ANALYSING SET B - [w.r.t. ELEMENTS AND PRINCIPLES OF GEOMETRY]

A. ANALYSIS ON PRIMARY OPTION # 1 & SECONDARY OPTION # 2 - [ref Chat GPT]

a) RESPONSES BASED ON **OPTION 1:**

Based on the scores provided:

- **Shapes** (32), **Scale** (23) and **Technical Constructions** (23), and **Proportion** (20) emerge as the most important aspects.
- **Shapes** indicate a strong emphasis on understanding and utilizing geometric forms.
- **Scale** and **Technical Constructions** highlight the importance of size, proportion, and practical construction methods.
- **Proportion** underscores the significance of balanced relationships within designs.

These insights suggest a focus on geometric understanding (Shapes), dimensional accuracy (Scale and Technical Constructions), and proportional harmony (Proportion) as critical aspects in the given context, likely related to design, technical drawing, and construction fields.

b) RESPONSES BASED ON **OPTION 2:**

Based on the scores provided:

- **Proportion** (22), **Measuring Area and Volume** (18), and **Angles** (20) emerge as the most important aspects.
- **Proportion** indicates a strong emphasis on maintaining relative sizes and ratios, crucial in design and technical fields.
- **Measuring Area and Volume** underscores the quantitative aspects of geometry.
- **Angles** highlight the importance of spatial relationships and configurations.

These insights suggest that understanding and applying concepts related to proportion, area and volume measurement, and angles are crucial in various fields such as architecture, engineering, design, and technical construction, where these elements play fundamental roles in accuracy, spatial planning, and aesthetic considerations.

B. CORELATION OF ATTRIBUTES –

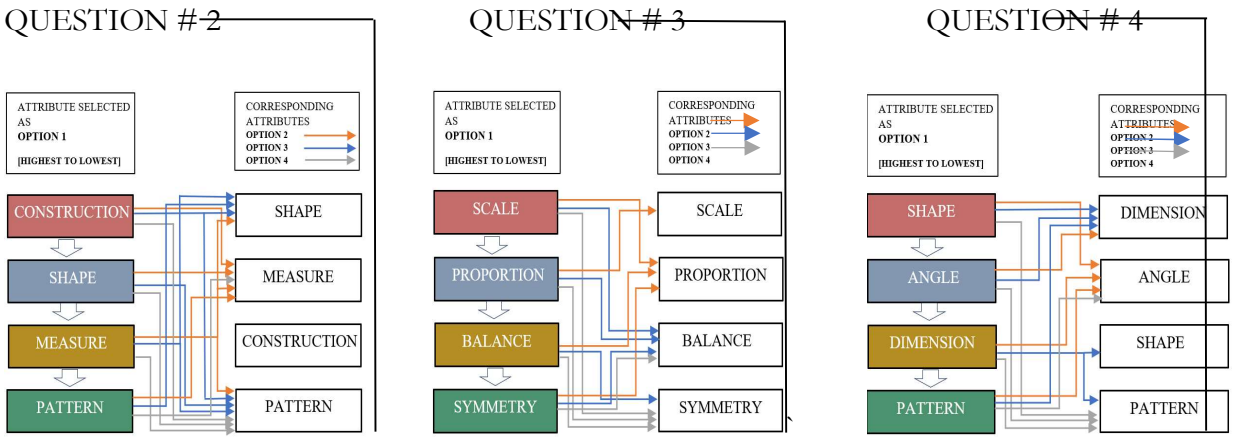


Fig.79: Preference and relation of attributes within SET B [pc: Author]

C. DERIVED OBSERVATION -

Based on the responses from the attributes selected with Options # 1 & 2 being the predominant preferences, the Parameters established in understanding the Geometry in Design in above context emerges as –

a) **Primarily recognized** – Shapes followed by Constructions and scale
b) **Secondarily recognized** – Proportion with Measurements, w.r.t Purpose, generating Patterns
c) **Tertiarily recognized** – Patterns w.r.t Measure and Shapes
d) **Least recognized** – Balance and Symmetry have least significance in identification of visual Geometry

*iii) ANALYSING SET C - [w.r.t GEOMETRY **AND NATURAL OBJECTS]***

A. ANALYSIS ON PRIMARY OPTION # 1 & SECONDARY OPTION # 2 - [ref Chat GPT]

a) RESPONSES BASED ON **OPTION 1:**

Based on the scores provided:

- **Forms** (40), **Textures** (36), and **Balance** (27) emerge as the most important aspects.
- **Forms** indicate a strong emphasis on fundamental three-dimensional shapes and structures.
- **Textures** underscore the importance of sensory and visual elements in enhancing perception.
- **Balance** highlights the significance of achieving visual stability and aesthetic harmony in compositions.

These insights suggest that understanding and utilizing forms, textures, and achieving balance are critical aspects in the given context, likely related to artistic, design, or perceptual fields where these elements play essential roles in creating impactful and harmonious compositions.

b) RESPONSES BASED ON **OPTION 2:**

Based on the scores provided:

- **Shapes** (34), **Balance** (17), **Proportion** (17), and **Rhythm** (16) emerge as the most important aspects.
- **Shapes** signify a strong focus on geometric forms and configurations.
- **Balance** and **Proportion** underscore aesthetic considerations and structural integrity.
- **Rhythm** highlights the importance of visual flow and spatial organization.

These insights suggest that understanding and applying concepts related to shapes, balance, proportion, and rhythm are crucial in various disciplines such as art, design, architecture, and engineering. These elements contribute significantly to the functionality, aesthetics, and overall impact of the created work, whether in visual arts, spatial design, or structural engineering.

B. CORELATION OF ATTRIBUTES –

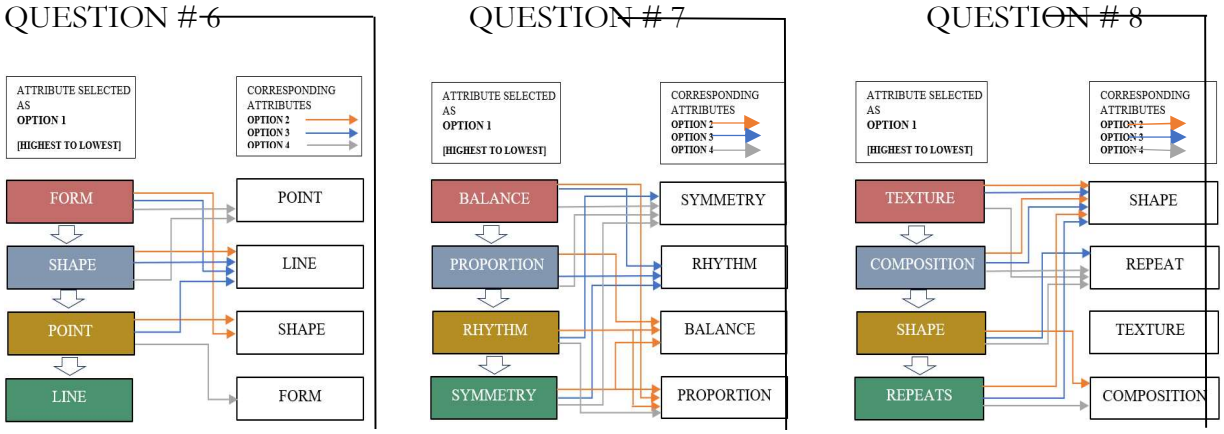


Fig. 80: Preference and relation of attributes within SET C [pc: Author]

C. DERIVED OBSERVATION -

Based on the responses from the attributes selected with Options # 1 & 2 being the predominant preferences, the Parameters established in understanding the Geometry in Design in above context emerges as –

a) **Primarily recognized** – 3D Forms followed by Texture and Balance
b) **Secondarily recognized** – Proportion and Rhythm emerge
c) **Tertiarily recognized** – Composition out of Shapes, Rhythm w.r.t Balance
d) **Least recognized** – Lines are not considered w.r.t. Forms and Balance

*iv) ANALYSING SET D - [w.r.t GEOMETRY **AND MAN MADE OBJECTS**]*

A. ANALYSIS ON PRIMARY OPTION # 1 & SECONDARY OPTION # 2 - [ref Chat GPT]

a) RESPONSES BASED ON **OPTION 1:**

Based on the scores provided:

- **Shapes** (33), **Outlines** (25), **Dimensions** (24), and **Proportion** (21) emerge as the most important aspects.
- **Shapes** indicate a strong emphasis on understanding and utilizing various geometric forms.
- **Outlines** underscore the importance of defining shapes and forms.
- **Dimensions** highlight the significance of size and spatial measurements.
- **Proportion** emphasizes maintaining balance and harmony in compositions and relationships between elements.

These insights suggest that understanding shapes, defining outlines, considering dimensions, and maintaining proportion are critical aspects in the given context, likely related to design, artistic creation, or architectural fields where these elements play essential roles in creating meaningful and coherent compositions.

b) RESPONSES BASED ON **OPTION 2:**

Based on the scores provided:

- **Proportion** (24), **Shapes** (20), **Textures** (22), and **Outlines** (21) emerge as the most important aspects.
- **Proportion** indicates a strong emphasis on maintaining relative sizes and ratios, crucial in design and composition.
- **Shapes** signify a focus on geometric forms and structures.
- **Textures** highlight the importance of surface quality and tactile aesthetics.
- **Outlines** emphasize the visual definition and structure of shapes and forms.

These insights suggest that understanding and applying concepts related to proportion, textures, and outlines are crucial in various fields such as art, design, architecture, and interior decoration, where these elements contribute significantly to visual appeal, composition, and spatial perception.

B. CORELATION OF ATTRIBUTES –

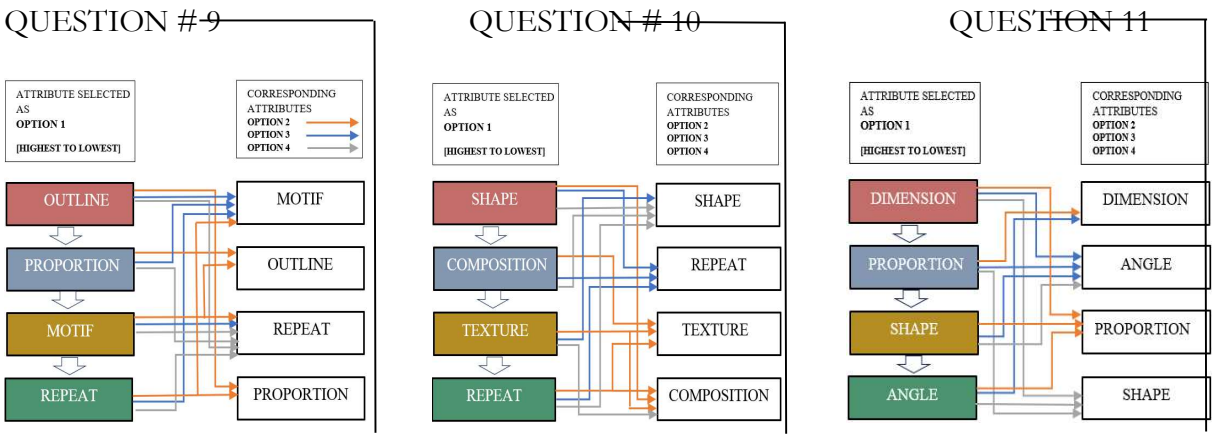


Fig. 81: Preference and relation of attributes within SET D [pc: Author]

C. DERIVED OBSERVATION -

Based on the responses from the attributes selected with Options # 1 & 2 being the predominant preferences, the Parameters established in understanding the Geometry in Design in above context emerges as –

a) **Primarily recognized** – Shapes with Outlines and Dimensions
b) **Secondarily recognized** – Proportion in Shape and w,r,t Texture & Outline
c) **Tertiarily recognized** – Repeat w.r.t Shape and Motif
d) **Least recognized** – Angle is least considered

v) ANALYSING SET E - [w.r.t SHAPES IN GEOMETRY]

A. ANALYSIS ON PRIMARY OPTION # 1 & SECONDARY OPTION # 2 - [ref Chat GPT]

a) RESPONSES BASED ON **OPTION 1:**

Based on the scores provided:

- **Rhombus** (33), **Square** (23), **Right-Angled Triangle** (23), and **Circle** (18) emerge as the most important geometric shapes.
- **Rhombus** indicates a strong emphasis on its unique properties and applications.
- **Square** and **Right-Angled Triangle** underscore their practical and geometric significance.
- **Circle** highlights its importance in mathematical and geometric discussions.

These suggest that understanding these specific geometric shapes—Rhombus, Square, Right Angled Triangle, and Circle—is crucial in various contexts, including mathematics, design, and architecture, where these shapes play essential roles in structure, symmetry, and mathematical principles.

b) RESPONSES BASED ON **OPTION 2:**

Based on the scores provided:

- **Circle** (27), **Pentagon** (23), and **Square** (22) emerge as the most important aspects.
- **Circle** indicates a strong emphasis on round shapes and forms.
- **Pentagon** highlights geometric complexity and unique properties.
- **Square** signifies stability and regularity in shapes.

These insights suggest that circles, pentagons, and squares are crucial shapes in various fields such as geometry, design, architecture, and engineering, where they contribute significantly to aesthetics, structural integrity, and functional design.

B. CORELATION OF ATTRIBUTES –

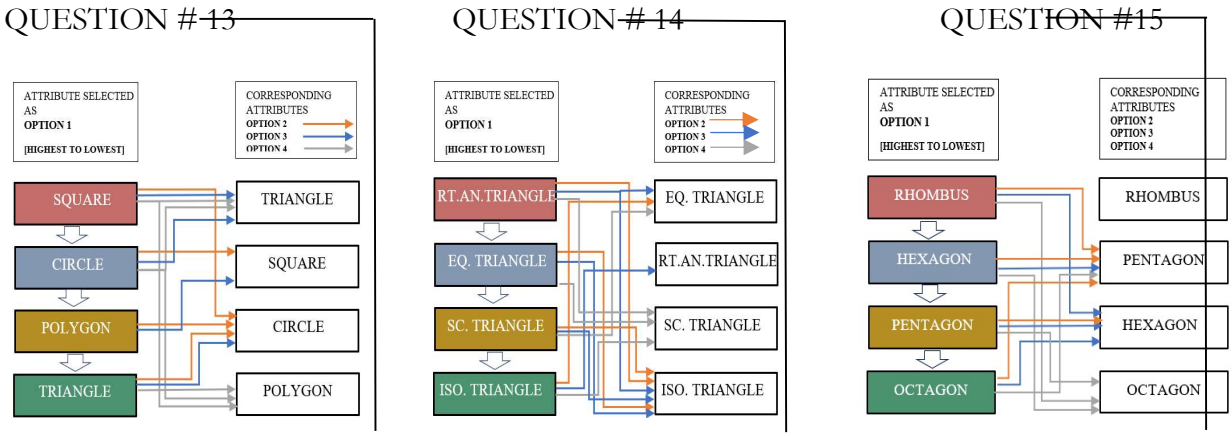


Fig. 82: Preference and relation of attributes within SET E [pc: Author]

C. DERIVED OBSERVATION -

Based on the responses from the attributes selected with Options # 1 & 2 being the predominant preferences, the Parameters established in understanding the Geometry in Design in above context emerges as –

e) **Primarily recognized** – Square with Rt Angled & Equilateral Triangle and Rhombus

f) **Secondarily recognized** – Circle and Triangle, with Isosceles Triangle and Hexagon

g) **Tertiarily recognized** – Polygon, especially Pentagon

h) **Least recognized** – Octagons and Scalene Triangle

4.3.4 STAGE 3: Assimilation of data across all sets [15 QUESTIONS]

The responses of all the questions are now mapped together to understand the overall perception of the respondents and emerging leading parameters across sets and questions.

a) COMPREHENSIVE OBSERVATION ON SAME OPTION ACROSS SETS:

The comprehensive charts on responses based on Options # 1- 4 are illustrated below. Options 1&2 showing more preferred choices and Options 3& 4 showing less preferred choices:

[The data is segregated by dividing 60 responses in 4 segments @ 1/3rd - 20 responses, ½ - 30 responses, 3/4th 45 responses, based on major bands of data as mapped]

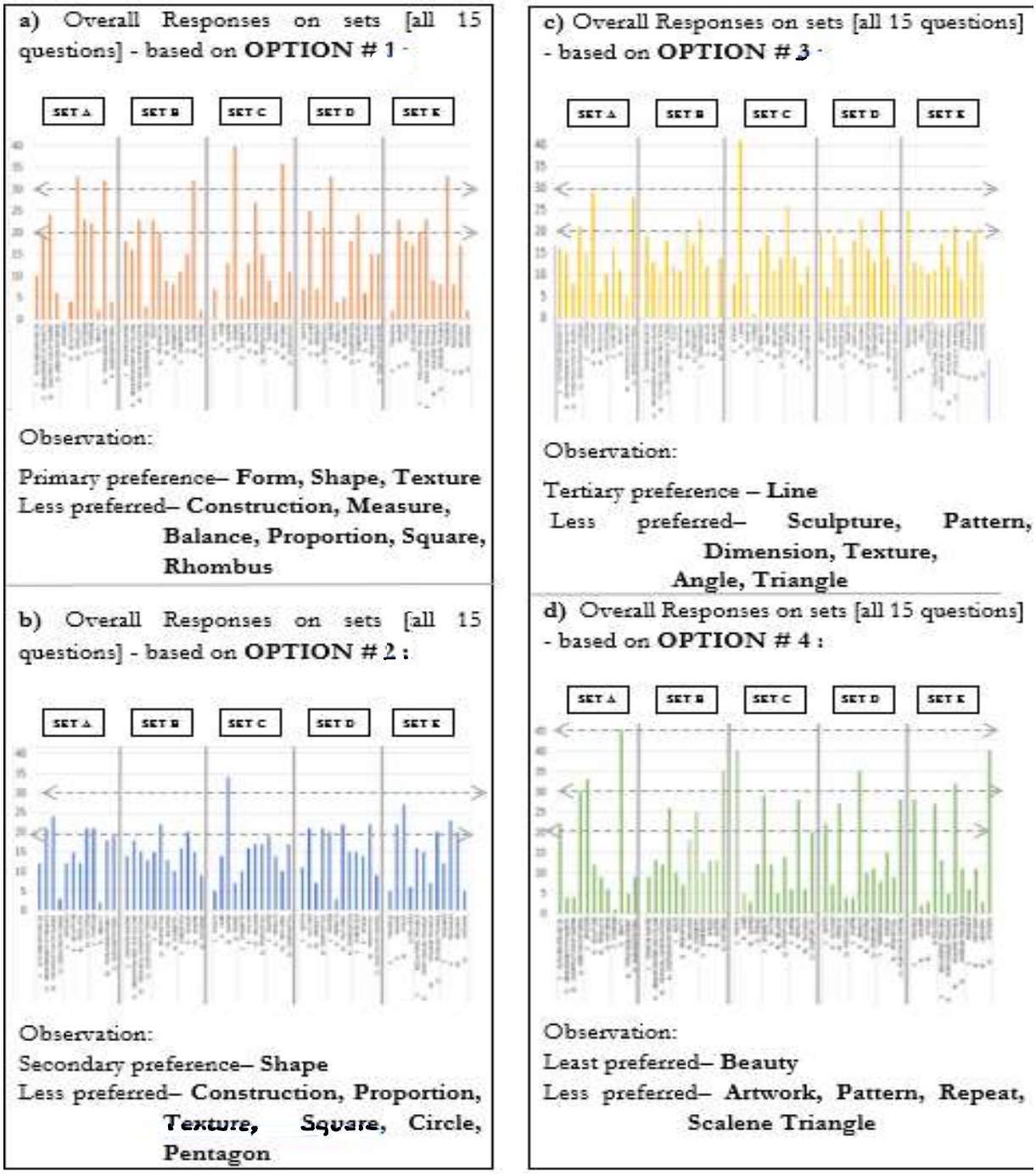


Fig. 83: Comprehensive data of all sets: Option based responses [pc: Author] [ANNEXURE 6a – 6d]

b) COMPREHENSIVE OBSERVATION ON ALL OPTIONS ACROSS 5 SETS:

In Human perception of visual frames in Design, Geometry is identified primarily through SHAPE, with focus on SQUARE & CIRCLE, related to FORM, MEASURE & CONSTRUCTION. PROPORTION, TEXTURE, BALANCE & PATTERN are considered later. LINE and POINT remain less recognized and GEOMETRY is not considered in relation to BEAUTY

Mapping all the options together – 5 Sets, 15 Questions, 4 Options:

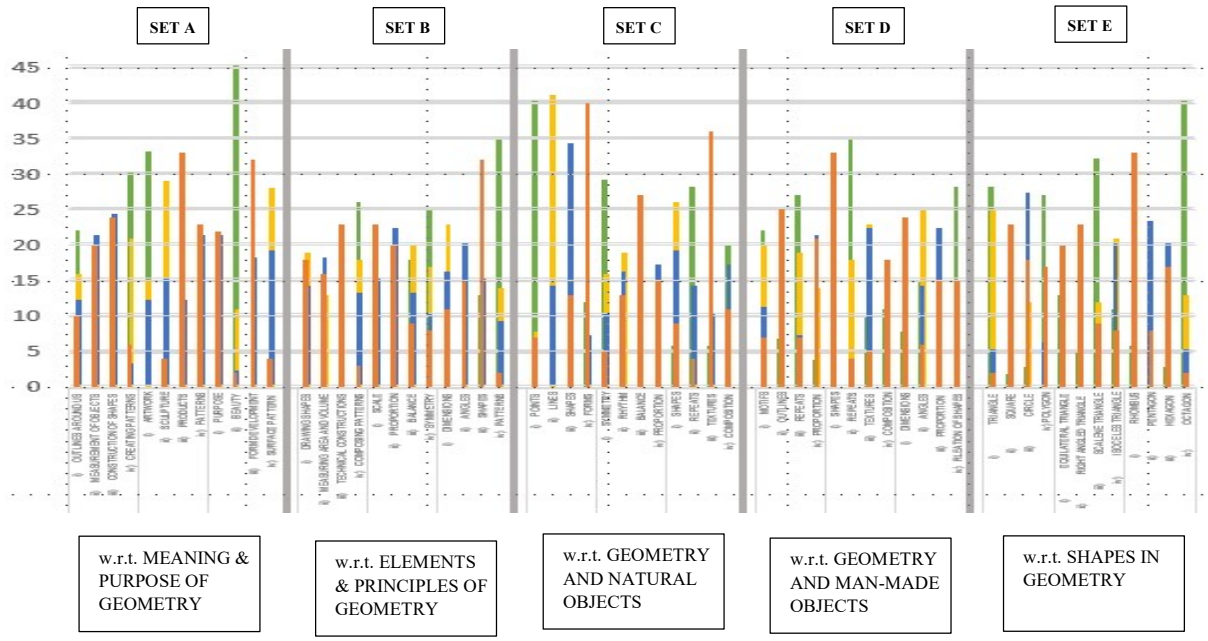


Fig. 84: Comprehensive data of all sets: Responses based on all sets [pc: Author] [ANNEXURE 6e]

c) EMERGING ASPECTS FOR CONSIDERATION:

The key aspects emerging from the above study are -

MEANING & PURPOSE OF GEOMETRY - **Form, Shape, Pattern, Purpose, Measure**

ELEMENTS & PRINCIPLES OF GEOMETRY - **Shape, Construction, Scale, Proportion**

GEOMETRY & NATURAL OBJECTS - **Form, Texture, Balance, Shape**

GEOMETRY & MAN-MADE OBJECTS - **Shape, Outline, Dimension, Texture**

SHAPES IN GEOMETRY - **Rhombus, Square, Right-angled & Equilateral Triangle**

From the above cited responses of all 60 respondents, it is found that **Form** emerges as the most significant Visual element followed closely by **Shape** and is related to the **purpose of the Design**. The perception of **Construction** relates to **Measures/ Dimensions** and **Scale / Proportion** is relevant to the Form. **Texture** is important for both natural and man-made objects. Shapes that are easily noted are **rectilinear and with regular outlines**.

4.4 Summarizing General Opinion Survey- w.r.t. STAGES 1, 2 & 3:

The *Parameters and their various aspects/ attributes,* derived from earlier chapters are now identified and to be termed as 'FACTORS' that guide the visual perception of Design. From the complete study of the responses, it is now seen that Visual Perception of Objects by human understanding segregates these FACTORS into 2 broad categories impacting the understanding of a designed object -

- ***Functional Aspects***
- ***Aesthetic Aspects***

Geometry is intrinsic to Design perception, but significantly aligned to Form and Function. The respondents have shown greater preference for the Functional aspect and less preference for aesthetics, which indicates Design in interpreted for its purpose, whether for natural or man-made objects. The major factors are illustrated as below:

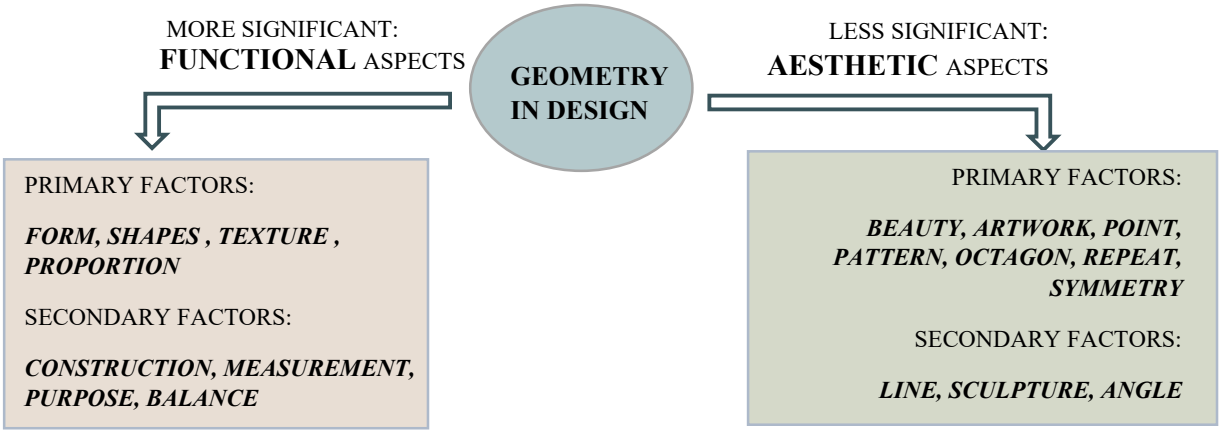


Fig. 85: Emerging Factors of perception of Geometry: Primary & Secondary [pc: Author]

From the preferences of the survey conducted emerges that Geometry is inherent to evolution of form, guiding visual perception towards Design., with specific identification - and the aspects, both functional and aesthetic, contribute to the structural stability and performance of the form.

4.5 Inference & Direction

The emergent Factors now requires further validation in the Chapter 5, where professionals of both domains – Fashion & Architecture - from various fields of practice, are to help establish the understanding and application of Geometry in Design. This is to be conducted as cited below:

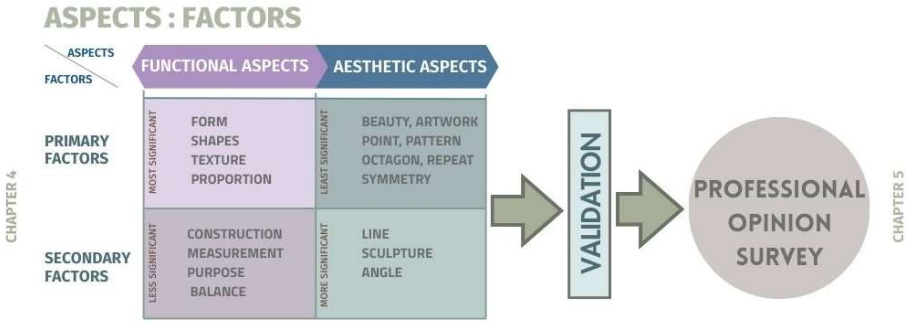


Fig. 86: **Pathway to final validation of factors:** Primary & Secondary [pc: Author]

CHAPTER 5

VALIDATION OF FINDINGS

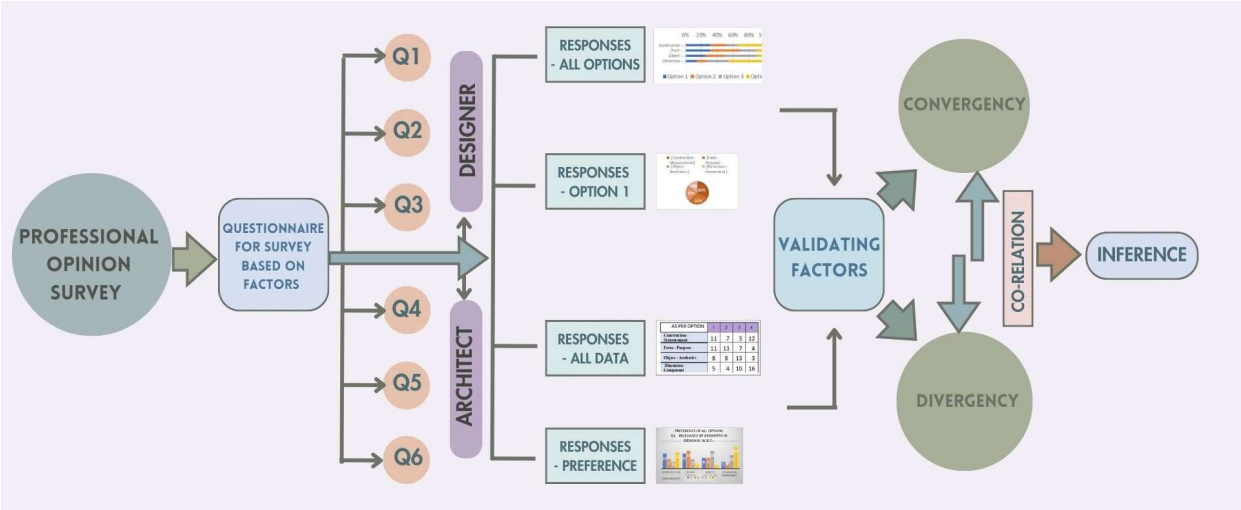
5.1 Framework for Analysis of Data

The General Opinion Survey in Chapter 4 generated a set of data based on the identified *Parameters & Attributes* emerging from Chapters 1-3 – now termed as '*FACTORS'* in this Thesis [ref. # 4.4] . These require further validation based on questions of the survey. The framework to the process of analysing the survey responses required another set of data to understand the applicability of these factors.

Chapter 5 introduces a methodology for preparing a second set of questions based on classifying the parameters towards generating response from professionals working in different capacities in their area of expertise, pertaining to their area of design – Architecture or Fashion, to be conducted through a second set of primary data collection. From the parameters to factors generated in the previous chapters, formulation of questionnaire relevant to the broad category of the aspects to be considered was to be prepared, which would generate specific responses pertaining to the area of expertise in application of Geometry in their area of Design, and hence may or may not justify the generic understanding of general opinion on geometry and indicate the factors that guide its application in Geometry. This would lead to understanding the veracity of the hypothesis.

In this chapter, the research would explore the areas of convergence and divergence in application of Geometry in Design – as had been identified in Chapter 1 – from the professional perspective of the two design communities and the findings will be evaluated to bridge the gap identified at the introduction of the thesis, through numerical data on factors that would emerge from the various viewpoints studied during the course of the research work.

The framework of action is indicated as below:



Approach to validating the factors: Fig. 87: Factors to professional understanding on Geometry [pc: Author]

5.2 Validation of elements of cognition derived through human perception – Professional Opinion Survey

The concluding derivatives from the Chapter 4 now requires to be analysed to arrive at the final concluding inference of the hypothesis taken. In continuation of the previous exercise, the methodology was adopted as follows –

a) The derivative elements were combined into 6 sets of factors related to each other
b) A final survey was conducted with 35 respondents each, from Fashion Designers and Architects, responding to the above 6 sets of questions, independently [ANNEXURE 7]
c) The 35 respondents in each group were chosen from *different region and communities pan India* and from *varying gender and age groups* (26-35, 36-45, 46-55, 56-65 years) to generate a holistic data without specific polarization on response
d) The respondents comprised of 4 segments of professionals, as found in practice, in both Design domains **– Academicians, Consultants, Entrepreneurs** and in **Service** – with nearly equal weightage across segments to generate uniformity in responses based on the professional understanding on the queries. [ANNEXURE 8]
e) The data thus collected was arranged as before and now in comparable mode to infer the convergence and divergence of thinking amongst Fashion Designers and Architects.

5.2.1 Categorizing the responses:

The 6 questions with their respective options based on the final context of the previous chapter encompasses the broad derivatives drawn from this research in Chapter 4. [ANNEXURE 9a]

The sets of questions are as follows –

Table 24– QUES 1-6- ALL ATTRIBUTES [pc: Author]

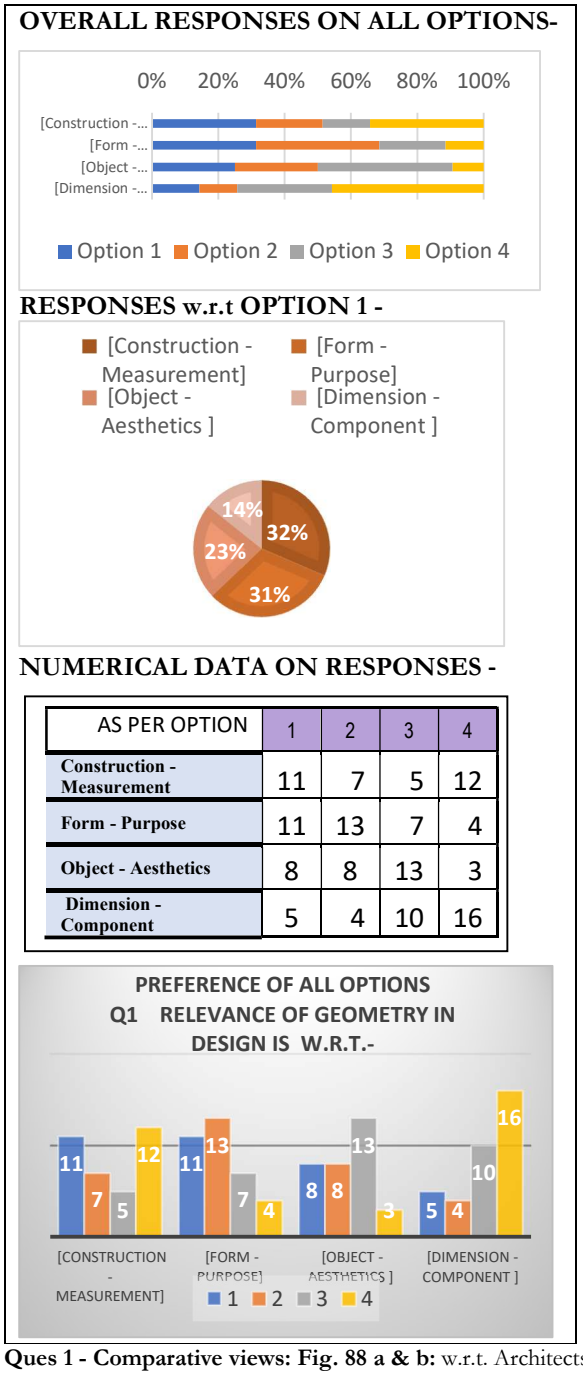
Ques. No.	Question	Options to select [rank from 1- 4 as per preference , 1 being highest]	
1	RELEVANCE OF GEOMETRY IN DESIGN IS W.R.T	i)	Construction - Measurement
		ii)	Form - Purpose
		iii)	Object - Aesthetics
		iv)	Dimension - Component
2	GEOMETRY IN DESIGN IS PERCEIVED WITH -	i)	Element - Component
		ii)	Outline - Dimension
		iii)	Technicality - Measurement
		iv)	Scale - Proportion
3	NATURE INFLUENCES GEOMETRY IN DESIGN THROUGH -	i)	Form - Element
		ii)	Planes - Outlines
		iii)	Balance - Proportion
		iv)	Component - Composition
4	MAN-MADE OBJECTS REFLECT GEOMETRY THROUGH -	i)	Component - Surface
		ii)	Outline - Arrangement
		iii)	Element - Composition
		iv)	Dimension - Proportion
5	GEOMETRY IN DESIGN IS SEEN IN THE CONTEXT OF -	i)	Square - Circle - Polygon
		ii)	Right angled-Equilateral- Isosceles Triangle
		iii)	Rhombus - Pentagon - Hexagon
		iv)	Scalene Triangle - Quadrilateral - Octagon
6	GEOMETRY IN DESIGN IS NECESSARY FOR -	i)	Symmetry - Motif
		ii)	Artwork - Beauty
		iii)	Repeat - Pattern
		iv)	Rhythm - Texture

5.2.2 The findings: [ref ANNEXURE 9b- 9d]

The findings are laid out side by side to prepare comparative analysis on responses from Architects vis-à-vis Designers.

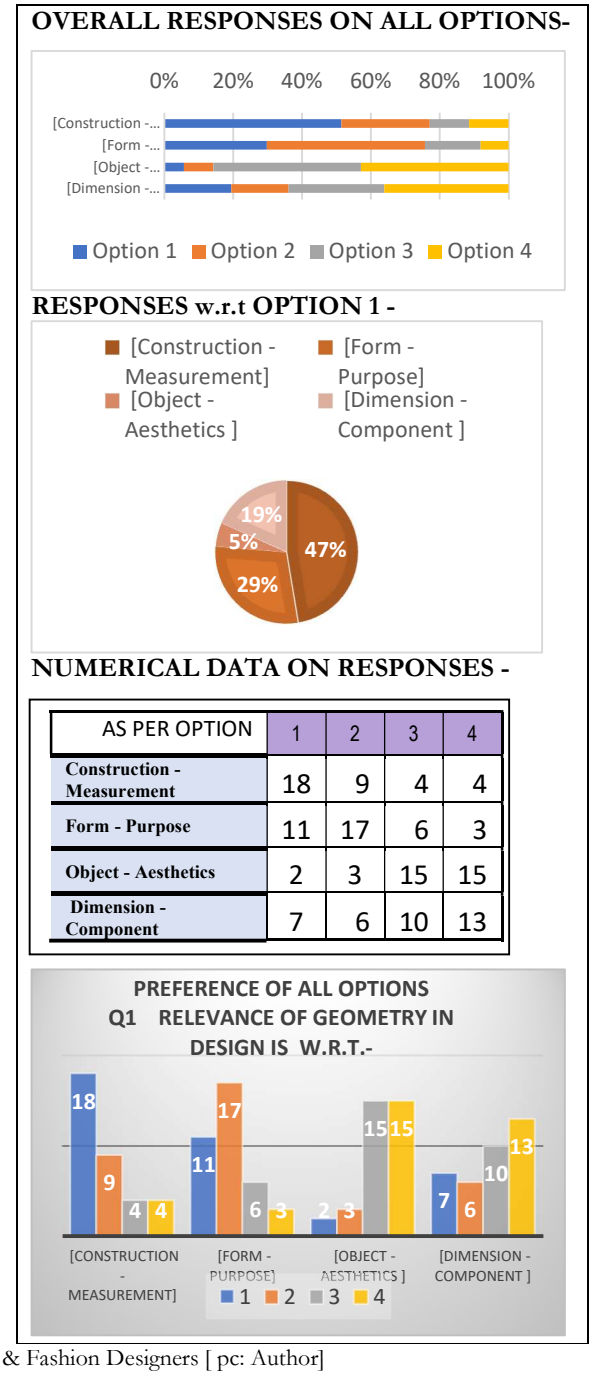
A) Q1 - Relevance of geometry in design is w.r.t.-

RESPONSE FROM **ARCHITECTS**



AS PER OPTION	1	2	3	4
Construction - Measurement	11	7	5	12
Form - Purpose	11	13	7	4
Object - Aesthetics	8	8	13	3
Dimension - Component	5	4	10	16

RESPONSE FROM **FASHION DESIGNERS**



AS PER OPTION	1	2	3	4
Construction - Measurement	18	9	4	4
Form - Purpose	11	17	6	3
Object - Aesthetics	2	3	15	15
Dimension - Component	7	6	10	13

Ques 1 - Comparative views: Fig. 88 a & b: w.r.t. Architects & Fashion Designers [pc: Author]

Observations:

i) Construction and measurement are most important to Fashion Designers while Forms and purpose is as much in consideration to Architects

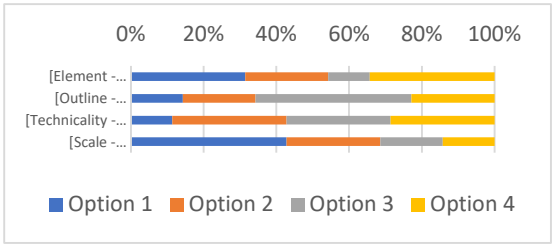
ii) Aesthetics and the object are not significant to Fashion Designers w.r.t Geometry but is considered by Architects for designing

iii) Dimensional aspect of components is similarly viewed by both sets of professionals for design

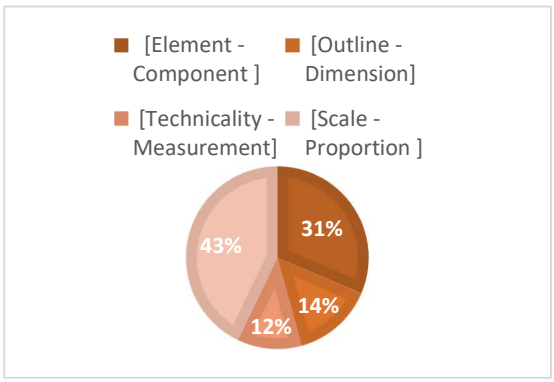
B) Q 2 - Geometry in design is perceived with -

RESPONSE FROM **ARCHITECTS**

OVERALL RESPONSES ON ALL OPTIONS -

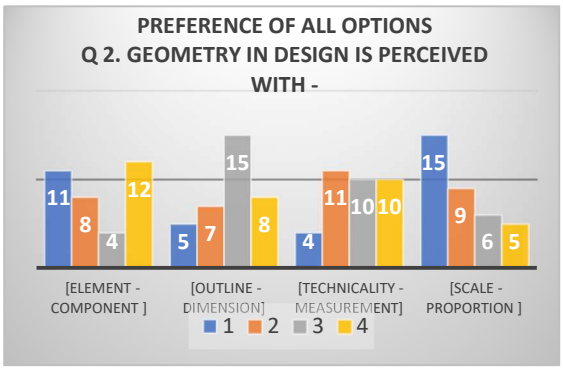


RESPONSES w.r.t OPTION 1 -



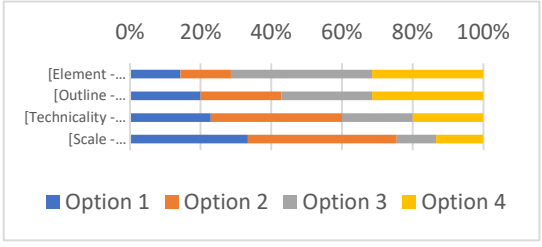
NUMERICAL DATA ON RESPONSES –

AS PER OPTION	1	2	3	4
Element - Component	11	8	4	12
Outline - Dimension	5	7	15	8
Technicality - Measurement	4	11	10	10
Scale - Proportion	15	9	6	5

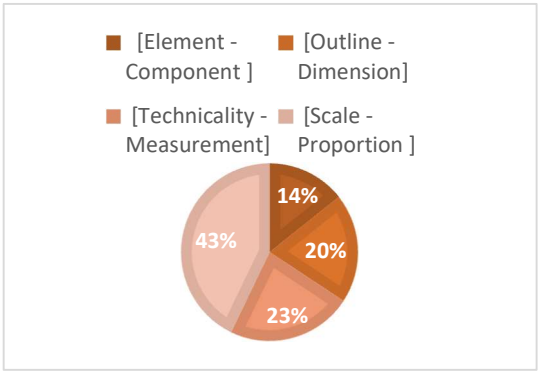


RESPONSE FROM **FASHION DESIGNERS**

OVERALL RESPONSES ON ALL OPTIONS-

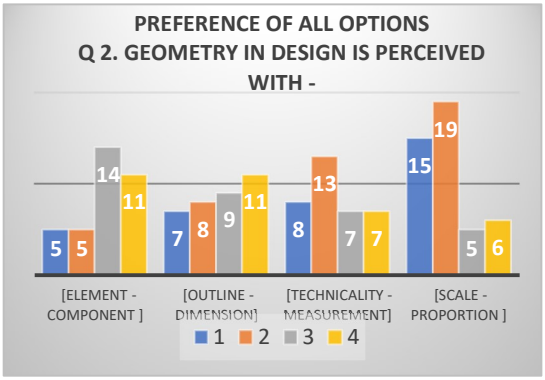


RESPONSES w.r.t OPTION 1 -



NUMERICAL DATA ON RESPONSES –

AS PER OPTION	1	2	3	4
Element - Component	5	5	14	11
Outline - Dimension	7	8	9	11
Technicality - Measurement	8	13	7	7
Scale - Proportion	15	9	5	6



Ques 2 - Comparative views: Fig. 89a & b: Preferences of Architects & Fashion Designers [pc: Author]

Observations:

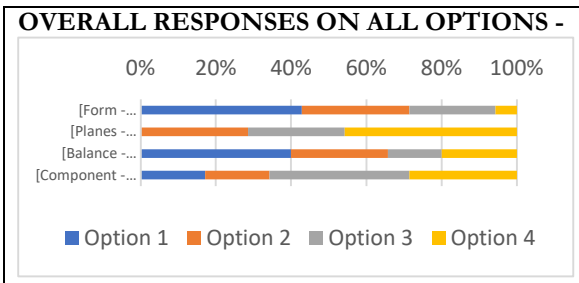
i) Elements and Components are insignificant to Fashion Designers and Architects have relative preference for these

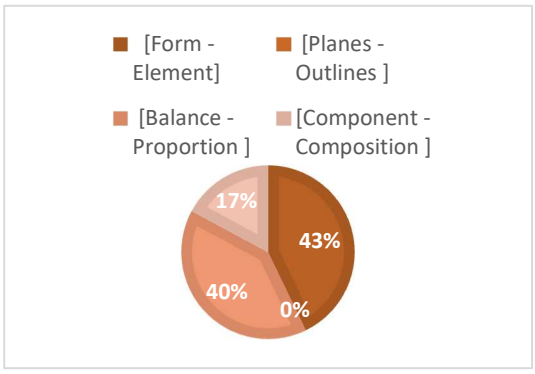
ii) Geometric perception in design is not based on Dimension and Technicality for architects and is equally less significant to Fashion Designers

iii) Scale and Proportion remains most important to both Fashion Designers and Architects for perceiving design

C) Q 3 - Nature influences geometry in design through -

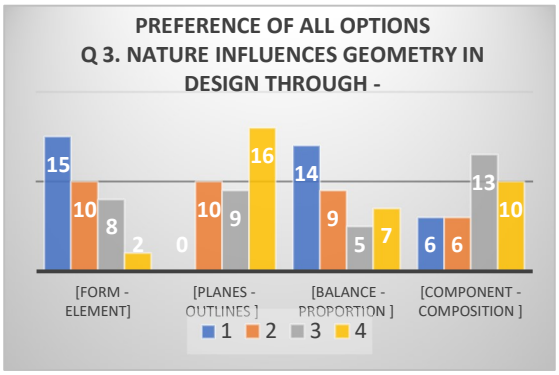
RESPONSE FROM **ARCHITECTS**



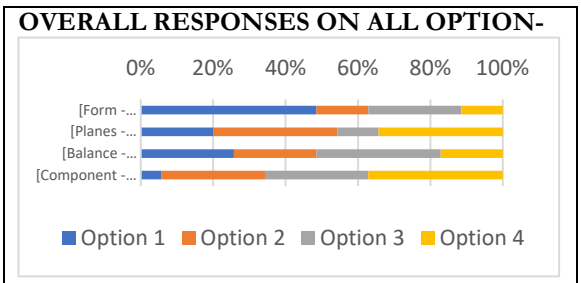


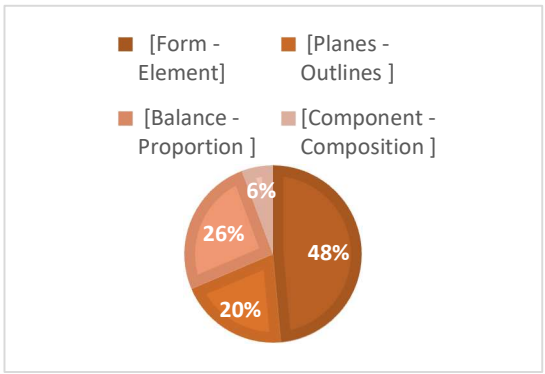
NUMERICAL DATA ON RESPONSES –

AS PER OPTION	1	2	3	4
Form - Element	15	10	8	2
Planes - Outlines	0	10	9	16
Balance - Proportion	14	9	5	7
Component - Composition	6	6	13	10



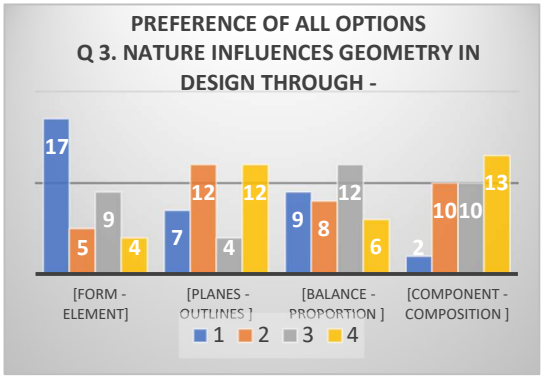
RESPONSE FROM **FASHION DESIGNERS**





NUMERICAL DATA ON RESPONSES –

AS PER OPTION	1	2	3	4
Form - Element	17	5	9	4
Planes - Outlines	7	12	4	12
Balance - Proportion	9	8	12	6
Component - Composition	2	10	10	13



Ques 3 - Comparative views: Fig. 90a & b: – Preferences of Architects & Fashion Designers [pc: Author]

Observations:

i) Form and Elements are most significant to Designers, and Architects have relative preference for these as also on Balance and Proportion towards, w.r.t influence of Nature

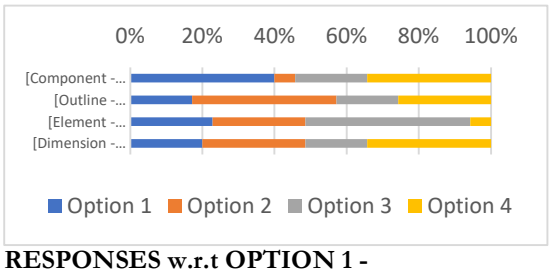
ii) Outlines, Planes and Balance is relatively less significant to Fashion Designers in perception of Geometry in nature

iii) Component and Composition remains less in consideration for both design practitioners

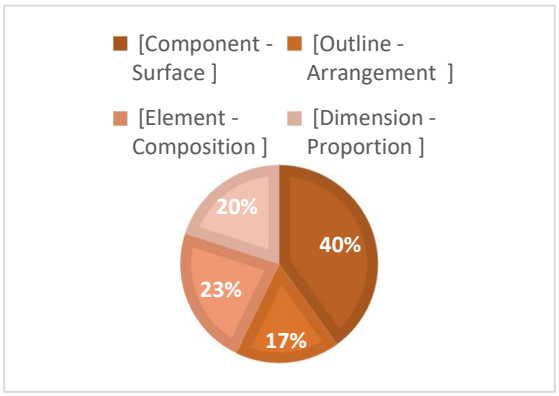
D) Q 4 - Man-made objects reflect geometry through -

RESPONSE FROM **ARCHITECTS**

OVERALL RESPONSES ON ALL OPTIONS -

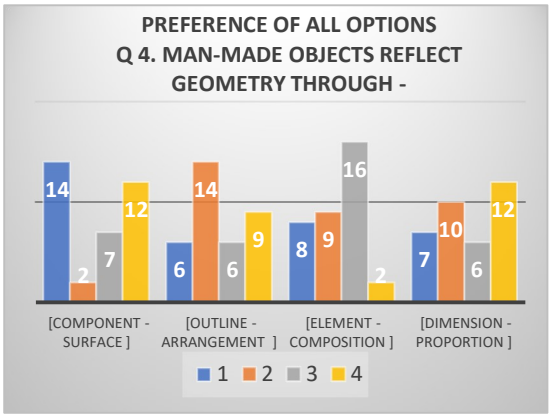


RESPONSES w.r.t OPTION 1 -



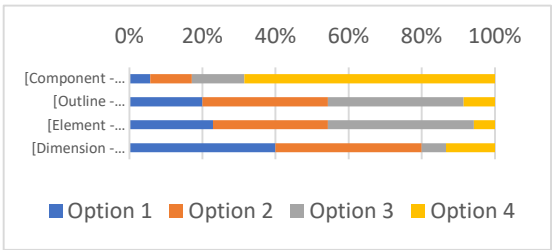
NUMERICAL DATA ON RESPONSES –

AS PER OPTION	1	2	3	4
Component - Surface	14	2	7	12
Outline - Arrangement	6	14	6	9
Element - Composition	8	9	16	2
Dimension - Proportion	7	10	6	12

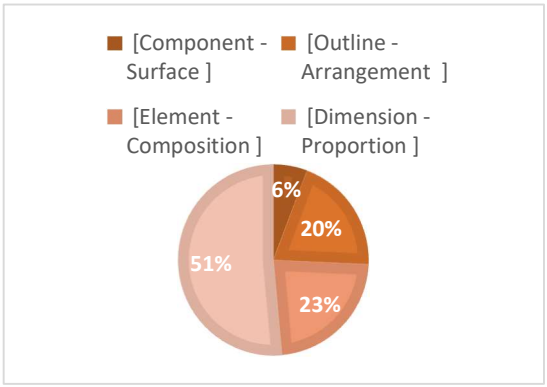


RESPONSE FROM **FASHION DESIGNERS**

OVERALL RESPONSES ON ALL OPTIONS -

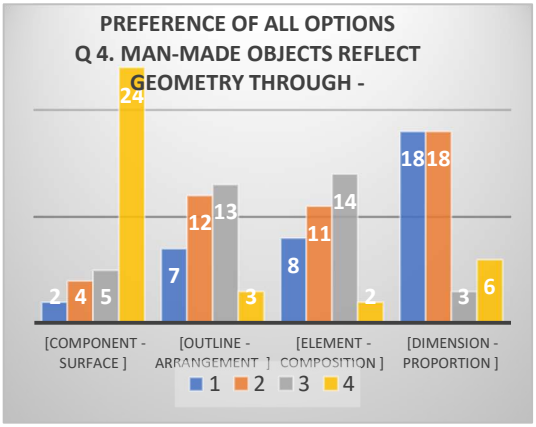


RESPONSES w.r.t OPTION 1 -



NUMERICAL DATA ON RESPONSES –

AS PER OPTION	1	2	3	4
Component - Surface	2	4	5	24
Outline - Arrangement	7	12	13	3
Element - Composition	8	11	14	2
Dimension - Proportion	18	8	3	6



Ques 4 - Comparative views: Fig. 91a & b: – Preferences of Architects & Fashion Designers [pc: Author]

Observations:

i) For man-made objects, Fashion Designers give more importance to Dimension and Proportion, while Architects focus on Component and Surfaces

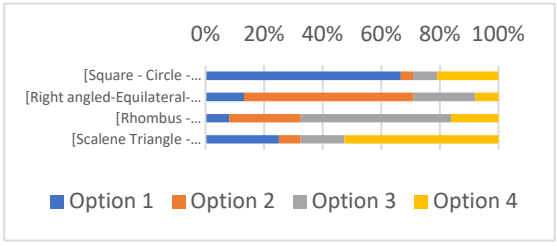
ii) Outlines, Elements and Composition is relatively less significant to both Fashion Designers and Architects for man-made designs

iii) Fashion Designers do not consider Surface and Components significant at all w.r.t. other factors

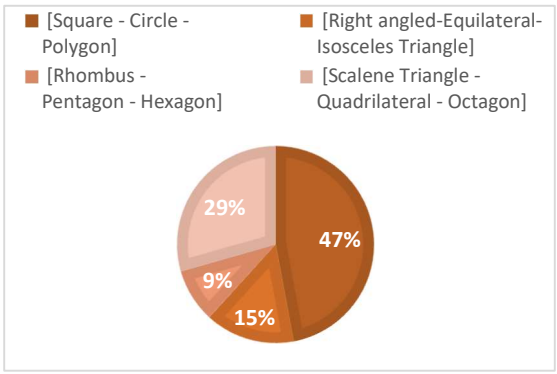
E) Q 5 - Geometry in design is seen in the context of -

RESPONSE FROM **ARCHITECTS**

OVERALL RESPONSES ON ALL OPTIONS -

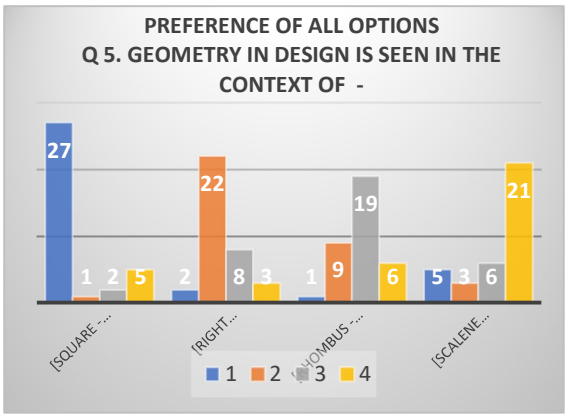


RESPONSES w.r.t OPTION 1 -



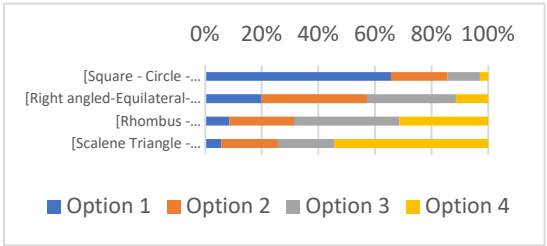
NUMERICAL DATA ON RESPONSES –

AS PER OPTION	1	2	3	4
Square - Circle - Polygon	27	1	2	5
Right angled-Equilateral-Isosceles Triangle	2	22	8	3
Rhombus - Pentagon - Hexagon	1	9	19	6
Scalene Triangle - Quadrilateral - Octagon	5	3	6	21

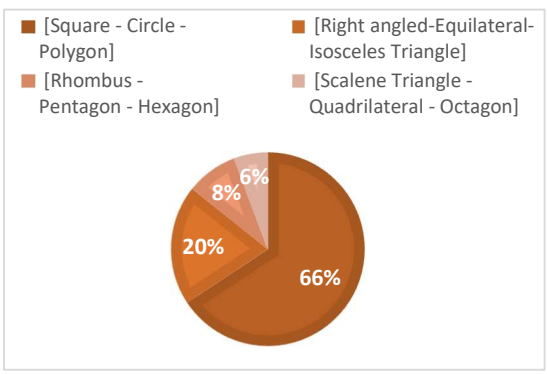


RESPONSE FROM **FASHION DESIGNERS**

OVERALL RESPONSES ON ALL OPTIONS -

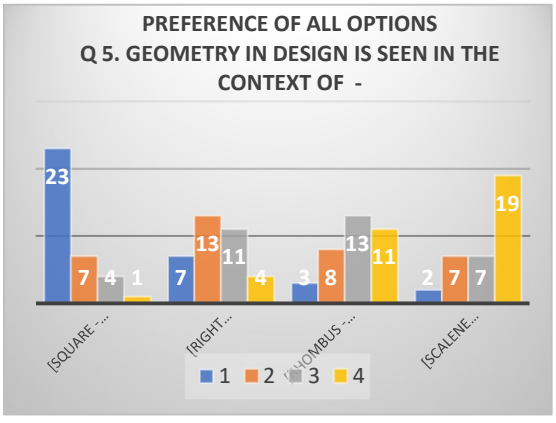


RESPONSES w.r.t OPTION 1 -



NUMERICAL DATA ON RESPONSES –

AS PER OPTION	1	2	3	4
Square - Circle - Polygon	23	7	4	1
Right angled-Equilateral-Isosceles Triangle	7	13	11	4
Rhombus - Pentagon - Hexagon	3	8	13	11
Scalene Triangle - Quadrilateral - Octagon	2	7	7	19



Ques 5 - Comparative views: Fig. 92a & b: Preferences of Architects & Fashion Designers [pc: Author]

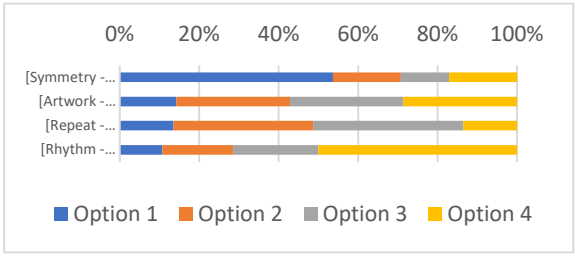
Observations:

i) Basic shapes like Square etc matter more to Fashion Designers while Architects give similar importance to other shapes alongside
ii) Triangles with specifics remain a secondary choice for both
iii) Polygons are less instrumental for perceiving Design through Geometry

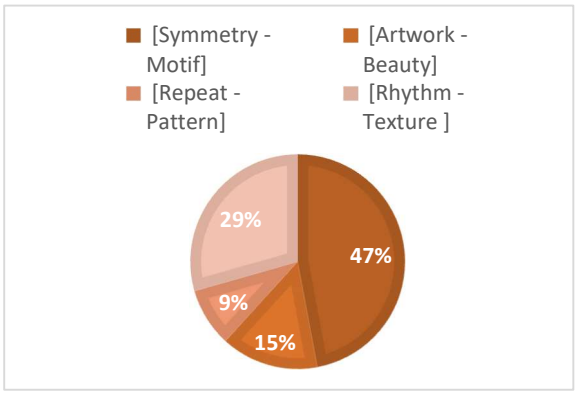
F) Q 6 - Geometry in design is necessary for -

RESPONSE FROM **ARCHITECTS**

OVERALL RESPONSES ON ALL OPTIONS -

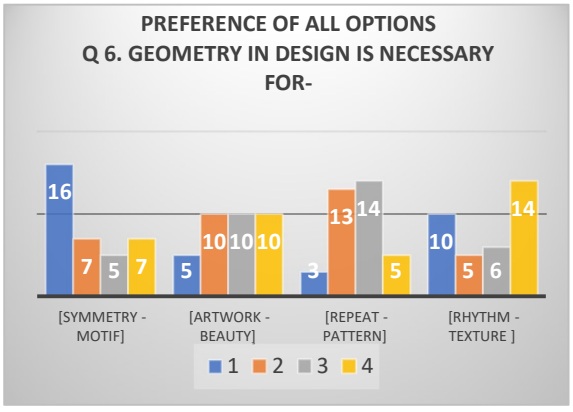


RESPONSES w.r.t OPTION 1 -



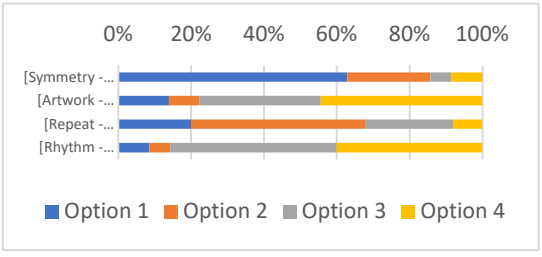
NUMERICAL DATA ON RESPONSES –

AS PER OPTION	1	2	3	4
Symmetry - Motif	16	7	5	7
Artwork - Beauty	5	10	10	10
Repeat - Pattern	3	13	14	5
Rhythm - Texture	10	5	6	14

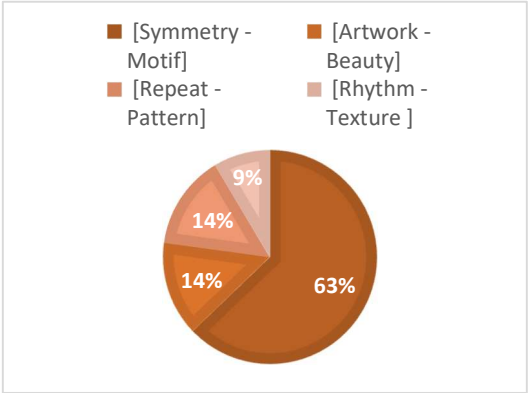


RESPONSE FROM **FASHION DESIGNERS**

OVERALL RESPONSES ON ALL OPTIONS -

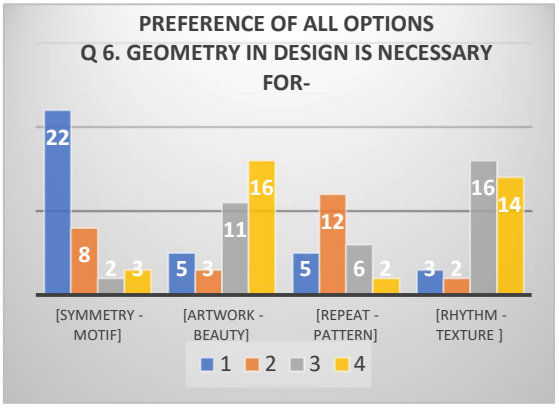


RESPONSES w.r.t OPTION 1 -



NUMERICAL DATA ON RESPONSES –

AS PER OPTION	1	2	3	4
Symmetry - Motif	22	8	2	3
Artwork - Beauty	5	3	11	16
Repeat - Pattern	5	12	6	2
Rhythm - Texture	3	2	16	14



Ques 6 - Comparative views: Fig. 93a & b: Preferences of Architects & Fashion Designers [pc: Author]

Observations:

i) Symmetry and Motif finds maximum preference from both Fashion Designers while Architects give similar importance to other shapes alongside

ii) Triangles with specifics remain a secondary choice for both

iii)Polygons are less instrumental for perceiving Design through Geometry

5.3 DERIVED FACTORS :

The final inference is now drawn on the perception of Design through Geometry interpreting the views of Fashion Designers and Architects on understanding and application of Geometry in Design.

5.3.1 Factors emerging from Architects:

i) W.r.t. Relevance of Geometry in design, Form and Purpose are more important than Construction based on Measures. Aesthetics of Objects and Components not being significant.

ii) Geometry in design is perceived with Scale and Proportion while Elements and Components are equally relevant and Technicality with Measures closely following. However, the latter being also insignificant to some.

iii) Natural Geometry is perceived through Forms and Elements, where Balance and Proportion are significant. Planes and Outlines remain insignificant with Components and Composition

iv) In Man made objects, Components and Surfaces are most significant followed by Outlines, Arrangements, Dimension and Proportion. Elements with Compositions are less preferred

v) Geometry in Design is identified predominantly with basic shapes of Square, Circle and Polygons, followed by Triangles defined in shape. Specific Polygonal Shapes with complex outlines are not preferred

vi) Geometry is necessary to generate Symmetry and Motifs, Rhythm and Texture following closely. Artwork or Beauty, and Repeats and Pattern is less relevant. However, Beauty and Texture can also be of least significance as well.

5.3.2 Factors emerging from Fashion Designers:

i) W.r.t. Relevance of Geometry in design, Construction based on Measures are primary, leading to Form generation based on Purpose being of similar significance. Aesthetics of Objects is less profound.

ii) Geometry in design is perceived primarily through Scale and Proportion generated through technicality and dimensions Outlines, Elements and Composition are less in consideration

iii) Nature influences Geometry through Forms and Elements, where Planes and Outlines help in identification and Composition of the structures. Planes and outlines are also less observed.

iv) For Man made objects, Dimensions and Proportions control primarily in Arrangements created through Lines and Elements. Planar Elements of Surfaces are least important.

v) Geometry in Design is identified primarily with basic shapes of Square, Circle and Polygons, defined Triangles following in significance. Specific Polygonal Shapes with complex outlines are avoided

vi) Geometry is necessary for creating Symmetry and Motifs, followed with Repeats leading to Patterns. Rhythm, Texture and Artwork or Beauty is least relevant to conceptualizing Design

5.3.3 Interrelationship:

From the views of Fashion Designers and Architects tabulated with number of responses received under each option, we now arrive at the similarities and dissimilarities in perception on understanding and application of Geometry in Design.

Based on their views on the 6 Questions, similarity of opinions is seen in the context of -

- *Relevance of geometry in design is w.r.t*
- *Nature influences geometry in design through*
- *Geometry in design is seen in the context of*
- *Geometry in design is necessary for*

On the other hand, the invariance of responses is found in the context of –

- *Geometry in design is perceived with*
- *Man-made objects reflect geometry through.*

The factors of convergence and divergence of perception are listed below –

*A) **CONVERGING FACTORS INTERPRETING GEOMETRY***:

Factors preferred similarly by Architects and Fashion Designers -

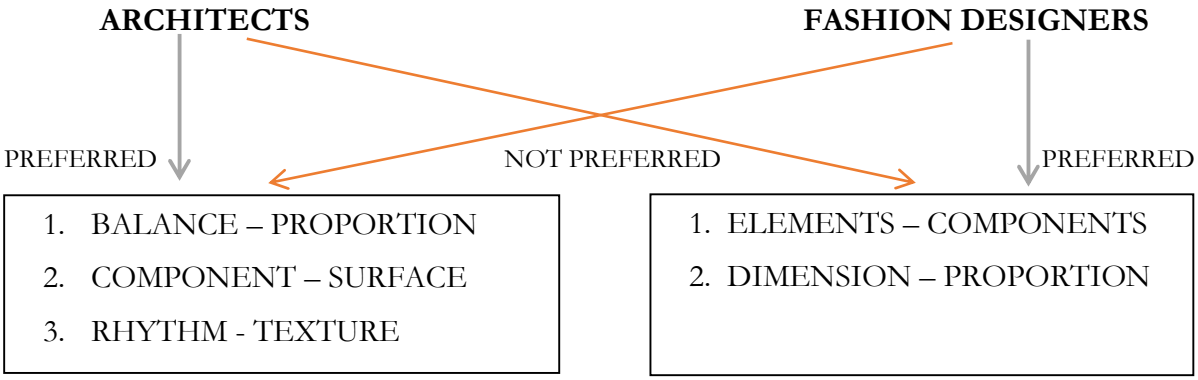
Table 25: Factors emerging from interpretation by Architects & Fashion Designers [pc: Author]

MOST PREFERRED	LEAST PREFERRED
1. Form - Purpose	1. Dimension - Component
2. Construction - Measurement	2. Object - Aesthetics
3. Scale- Proportion	3. Outline - Component
4. Technicality - Measurements	4. Element - Dimension
5. Forms - Elements	5. Planes - Outlines
6. Outline -Arrangement	6. Component – Composition
7. Square - Circle – Polygon	7. Scalene Triangle - Quadrilateral – Octagon
8. Right angled-Equilateral- Isosceles Triangle	8. Rhombus - Pentagon – Hexagon
9. Symmetry – Motif	9. Artwork – Beauty
10. Repeat – Pattern	10. Rhythm – Texture

B) DIVERGING FACTORS INTERPRETING GEOMETRY:

Factors contradictorily preferred by Architects and Fashion Designers

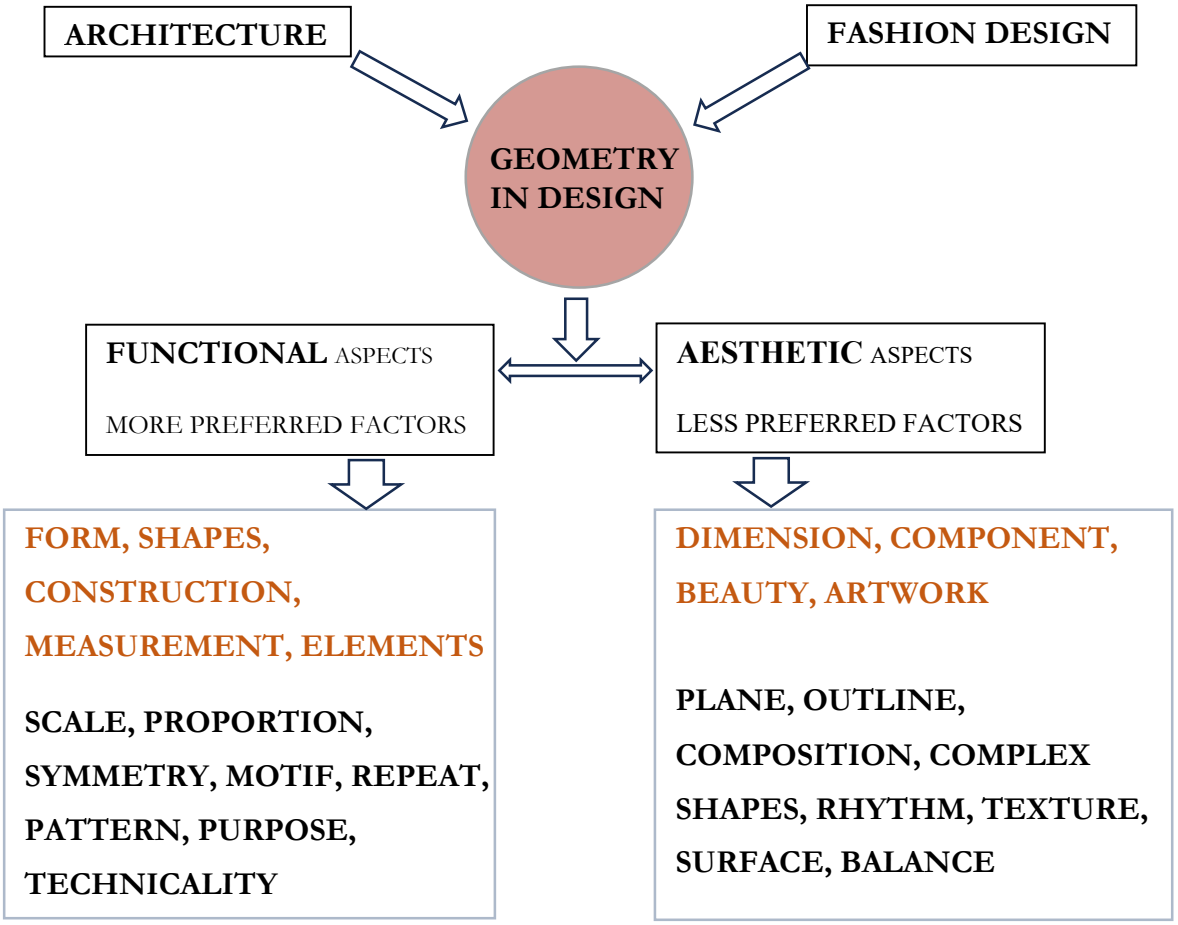
Table 26: Factors from differing opinion of Architects & Fashion Designers [pc: Author]



5.4 Co-relation of factors of visual perception of geometry

From the above segregation of responses, we now arrive at the final interpretive listing of responses validating it to the findings at the conclusion of Chapter 4.

Table 27: Factors from interpretation by Architects & Fashion Designers [pc Author]:



5.5 Final Observations

- Human mind perceives Design as a holistic Form, with Shapes and Proportion.
- Geometry is found intrinsic to physical realization of Form with regular outlines and proportions.
- It is aligned to Measurements and Construction for fulfilment of Purpose.
- Cognizance is given to regular shapes and angles, with less recognition to points, lines, angles and other shapes in general
- Patterns and textures are recognized and balance is significant. But symmetry and repeats are not relevant to their generation.
- Individual shapes are most recognized than composition, making their structures more relevant to Design, leading to relation of shapes insignificant
- Aesthetics, in respect of Geometry, is considered in the structure of forms and not based on generic beauty and least considered on basic artistic creations. It is not associative with artistic expressions and Beauty is thus least aligned to Geometry in human observation.

5.6 Summary

A) Interpretation and Application of Geometry in Design is similar in most aspects of Fashion and Architecture

B) Perception factors are most significant based on Scale and Proportion, followed by Construction, Technicalities and measurements

C) Basic Shapes are more aligned than complex ones while preference remains for defined shapes than irregular ones

D) Symmetry is significant for Motifs and Patterns generate through Repeats

E) Individual Elements are important but overall Composition is not as important

F) Function and Purpose is most important while Aesthetics and Beauty is not primary for application of Geometry

G) In Fashion, Components and Elements are significant, while in Architecture, Surfaces and Textures are important

H) While Fashion focusses on Form and its Components, Architecture generates Form on Balance

I) Visual perception of Geometry in Fashion thus evolves out of Form generation through individual Components, their Construction and Measures, Elements leading to Components of the Object, use of Basic shapes and Repeats

J) Visual perception of Geometry in Architecture, on the other hand, evolves out of Form generation for Purpose, their Construction and Measures, Components of the Object considering the Surfaces, Textures and Planes, using Shapes with Technicality.

K) Proportion of Form emerges as most vital in the context of Geometry in Design

5.7 Inference & Direction on the Thesis

Visual preference surveys are an effective tool to identify potential design directions – making them ideal for envisioning future projects and design solutions. People respond according to their own visual context, ranking their imagery from highly preferred to the most disliked. These responses allow Experts to better visualize the design options. [Najar, et al, 2024] The various findings from such surveys and opinions in this Thesis are validated now through the professionals in practice to establish the significance of Geometry in Design of both the fields, their inter-relationships, convergence of thinking, divergence in application and the different perspectives in which form visualization takes place in terms of designed products. Thus, from the parameters emerges the factors that are images. appropriate to visual appreciation of design in terms of design in Architecture and Fashion.

This now would need summarization into specific sets of factors which can be taken up for design thinking and form generation in order to act as a set of elements and principles that lead to appealing design appreciation of the form generated. In order to establish the same in the concluding Chapter 6, the method adopted may be illustrated as follows:

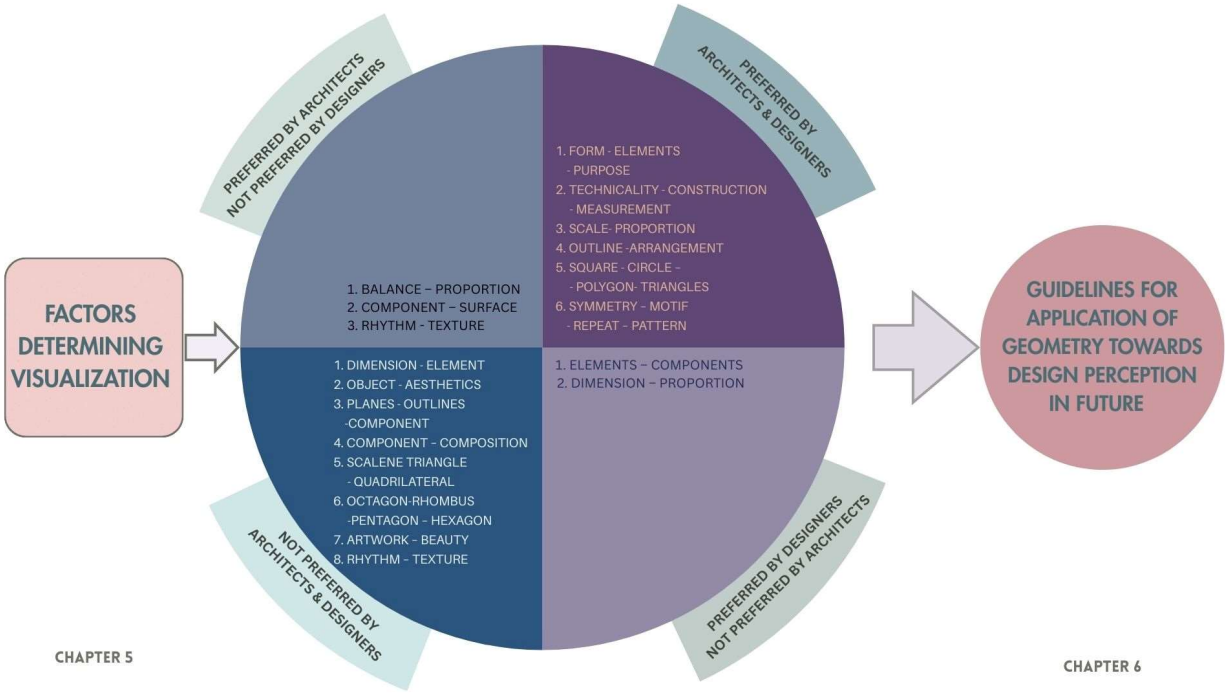


Fig. 94: **Emerging factor-based guidelines:** Towards application in Design [pc: Author]

CHAPTER 6

CONCLUSIONS

6.1 Framework for application of findings

The research on the hypothesis passed through a sequence of actions, starting from formulation of the hypothesis to arriving at the final directions on future design & research. Each chapter has been elucidated on the framework adopted, taking cues and conclusions of earlier chapter, and inference leading to the methodology or action in the following chapter. This final chapter will summarize the overall actions and findings into identifying guidelines towards application of Geometry towards visual perception in Geometry based out of Design related to Architecture and Fashion.

This chapter, in conclusion will identify the different areas which will conclude the research as well as lead to the directions from the findings. These would include:

a) *ISSUES* –

The broad categories of understanding the hypothesis towards framing the research activity

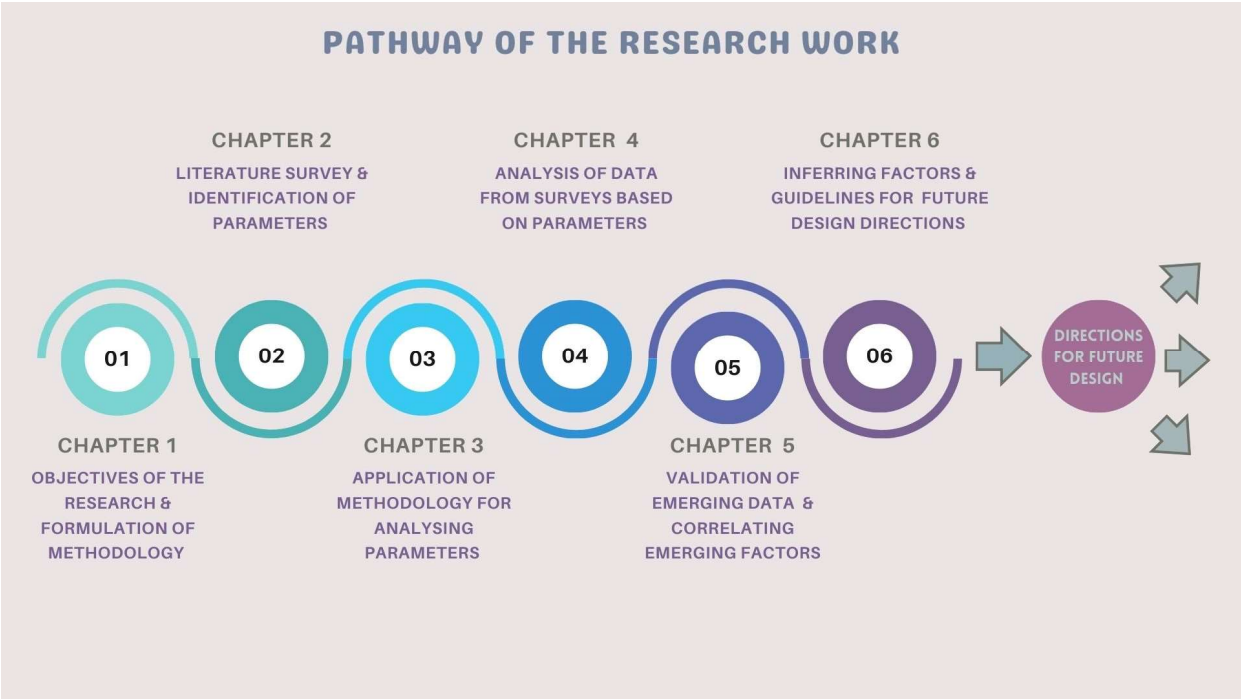
b) *CONTRIBUTIONS* –

Identifying the factors responsible for the visual perception of Geometry in design

c) *FUTURE DIRECTIONS* –

Formulating guidelines that may be adopted in design thinking in future and providing the various directions the research may lead to from the emerging data of this research

The overall framework of the research activity can be summed up as illustrated below:



Formulating framework of the research: Fig. 95 – Chapter based pathway of action followed [pc: Author]

6.2 ISSUES

Fashion and Architecture have shown forms influenced by each other and is a popular method when products are designed taking either as inspiration, although Architecture influences largely. The issues that emerged from the research on the hypothesis can be listed as follows –

A) Understanding of geometry through ages

The Literature surveys showed that Geometry and its understanding has existed though era, cultures, communities and practices. It remained embedded in cultures and became a way of life. However, the logic that was understood ages back by philosophers and scientists like Plato or Galileo, considering it to be a universal presence and necessity in Design of structures, remained in application and practised sub consciously but not perceiving the logical need in design. Nature and its inherent Geometry went to influence without the understanding of doing so.

B) Established perception on geometry

At the onset of research, it was found that for general people, Geometry was a mathematical subject, while they remained aware of their design appreciation subconsciously applying an inherent Geometric sensibility. Geometric expressions and choices were all the time being used and applied in daily lives, natural and man-made surroundings. It was necessary to identify this inherent Geometry in human mind that guides the visual perception of Forms all around us

C) Visual influence

It is often found when Fashion Products and Architectural structures are identifiable based on their physical forms. However, the logic for adopting the form remains only visual in expression, although the design process needs to integrate lot more.

D) Subjective studies

Several studies have been done on how Fashion and Architecture influences their designs. But these studies centred on the looks and examples only, but not seeking deeper introspection into the logic behind the adaptation

E) Absence of data

While researching on this hypothesis, it was very difficult to come across any quantitative data which could be aligned to the study. Opinions available was qualitative and personal, making it not relevant as research data. It necessitated the formulation of a methodology for quantification of qualitative data, converting subjective information into objective factors.

F) Interdependence

Design in Fashion and Architecture showed convergence in form and can be related to Natural Forms and systems. However, where the commonality ended and the deviations started are hard to decipher although it is evident that there is a strong cohesiveness in the thinking and manifestations. It required to be defined with directions.

6.3 CONTRIBUTION

The major contribution of this research attributes to the identification of the factors that help establish the reason behind the interdependency of Fashion and Architecture which has existed side by side and influenced each other in their expressions of creations. These are synced with the initial objectives framed for the research, and has evolved out of sequential action on the methodology adopted towards determining objective directions based on subjective observations. With little or no data available to identify the logic of this corelation, this thesis has been able to ascertain the qualitative aspects through quantitative measures and methodologies which can now be used to determine further studies into this domain. The major aspects contributed are as follows –

1. ***Determination of parameters of Geometry in Design, related to Fashion and Architecture***

The absence of any identified factor / value, it was essential to scrutinize the areas where Geometry emerged in Design. This led to intensive Literature Review in Chapter 2 to establish all sectors where Geometry manifested in Design and was intrinsic to. From these studies emerged the existence of Geometry in nature and the Universe, which has been applied and practised in historical periods and beyond since existence of human settlements. Analysing these, the parameters of application and understanding based on Geometry gradually evolved.

2. ***Analysis of the parameters from different perspectives***

The parameters, on identification, required analysis on their logical contribution in different aspects w.r.t both design disciplines in concern. The evolution of design in the two directions had both similar and dissimilar pathways, generating diverse logic of application. The absolute existence of Geometry was identified on regional, cultural or ethnographic differences as also the understanding of mathematics, materials, techniques and technological factors that Geometry has to align with.

3. ***Formulation of a methodology to derive quantified direction for qualitative studies***

Quantification becoming an absolute necessity, it was essential to formulate a methodology to gather numerical data to understand the qualitative factors. Accordingly, surveys were framed interposing analysis and validation, and leading to further surveys. As seen in Chapters 3 & 4, these eventually helped in filtering the final factors that emerge universally applicable to understanding the perception of Geometry in Design.

4. Determining the Interdependency of Fashion and Architecture based on Geometry

Through this methodology and the factors identified finally, it was possible to establish the similarities and dissimilarities in the two directions of Design, establishing Convergence and Divergence of the domains. In Chapter 5, it was possible to establish that these Geometric factors are the logic behind the design and form developments, whether in Fashion or Architecture. It also emerged that though design thinking remains mostly identical guided by Geometry, there are a few areas which are more preferred by either domain while sidelined by the others.

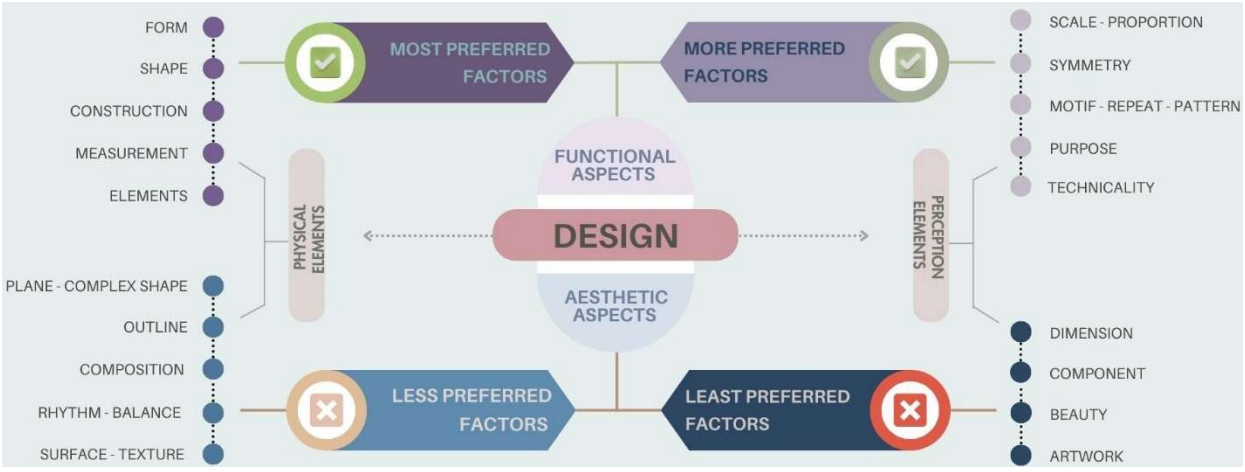
5. Opinion of Experts and General users to establish universal guidelines

After the identification of factors and validation through surveys, it was necessary to justify the findings as gained from common people's perception on design through that of existing practitioners from both domains who consciously apply Geometry in Design, since the thesis wanted to understand whether the visual perception of Geometry is absolute in general or differs for those involved in designing. The survey outputs correlated with the parameters and analysis revealed that all Geometric forms thus created subconsciously adopted these factors, prioritized and also perceived forms based on the same. It was interesting to note how nearly similar number of respondents selected certain factors across both domains, thus establishing the absoluteness of the geometric factors involved and their necessity in design

6.4 EMERGING FACTORS OF GEOMETRY TO GUIDE DESIGN PROCESS

The factors that finally emerged from the above research is seen to fall within the ***Physical*** and ***Perception Elements*** determined earlier. These are now listed below for consideration in future design process . ***Functional aspects*** remain more significant than ***Aesthetic aspects*** and the factors are sequenced from ***Most preferred*** to the ***Least preferred*** for consideration in Design thinking.

Table 28: Factors to determine future design directions [pc: Author]



6.5 FUTURE DIRECTIONS FOR FURTHER RESEARCH

The research lies in the appreciation of Design w.r.t Fashion and Architecture, through human perception, evolving through designed methodologies into generating empirical findings that can be related and understood towards the appreciation of design on the basis of Geometry. Evolving from subjective aspects into quantification, though primary information rested on most evident factors emerging from Literature survey and the Respondents, but the responses had relative perception in terms of *Gender, Age, Community, Culture, History, Knowledge, Professio*n etc. This journey of exploring the hypothesis revealed the huge umbrella of directions that can be now considered and taken as individual pathways towards design thinking and design generation. While this research concludes on identification of the Functional and Aesthetic factors only over a certain range of data gathered, there lies a tranche of information which had to be sidelined in order focus on a singular pathway. The directions that can take its pathways from here are as follows –

A) Understanding Proportion and Sacred Geometry and its influence on Design elements

The Literature Survey revealed the significance of Sacred Geometry over ages and cultures and its conscious and sub conscious application. From the primary data collections too, Proportion emerges as the most preferred option for appreciation of Geometry in designed objects. This can be a very significant direction to identify the factors and elements in sacred Geometry and Proportion system which is inherent to different cultures.

As Cavin Harlan says -

> "*A spontaneous, visual intuitive grasp of harmonious proportions must enliven all mathematical formulations, give energy and direction to every design from the moment of conception. Then, when one is working through difficulties, intuition and theory may be able to establish a partnership that is at the heart of classicism of whatever time or place. Other modalities spring from other relations between the extremes of passion and construction, chaos and geometry."* [Harlan, 1986]

B) Considering perception based on Gender, Age, Culture and other ethno-social factors

The surveys have generated varied responses based on the above factors which draws attention to the various ways the aspects are interpreted and visual perception diversifies into generating different response to the same aspect / object. The perception surfaces out of a Human mind through their individual vision, with memories, cultural practices and elements of ethnicity determining the exact appreciation within the visual frame. Age, Gender plays similar roles. Further study based on these aspects can lead to interesting research on virgin directions.

Kapila Vatsyayan has identified this as -

"…. with the body as an organic as well as a physical entity with an ability to establish relationships with space above and around, we must necessarily turn to the question of the methodologies which a culture evolves to locate this body in time present, past and future. Our objective is to identify and interpret a few select notions of speculative thought which govern the artistic vision and give rise to a group of formal elements of artistic form…. the broader structure must be briefly mentioned, merely to place the more specific inquiry of Man in space and time against its appropriate background and frame of reference." [Vatsyayan, 1997]

C) Study on the visual elements

The surveys generated a separate set of responses where the 120 young respondents expressed their understanding of Geometry in objects around them through sketches. Being too vast for consideration under this research, the data was kept aside for continuing the research on visual directions. From this visual data emerges the exact elements, shapes and forms that impact perception in natural and man-made objects. This can lead to further research on detailed findings on the hierarchy of the primarily functional factors identified in conclusion of this research and their individual relevance and impact.

Like Yatin Pandya says -

"Each of these elements possess attributes inherent to their morphological construct which endow them with particular special properties providing potential for their use and design in architectural compositions. They thus influenced space and its experience, thereby orchestrating the perception of the built environment. For this, the elements rely almost entirely on their basic inherent special properties to which the additional overlays of stylization construction rendering and treatment only add value" [Pandya, 2012]

Yuniya Kawamura iterates -

"Fashion is not visual clothing but is the invisible elements in clothing" [Kawamura, 2004]

D) Category of Experts and their perception

In the final Expert survey, it was identified as 4 sets of professions involved – Academics, Consultant, Entrepreneur, Service. The responses illustrate a similarity based on the area of practice, as also amongst similar area of practice across the two professions, and generating similar perception within same age groups. This can trigger a new direction of research to identify the influence of the profession and experience in generation of their visual perception.

Kimberly Elam rightly points out -

"By revealing some of the geometry, systems, and proportions it is possible to understand better the intent and reasoning of a number of designers and architects. It gives insight into the process of realization and a rational explanation for many decisions, whether the use of organizational geometry is intuitive or deliberate, rightly applied or casually considered [Elam, 2011]

E) Design / Product based intensive study

Taking the findings of this research ahead, now the designs / products in either domain of Fashion & Architecture can be interpreted and further study conducted to identify the specific factors that determine realization of the creative process. In this research the macro factors have been identified. Further research can lead to micro inspection of product groups for identification of relevant elements and factors that generate form.

Summing up in the words of F. D. K. Ching -

> *"Throughout the design process we use drawing to guide the development of an idea from concept to proposal to constructed reality…. Seeing creates the images of external reality we perceive with our eyes open which give rise to our discovery of the world. With our eyes closed, the mind's eye presents images of an inner reality - visual memories of past events or projections of an imagined future…. The visual data received by the I is processed manipulated and filtered by the mind in its active search for structure and meaning."* [Ching, 1979]

6.6 CONCLUDING INFERENCE

The research work concentrated in one central track to identify the most concerned areas of perception for the appreciation of the two design streams. However, a large amount of data remains available for exploration to identify more specific directions that lead unconsciously to design guided by geometry. The socio-cultural aspects or the regional / community factors that have always cocooned design evolution in communities and human evolution, largely remains untouched. With a basic quantification done in this research on most obvious and generic, yet completely subjective decisions on design thinking, can now be taken forward to decide on the subsequent directions, some of the data derived being visual and rather interesting to inspect further.

The research can thus branch out in many subsidiary micro areas from this stage …….

Geometry integrating Architecture & Fashion: Fig. 96: Works of Zaha Hadid [pc: Pinterest & ArchDaily.com]

CHAPTER BASED

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CHAPTER 6: **CONCLUSION**

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ANNEXURES

ANNEXURE 1 –

QUESTIONNAIRE -GENERAL OPINION SURVEY

OPTION	1	2	3	4
1. **'GEOMETRY' MEANS** -				
i) OUTLINES AROUND US				
ii) MEASUREMENT OF OBJECTS				
iii) CONSTRUCTION OF SHAPES				
iv) CREATING PATTERNS				
2 **APPLICATION OF GEOMETRY** -				
i) DRAWING SHAPES				
ii) MEASURING AREA AND VOLUME				
iii) TECHNICAL CONSTRUCTIONS				
iv) COMPOSING PATTERNS				
3. **GEOMETRY CONTAINS** -				
i) SCALE				
ii) PROPORTION				
iii) BALANCE				
iv) SYMMETRY				
4. **GEOMETRY IS SEEN THROUGH** -				
i) DIMENSIONS				
ii) ANGLES				
iii) SHAPES				
iv) PATTERNS				
5. **GEOMETRY IS NECESSARY FOR** -				
i) ARTWORK				
ii) SCULPTURE				
iii) PRODUCTS				
iv) PATTERNS				

OPTION	1	2	3	4
6. **IN NATURE WE SEE** -				
i) POINTS				
ii) LINES				
iii) SHAPES				
iv) FORMS				
7. **NATURAL ENVIRONMENT HAS** -				
i) SYMMETRY				
ii) RHYTHM				
iii) BALANCE				
iv) PROPORTION				
8. **SURFACE OF NATURAL OBJECTS SHOW** -				
i) SHAPES				
ii) REPEATS				
iii) TEXTURES				
iv) COMPOSITION				
9. **GEOMETRY OF MAN MADE DESIGN LIES IN** -				
i) MOTIFS				
ii) OUTLINES				
iii) REPEATS				
iv) PROPORTION				
10. **MAN MADE OBJECTS SHOW** -				
i) SHAPES				
ii) REPEATS				
iii) TEXTURES				
iv) COMPOSITION				

OPTION	1	2	3	4
11. **MAN MADE DESIGNS DEPEND ON** -				
i) DIMENSIONS				
ii) ANGLES				
iii) PROPORTION				
iv) RLEATION OF SHAPES				
12. **GEOMETRY IN DESIGN IS ESSENTIAL FOR** -				
i) PURPOSE				
ii) BEAUTY				
iii) FORM DEVELOPMENT				
iv) SURFACE PATTERN				
1. **SHAPES SEEN MOSTLY AROUND US** -				
i) TRIANGLE				
ii) SQUARE				
iii) CIRCLE				
iv) POLYGON				
2. **TYPE OF TRIANGLE SEEN MOSTLY IN OBJECTS – NATURAL AND MAN MADE**				
i) EQUILATERAL TRIANGLE				
ii) RIGHT ANGLED TRIANGLE				
iii) SCALENE TRIANGLE				
iv) ISOCELES TRIANGLE				
3. **TYPE OF POLYGON SEEN MOSTLY IN OBJECTS – NATURAL AND MAN MADE**				
i) RHOMBUS				
ii) PENTAGON				
iii) HEXAGON				
iv) OCTAGON				

QUESTIONNAIRE FOR GENERAL OPINION SURVEY – 15 QUESTIONS

ANNEXURE 2 –

SAMPLE SURVEY RESPONSES- GENERAL OPINION SURVEY

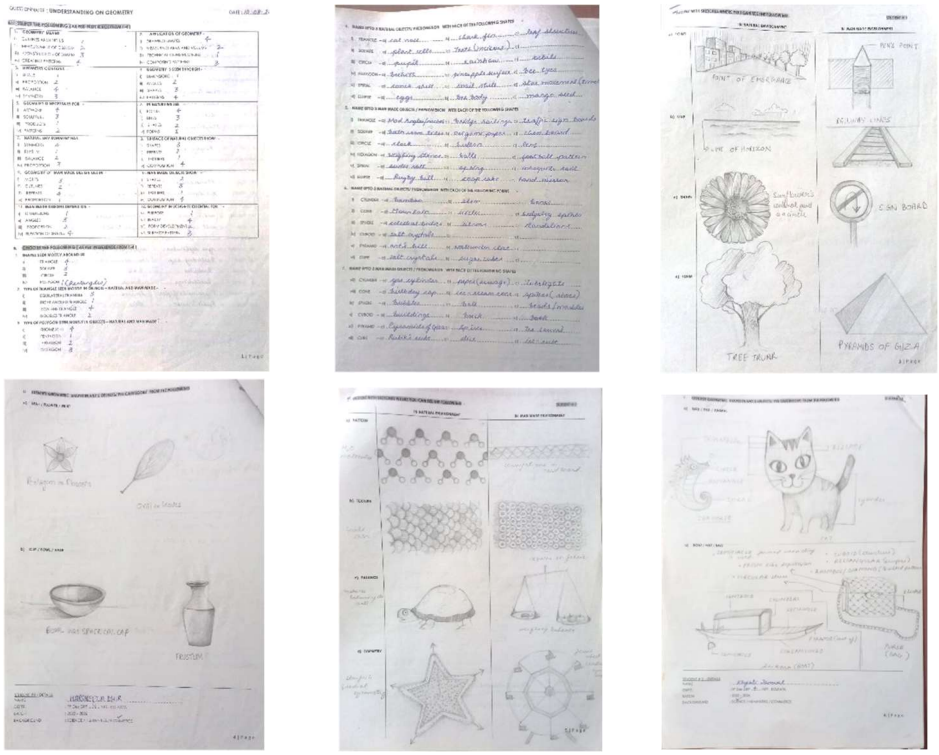


ILLUSTRATION # 1 : RESPONSES OF 2 MEMBER TEAM

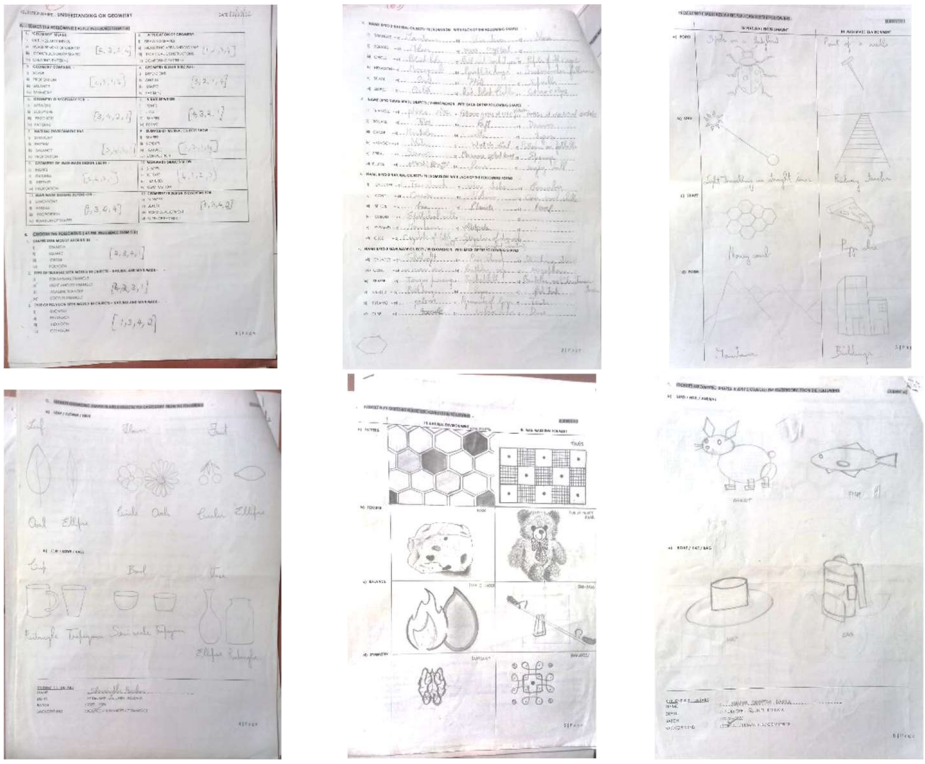
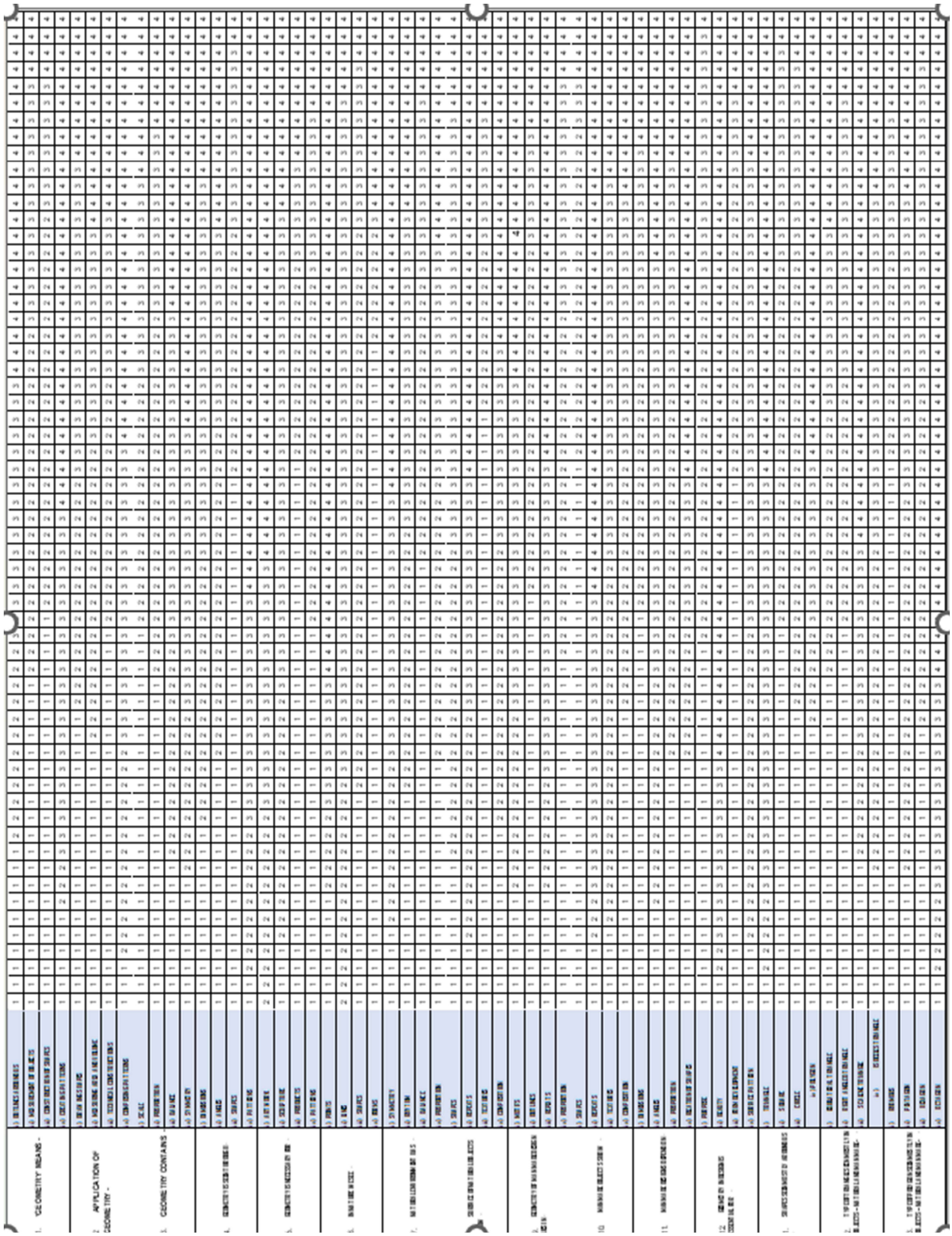


ILLUSTRATION # 2: RESPONSES OF 2 MEMBER TEAM –

ANNEXURE 3 –
RESPONSE DATA - GENERAL OPINION SURVEY



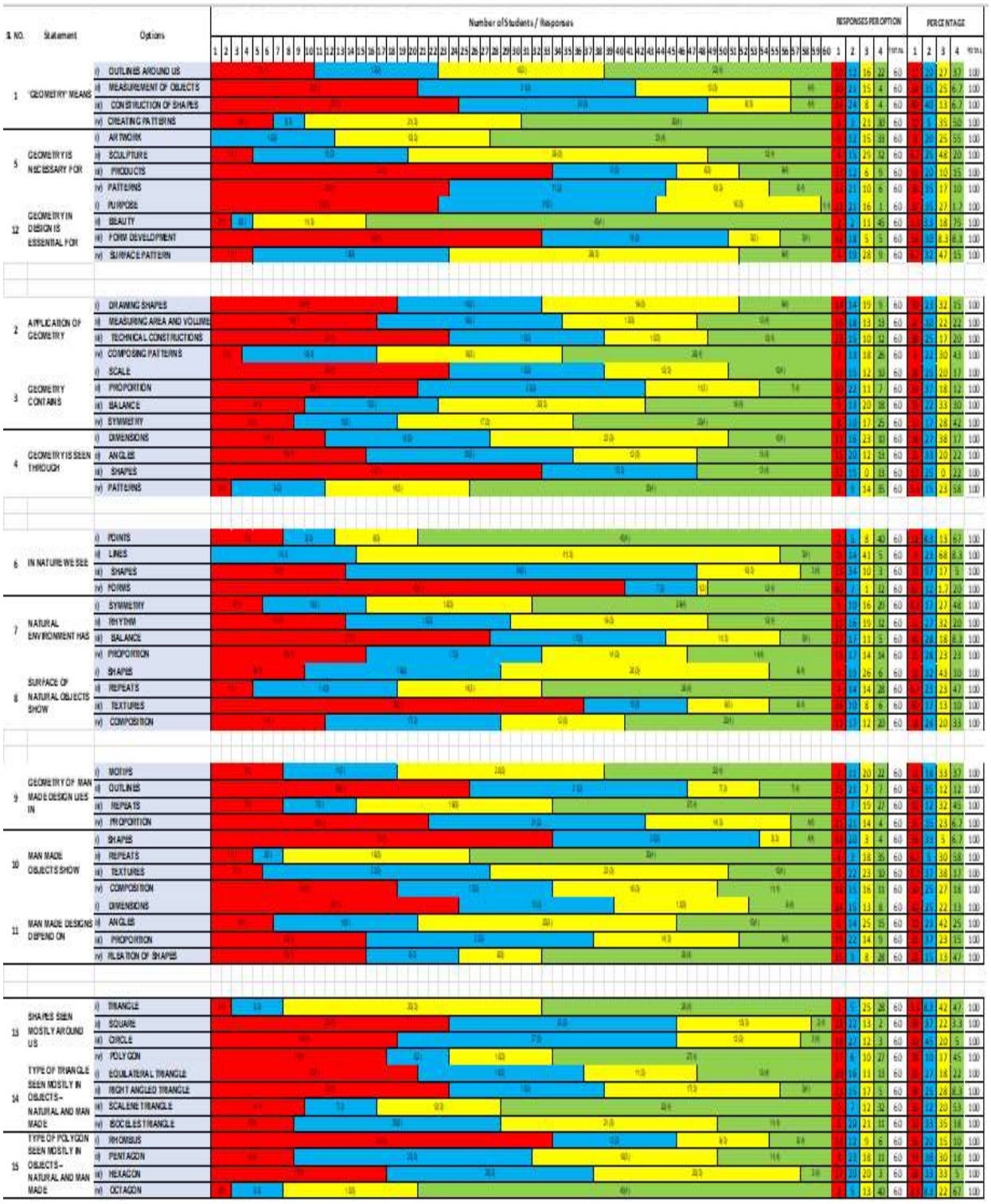
a) ALL RESPONSES ON 15 QUESTIONS

SL NO:	Statement	Options	RESPONSES PER OPTION					PERCENTAGE				
			1	2	3	4	TOTAL	1	2	3	4	TOTAL
1	'GEOMETRY' MEANS	i) OUTLINES AROUND US	13	12	16	22	60	22	20	27	37	100
		ii) MEASUREMENT OF OBJECTS	20	27	15	4	60	33	45	25	6.7	100
		iii) CONSTRUCTION OF SHAPES	19	24	8	4	60	32	40	13	6.7	100
		iv) CREATING PATTERNS	8	7	21	30	60	13	12	35	50	100
2	APPLICATION OF GEOMETRY	i) DRAWING SHAPES	19	14	15	12	60	32	23	25	20	100
		ii) MEASURING AREA AND VOLUME	20	22	13	13	60	33	37	22	22	100
		iii) TECHNICAL CONSTRUCTIONS	23	15	10	12	60	38	25	17	20	100
		iv) COMPOSING PATTERNS	7	13	16	26	60	12	22	27	43	100
3	GEOMETRY CONTAINS	i) SCALE	20	15	12	13	60	33	25	20	22	100
		ii) PROPORTION	20	22	11	7	60	33	37	18	12	100
		iii) BALANCE	7	13	20	18	60	12	22	33	30	100
		iv) SYMMETRY	9	10	17	25	60	15	17	28	42	100
		i) DIMENSIONS	13	16	23	10	60	22	27	38	17	100
4	GEOMETRY IS SEEN THROUGH	ii) ANGLES	14	20	12	13	60	23	33	20	22	100
		iii) SHAPES	20	15	5	13	60	33	25	8	22	100
		iv) PATTERNS	7	5	14	35	60	12	8	23	58	100
5	GEOMETRY IS NECESSARY FOR	i) ARTWORK	5	12	15	33	60	8	20	25	55	100
		ii) SCULPTURE	4	15	25	22	60	7	25	42	37	100
		iii) PRODUCTS	18	12	6	5	60	30	20	10	8	100
		iv) PATTERNS	23	21	10	6	60	38	35	17	10	100
6	IN NATURE WE SEE	i) POINTS	7	5	8	40	60	12	8.3	13	67	100
		ii) LINES	6	24	41	9	60	10	40	68	8.3	100
		iii) SHAPES	23	34	10	3	60	38	57	17	5	100
		iv) FORMS	40	7	1	12	60	67	12	1.7	20	100
7	NATURAL ENVIRONMENT HAS	i) SYMMETRY	9	10	16	25	60	15	17	27	42	100
		ii) RHYTHM	11	16	19	14	60	18	27	32	23	100
		iii) BALANCE	23	17	11	5	60	38	28	18	8.3	100
		iv) PROPORTION	15	17	14	14	60	25	28	23	23	100
8	SURFACE OF NATURAL OBJECTS SHOW	i) SHAPES	9	21	26	6	60	15	32	43	10	100
		ii) REPEATS	9	14	14	23	60	15	23	23	47	100
		iii) TEXTURES	19	10	8	23	60	32	17	13	38	100
		iv) COMPOSITION	11	17	12	20	60	18	28	20	33	100
9	GEOMETRY OF MAN MADE DESIGN LIES IN	i) MOTIFS	7	11	20	22	60	12	18	33	37	100
		ii) OUTLINES	25	21	7	7	60	42	35	12	12	100
		iii) REPEATS	7	7	19	27	60	12	12	32	45	100
		iv) PROPORTION	13	21	14	4	60	22	35	23	6.7	100
10	MAN MADE OBJECTS SHOW	i) SHAPES	23	20	3	4	60	38	33	5	6.7	100
		ii) REPEATS	4	3	18	35	60	6.7	5	30	58	100
		iii) TEXTURES	5	22	23	10	60	8.3	37	38	17	100
		iv) COMPOSITION	16	15	16	13	60	27	25	27	22	100
11	MAN MADE DESIGNS DEPEND ON	i) DIMENSIONS	25	21	13	8	60	42	35	22	13	100
		ii) ANGLES	6	14	25	15	60	10	23	42	25	100
		iii) PROPORTION	5	22	14	9	60	8	37	23	15	100
		iv) RELATION OF SHAPES	23	5	9	23	60	38	8	15	38	100
12	GEOMETRY IN DESIGN IS ESSENTIAL FOR	i) PURPOSE	13	21	16	1	60	22	35	27	1.7	100
		ii) BEAUTY	1	2	11	45	60	1.7	3.3	18	75	100
		iii) FORM DEVELOPMENT	2	3	5	5	60	3.3	5	8.3	8.3	100
		iv) SURFACE PATTERN	4	9	28	9	60	6.7	15	47	15	100
13	SHAPES SEEN MOSTLY AROUND US	i) TRIANGLE	2	3	25	28	60	3.3	5	42	47	100
		ii) SQUARE	23	22	13	2	60	38	37	22	3.3	100
		iii) CIRCLE	10	27	12	3	60	17	45	20	5	100
		iv) POLYGON	12	8	10	27	60	20	13	17	45	100
14	TYPE OF TRIANGLE SEEN MOSTLY IN OBJECTS– NATURAL AND MAN MADE	i) EQUILATERAL TRIANGLE	20	16	11	13	60	33	27	18	22	100
		ii) RIGHT ANGLED TRIANGLE	13	15	17	5	60	22	25	28	8.3	100
		iii) SCALENE TRIANGLE	5	7	12	32	60	8	12	20	53	100
		iv) ISOCELES TRIANGLE	8	21	21	11	60	13	35	35	18	100
15	TYPE OF POLYGON SEEN MOSTLY IN OBJECTS– NATURAL AND MAN MADE	i) RHOMBUS	10	12	9	6	60	17	20	15	10	100
		ii) PENTAGON	6	23	18	13	60	10	38	30	22	100
		iii) HEXAGON	17	20	20	3	60	28	33	33	5	100
		iv) OCTAGON	2	5	13	40	60	3.3	8.3	22	67	100

b) QUANTIFICATION OF RESPONSE – 60 RESPONDENTS

INDEX

OPTION 1	OPTION 2	OPTION 3	OPTION 4

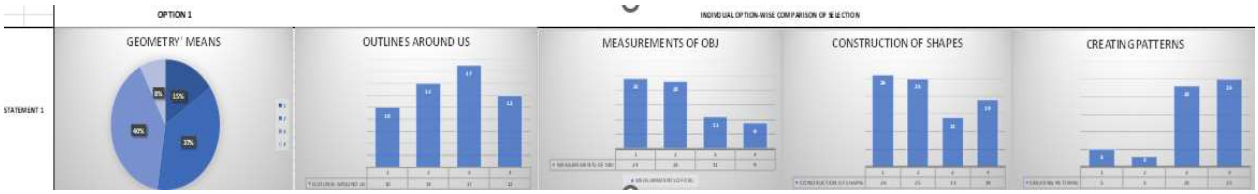


c) RELATIVE RESPONSES

INDEX

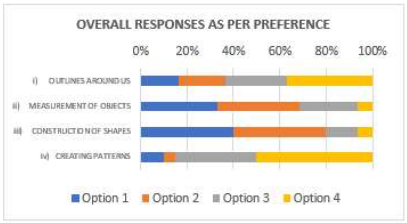
OPTION 1	OPTION 2	OPTION 3	OPTION 4

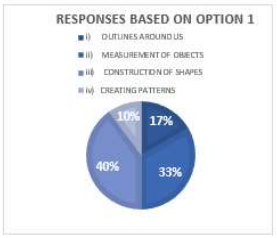
ANNEXURE 4 –
DATA ANALYSIS - GENERAL OPINION SURVEY

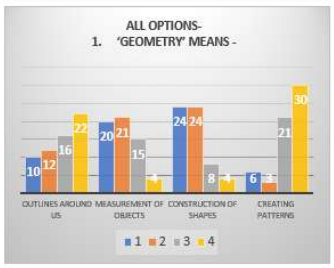


a) ILLUSTRATION # 1 : QUESTION BASED ANALYSIS

1. 'GEOMETRY' MEANS –

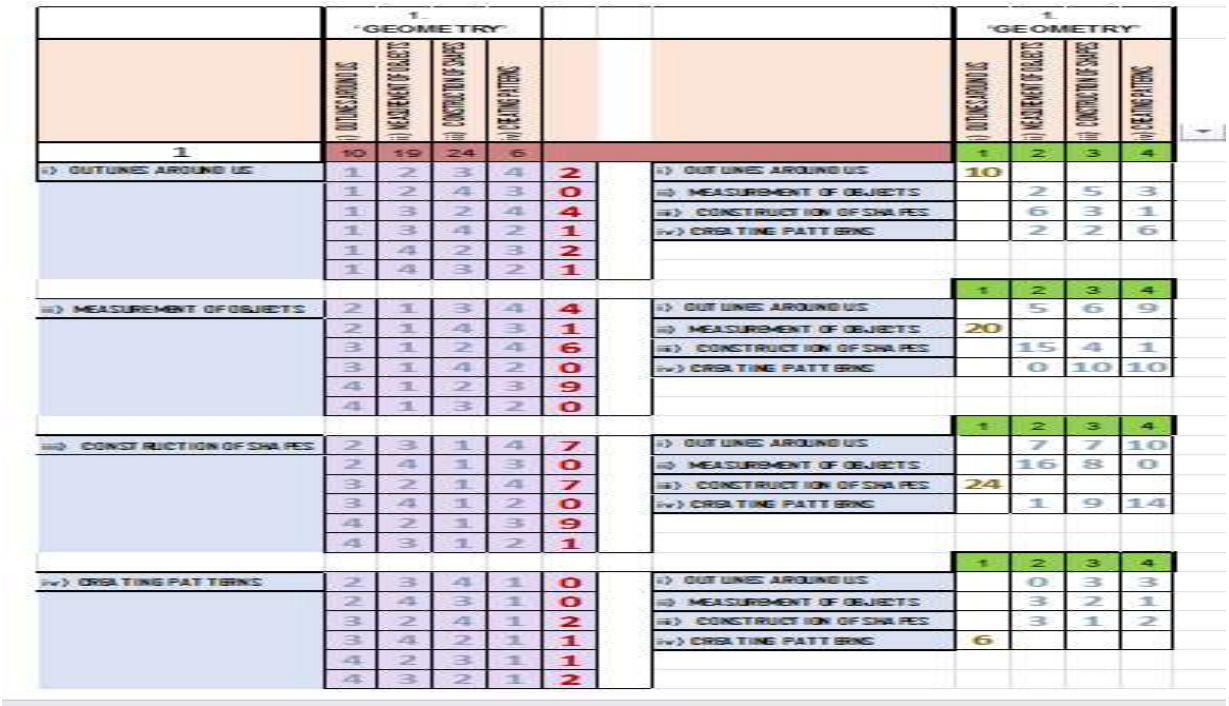






AS PER OPTION	1	2	3	4
OUTLINES AROUND US	10	12	16	22
MEASUREMENT OF OBJECTS	20	21	15	4
CONSTRUCTION OF SHAPES	24	24	8	4
CREATING PATTERNS	6	3	21	30

b) ILLUSTRATION # 2 : QUESTION BASED DERIVATIONS



1 "GEOMETRY"	i) OUTLINES AROUND US	ii) MEASUREMENT OF OBJECTS	iii) CONSTRUCTION OF SHAPES	iv) CREATING PATTERNS	
1	10	19	24	6	
i) OUTLINES AROUND US	1	2	3	4	2
	1	2	4	3	0
	1	3	2	4	4
	1	3	4	2	1
	1	4	2	3	2
	1	4	3	2	1
ii) MEASUREMENT OF OBJECTS	2	1	3	4	4
	2	1	4	3	1
	3	1	2	4	6
	3	1	4	2	0
	4	1	2	3	9
	4	1	3	2	0
iii) CONSTRUCTION OF SHAPES	2	3	1	4	7
	2	4	1	3	0
	3	2	1	4	7
	3	4	1	2	0
	4	2	1	3	9
	4	3	1	2	1
iv) CREATING PATTERNS	2	3	4	1	0
	2	4	3	1	0
	3	2	4	1	2
	3	4	2	1	1
	4	2	3	1	1
	4	3	2	1	2

1 "GEOMETRY"	1	2	3	4
i) OUTLINES AROUND US	10			
ii) MEASUREMENT OF OBJECTS		2	5	3
iii) CONSTRUCTION OF SHAPES		6	3	1
iv) CREATING PATTERNS		2	2	6
	1	2	3	4
i) OUTLINES AROUND US		5	6	9
ii) MEASUREMENT OF OBJECTS	20			
iii) CONSTRUCTION OF SHAPES		15	4	1
iv) CREATING PATTERNS		0	10	10
	1	2	3	4
i) OUTLINES AROUND US		7	7	10
ii) MEASUREMENT OF OBJECTS		16	8	0
iii) CONSTRUCTION OF SHAPES	24			
iv) CREATING PATTERNS		1	9	14
	1	2	3	4
i) OUTLINES AROUND US		0	3	3
ii) MEASUREMENT OF OBJECTS		3	2	1
iii) CONSTRUCTION OF SHAPES		3	1	2
iv) CREATING PATTERNS	6			

c) ILLUSTRATION # 3 : OPTIONS & RELATIVE RESPONSES /QUESTION

d) SET BASED ANALYSIS - 3 QUESTION SETS

ANNEXURE 5 –
CORRELATION OF ATTRIBUTES

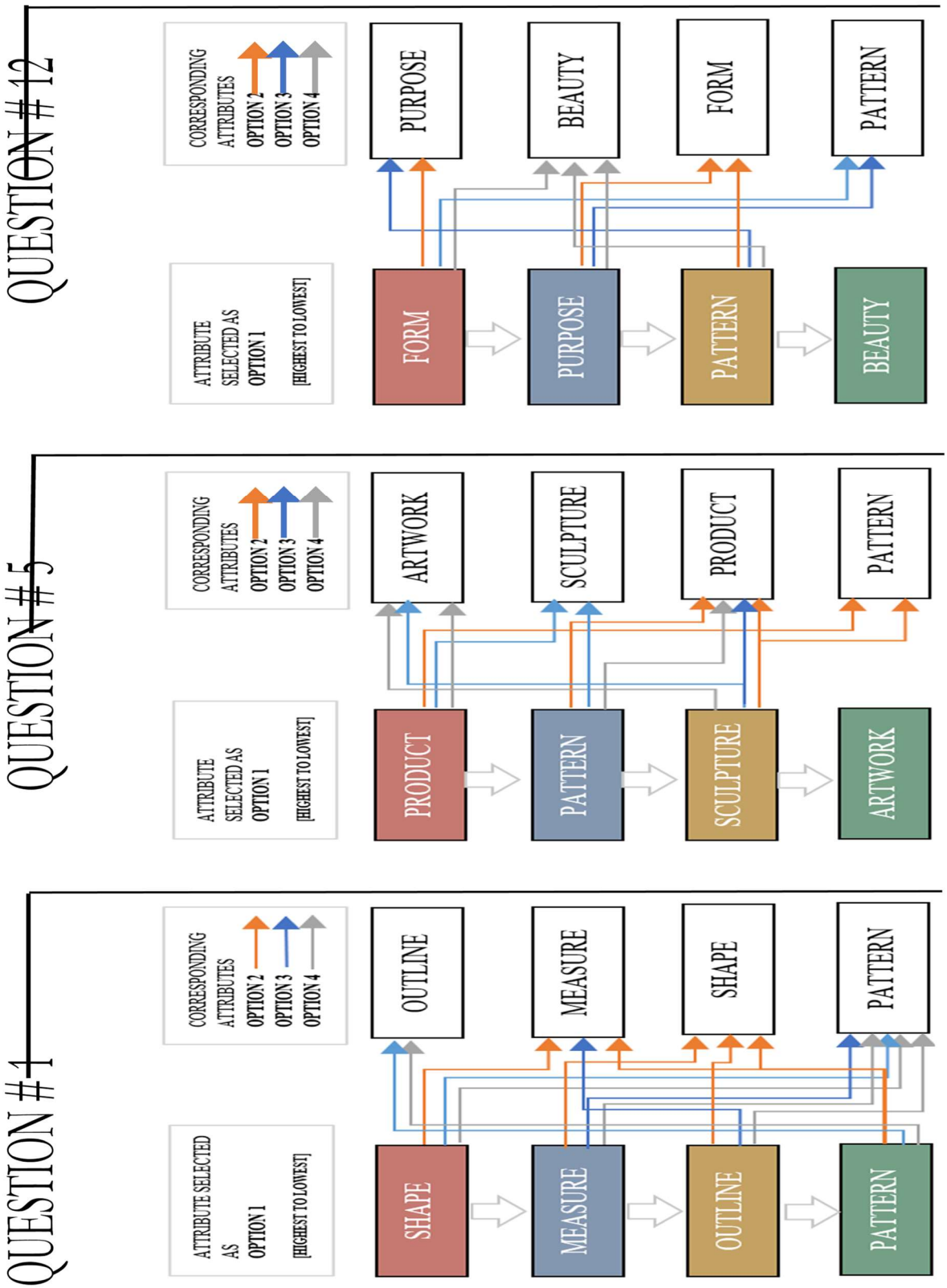
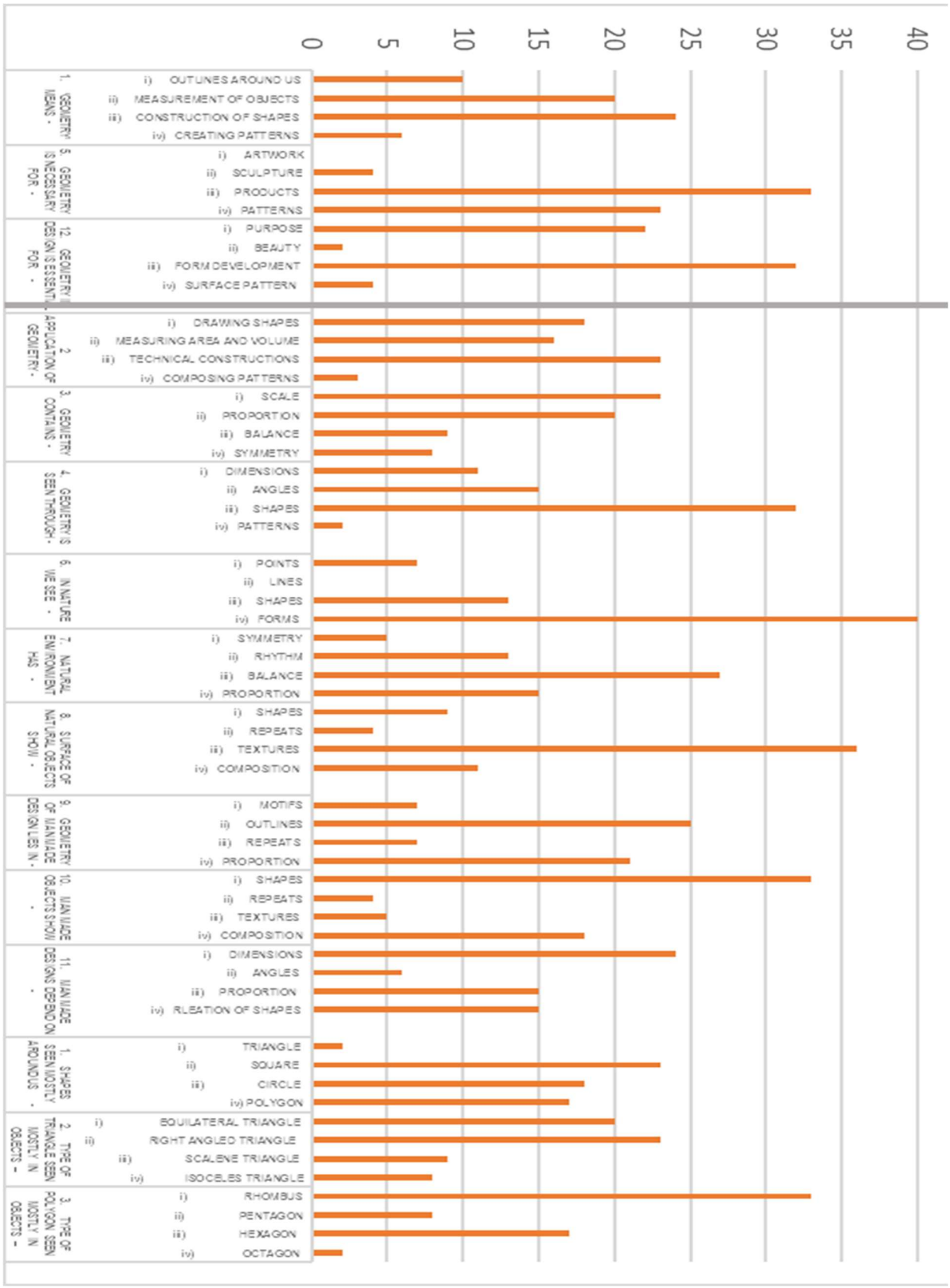
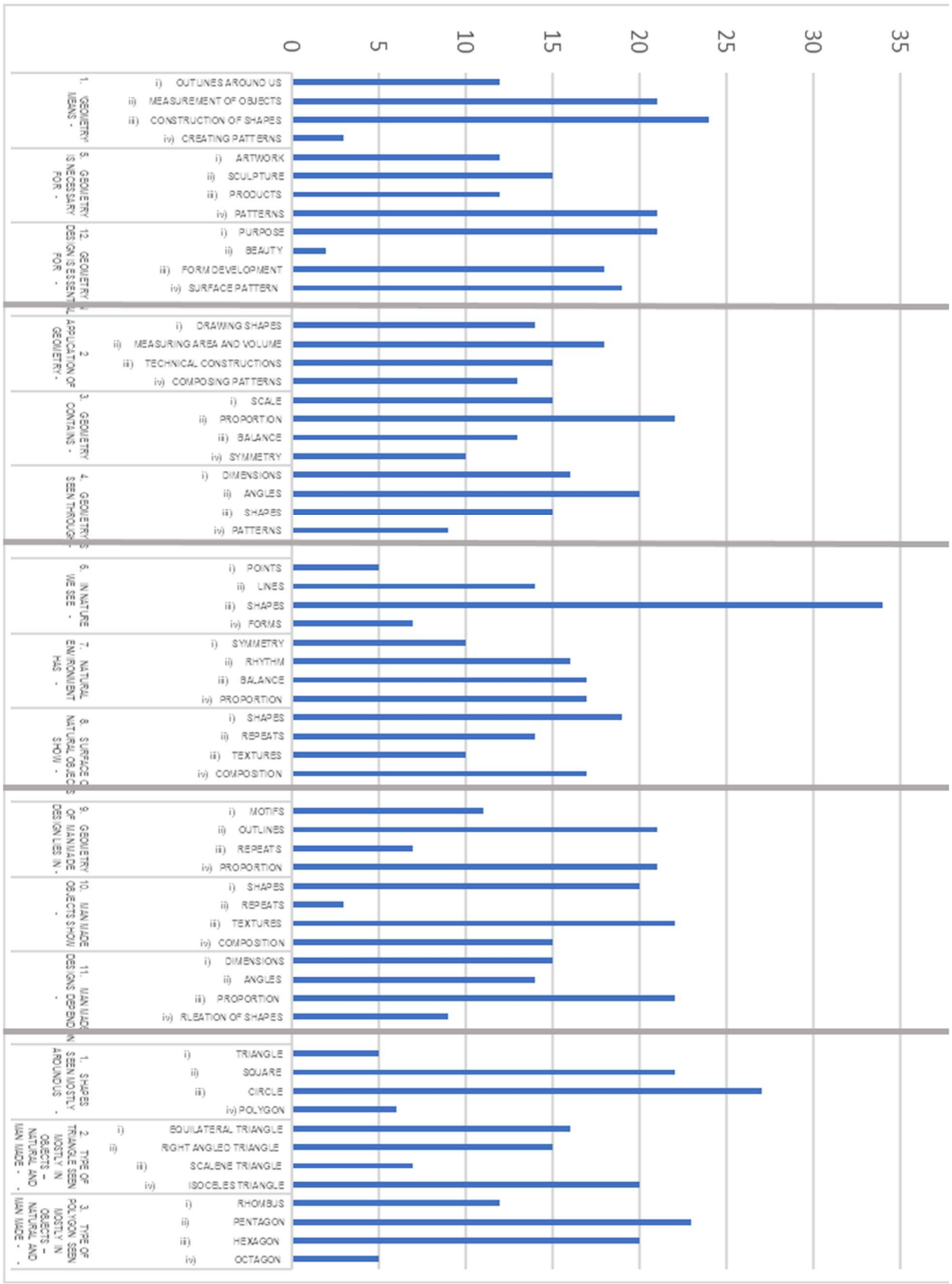


ILLUSTRATION: SET 'A' –
PREFERENCE OF OPTION 1W.R.T OPTIONS # 2-4

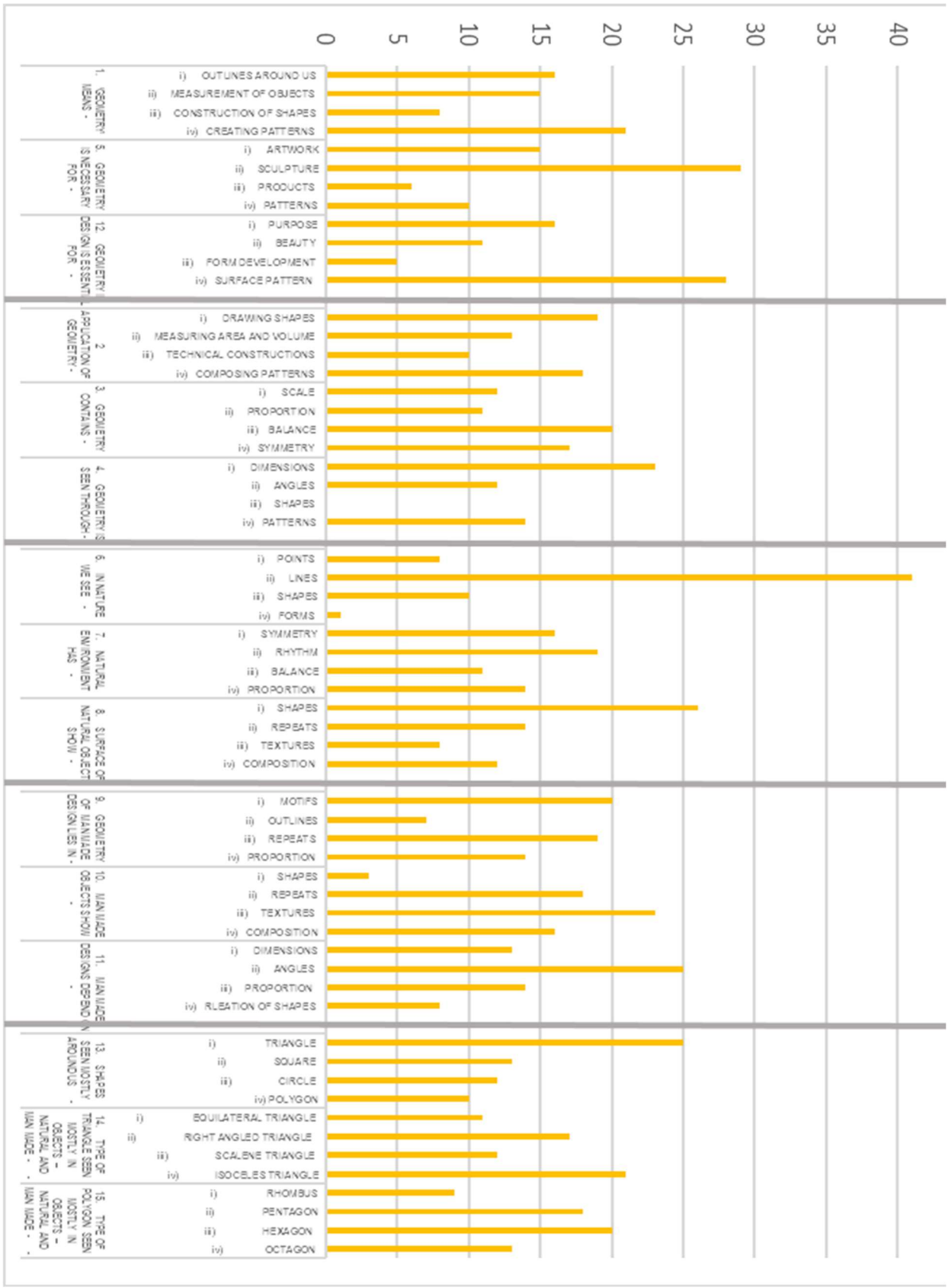
ANNEXURE 6 –
RESPONSES ON ALL 5 SETS / 15 QUESTIONS / OPTION



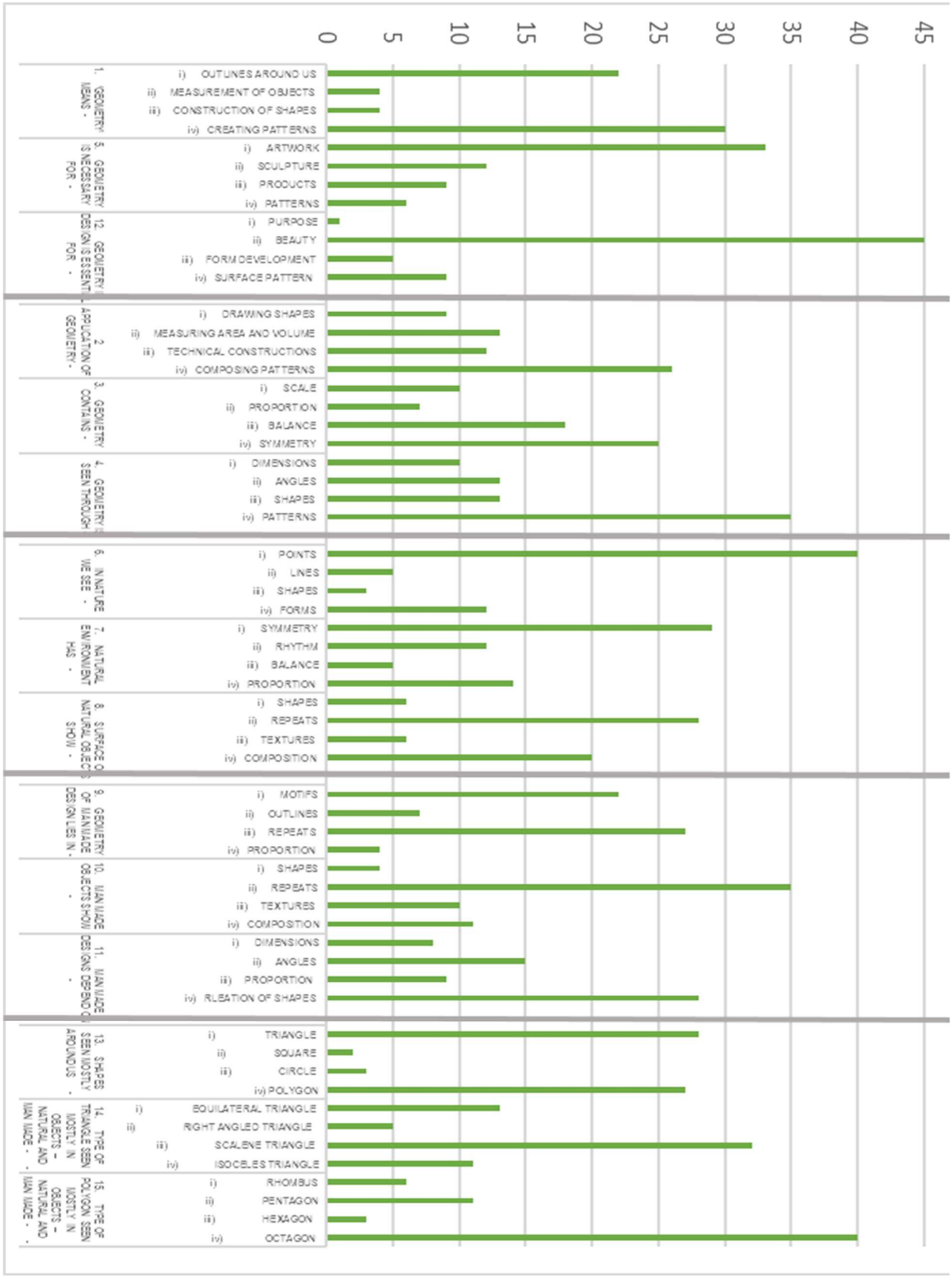
a) RESPONSES BASED ON OPTION #1



b) RESPONSES BASED ON OPTION #2

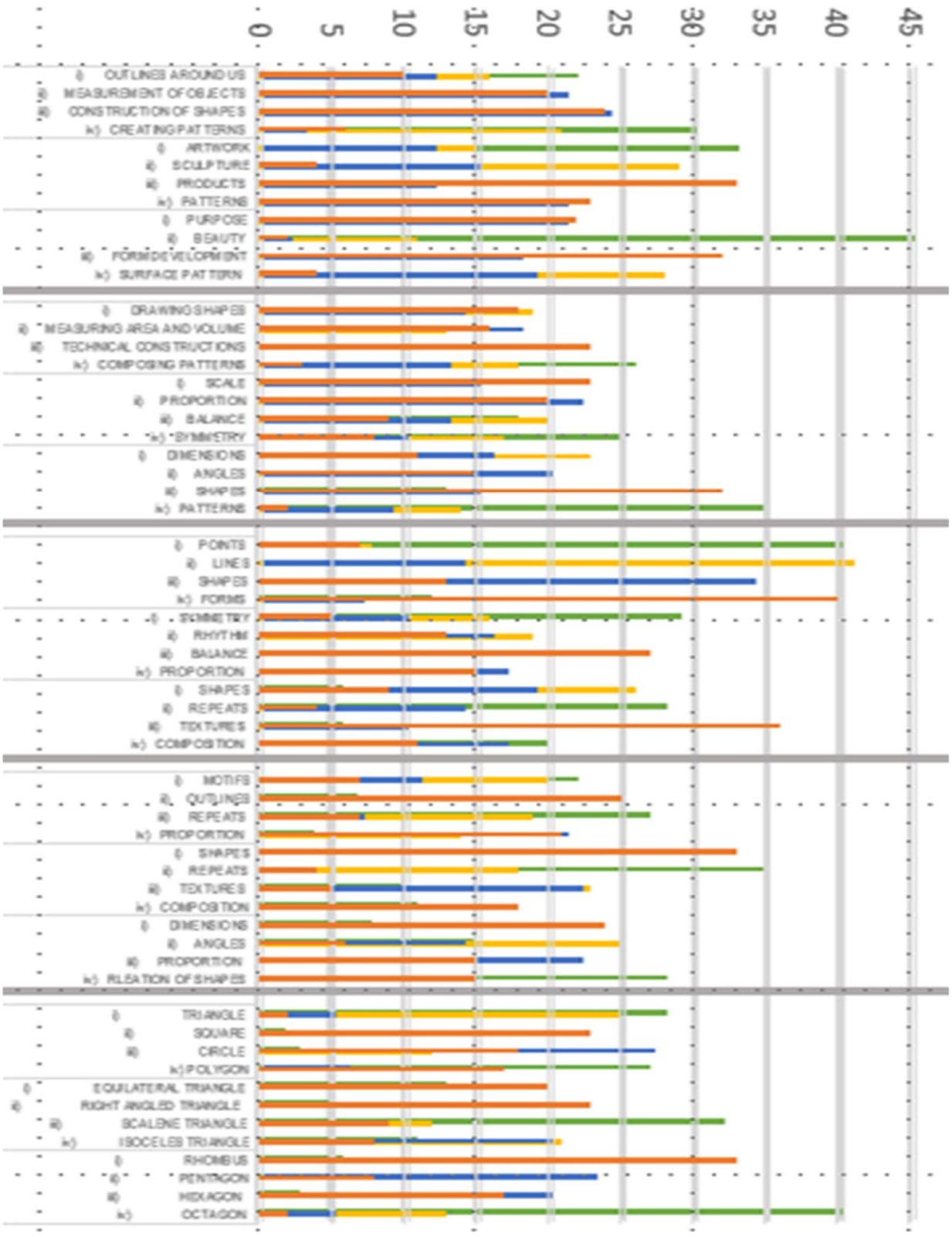


c) RESPONSES BASED ON OPTION #3



d) RESPONSES BASED ON OPTION #4

COMPREHENSIVE ANALYSIS OF RESPONSES - ALL OPTIONS

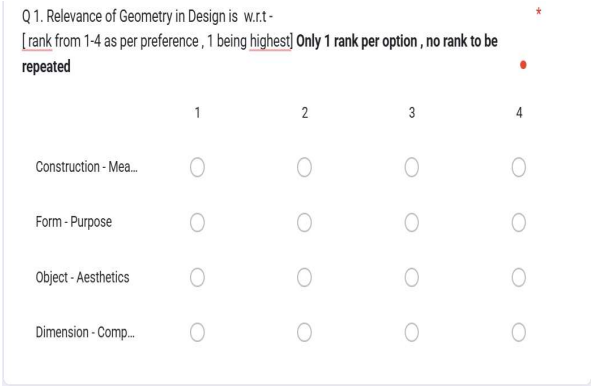


e) OVERLAPPING RESPONSES ON OPTIONS # 1-4 / ALL QUESTIONS

INDEX

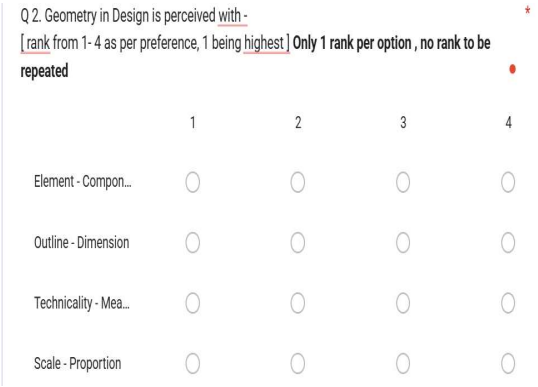
OPTION 1	OPTION 2	OPTION 3	OPTION 4

ANNEXURE 7 –
QUESTIONNAIRE -EXPERT OPINION SURVEY


Q 1. Relevance of Geometry in Design is w.r.t - *
[rank from 1-4 as per preference , 1 being highest] **Only 1 rank per option , no rank to be repeated**

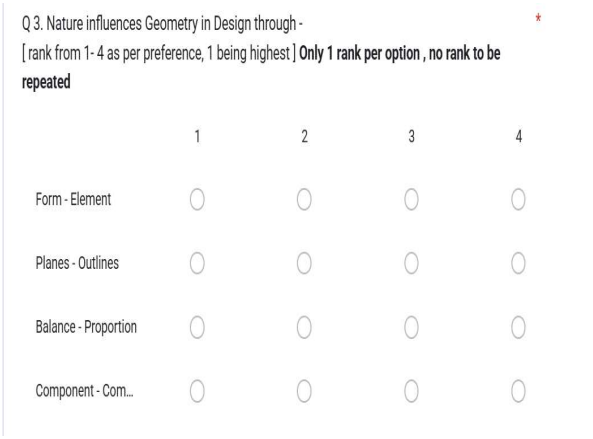
	1	2	3	4
Construction - Mea...	○	○	○	○
Form - Purpose	○	○	○	○
Object - Aesthetics	○	○	○	○
Dimension - Comp...	○	○	○	○

QUESTION 1


Q 2. Geometry in Design is perceived with - *
[rank from 1- 4 as per preference, 1 being highest] **Only 1 rank per option , no rank to be repeated**

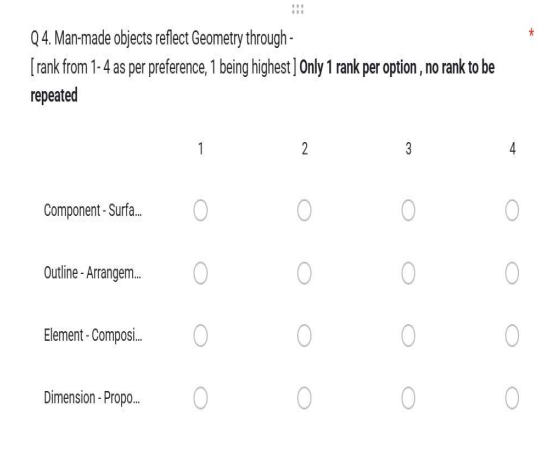
	1	2	3	4
Element - Compon...	○	○	○	○
Outline - Dimension	○	○	○	○
Technicality - Mea...	○	○	○	○
Scale - Proportion	○	○	○	○

QUESTION 2


Q 3. Nature influences Geometry in Design through - *
[rank from 1- 4 as per preference, 1 being highest] **Only 1 rank per option , no rank to be repeated**

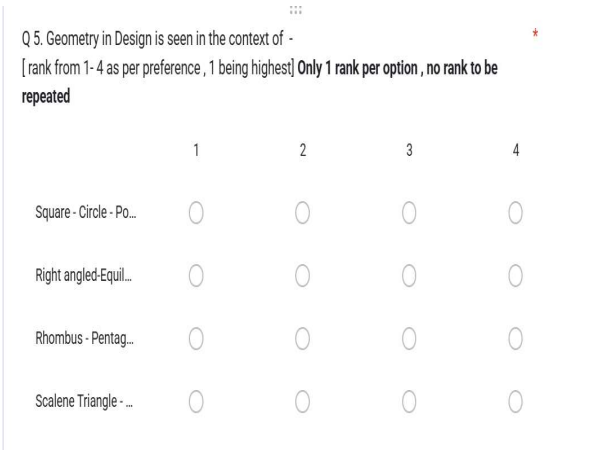
	1	2	3	4
Form - Element	○	○	○	○
Planes - Outlines	○	○	○	○
Balance - Proportion	○	○	○	○
Component - Com...	○	○	○	○

QUESTION 3


Q 4. Man-made objects reflect Geometry through - *
[rank from 1- 4 as per preference, 1 being highest] **Only 1 rank per option , no rank to be repeated**

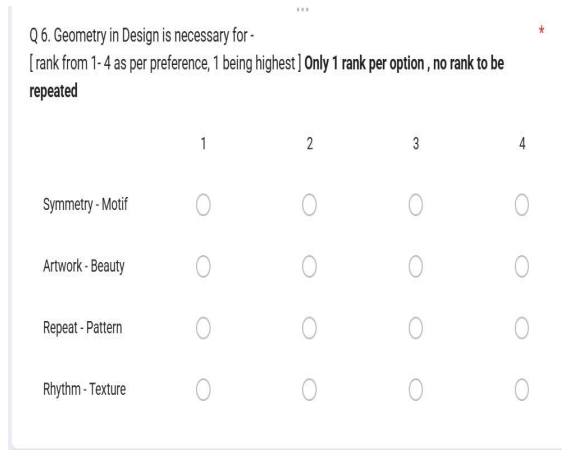
	1	2	3	4
Component - Surfa...	○	○	○	○
Outline - Arrangem...	○	○	○	○
Element - Composi...	○	○	○	○
Dimension - Propo...	○	○	○	○

QUESTION 4


Q 5. Geometry in Design is seen in the context of - *
[rank from 1- 4 as per preference , 1 being highest] **Only 1 rank per option , no rank to be repeated**

	1	2	3	4
Square - Circle - Po...	○	○	○	○
Right angled-Equil...	○	○	○	○
Rhombus - Pentag...	○	○	○	○
Scalene Triangle - ...	○	○	○	○

QUESTION 5


Q 6. Geometry in Design is necessary for - *
[rank from 1- 4 as per preference, 1 being highest] **Only 1 rank per option , no rank to be repeated**

	1	2	3	4
Symmetry - Motif	○	○	○	○
Artwork - Beauty	○	○	○	○
Repeat - Pattern	○	○	○	○
Rhythm - Texture	○	○	○	○

QUESTION 6

ANNEXURE 8–
RESPONSE DATA - EXPERT OPINION SURVEY

	Profile as Architect	Q 1. Relevance of Geometry in Design is w.r.t - [rank from 1-4 as per preference , 1 being highest] Only 1 rank per option , no rank to be repeated				Q 2. Geometry in Design is perceived with - [rank from 1- 4 as per preference, 1 being highest] Only 1 rank per option , no rank to be repeated				Q 3. Nature influences Geometry in Design through - [rank from 1- 4 as per preference, 1 being highest] Only 1 rank per option , no rank to be repeated				Q 4. Man-made objects reflect Geometry through - [rank from 1- 4 as per preference, 1 being highest] Only 1 rank per option , no rank to be repeated				Q 5. Geometry in Design is seen in the context of - [rank from 1- 4 as per preference , 1 being highest] Only 1 rank per option , no rank to be repeated				Q 6. Geometry in Design is necessary for - [rank from 1- 4 as per preference, 1 being highest] Only 1 rank per option , no rank to be repeated			
1	Academics	4	2	3	1	4	3	2	1	4	3	2	1	4	3	2	1	4	3	2	1	4	2	3	1
2	Academics	4	2	3	1	4	3	2	1	3	4	2	1	4	3	2	1	4	3	2	1	4	2	3	1
3	Academics	2	4	3	1	4	3	2	1	3	4	2	1	3	4	2	1	4	3	2	1	4	2	3	1
4	Academics	2	3	4	1	4	3	2	1	2	3	4	1	4	2	3	1	4	3	2	1	4	2	3	1
5	Academics	2	3	4	1	3	4	2	1	2	3	4	1	4	2	3	1	3	2	4	1	4	2	3	1
6	Academics	4	3	1	2	3	4	2	1	2	3	4	1	2	4	3	1	4	3	1	2	2	4	3	1
7	Academics	4	3	1	2	4	2	3	1	3	4	1	2	3	2	4	1	1	4	3	2	2	4	3	1
8	Academics	1	4	3	2	2	4	3	1	3	4	1	2	4	3	1	2	3	1	4	2	2	4	3	1
9	Academics	1	3	4	2	2	4	3	1	3	4	1	2	4	3	1	2	1	4	2	3	3	2	4	1
10	Academics	4	2	1	3	3	2	4	1	1	4	3	2	3	4	1	2	1	4	2	3	2	3	4	1
11	Academics	4	2	1	3	3	2	4	1	1	3	4	2	3	4	1	2	1	2	4	3	3	4	1	2
12	Academics	4	2	1	3	2	3	4	1	1	3	4	2	3	4	1	2	1	2	4	3	4	1	3	2
13	Academics	2	4	1	3	2	3	4	1	4	2	1	3	4	1	3	2	1	2	4	3	1	4	3	2
14	Academics	4	1	2	3	2	3	4	1	2	4	1	3	4	1	3	2	1	2	4	3	1	3	4	2
15	Consultant	4	1	2	3	2	3	4	1	2	4	1	3	4	1	3	2	1	3	2	4	1	3	4	2
16	Consultant	4	1	2	3	4	3	1	2	2	4	1	3	1	4	3	2	1	3	2	4	1	4	2	3
17	Consultant	4	1	2	3	4	3	1	2	2	4	1	3	1	4	3	2	1	3	2	4	1	4	2	3
18	Consultant	4	1	2	3	4	3	1	2	2	4	1	3	4	2	1	3	2	1	3	4	1	4	2	3
19	Consultant	1	4	2	3	4	1	3	2	1	4	2	3	4	2	1	3	1	2	3	4	1	4	2	3
20	Proprietor	3	2	1	4	4	1	3	2	1	4	2	3	4	1	2	3	1	2	3	4	1	4	2	3
21	Proprietor	3	2	1	4	1	4	3	2	1	4	2	3	1	4	2	3	1	2	3	4	2	1	4	3
22	Proprietor	3	1	2	4	1	4	3	2	1	4	2	3	1	4	2	3	1	2	3	4	3	2	1	4
23	Proprietor	3	1	2	4	1	3	4	2	1	4	2	3	1	2	4	3	1	2	3	4	2	3	1	4
24	Proprietor	3	1	2	4	1	3	4	2	1	2	4	3	3	2	1	4	1	2	3	4	3	1	2	4
25	Proprietor	1	3	2	4	4	2	1	3	1	2	4	3	3	1	2	4	1	2	3	4	3	1	2	4
26	Proprietor	1	3	2	4	4	1	2	3	3	2	1	4	1	3	2	4	1	2	3	4	1	3	2	4
27	Proprietor	2	1	3	4	1	4	2	3	3	2	1	4	1	3	2	4	1	2	3	4	1	3	2	4
28	Service	2	1	3	4	1	4	2	3	3	2	1	4	2	1	3	4	1	2	3	4	1	3	2	4
29	Service	2	1	3	4	2	1	4	3	2	3	1	4	1	2	3	4	1	2	3	4	1	3	2	4
30	Service	1	2	3	4	1	2	4	3	2	3	1	4	1	2	3	4	1	2	3	4	1	3	2	4
31	Service	1	2	3	4	1	3	2	4	1	3	2	4	1	2	3	4	1	2	3	4	1	3	2	4
32	Service	1	2	3	4	1	3	2	4	1	2	3	4	1	2	3	4	1	2	3	4	2	1	3	4
33	Service	1	2	3	4	2	1	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
34	Service	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
35	Service	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
	Service	[Construction - Measurement]	[Form - Purpose]	[Object - Aesthetics]	[Dimension - Component]	[Element - Component]	[Outline - Dimension]	[Technicality - Measurement]	[Scale - Proportion]	[Form - Element]	[Planes - Outlines]	[Balance - Proportion]	[Component - Composition]	[Component - Surface]	[Outline - Arrangement]	[Element - Composition]	[Dimension - Proportion]	[Square - Circle - Polygon]	[Right angled- Equilateral- Isosceles Triangle]	[Rhombus - Pentagon - Hexagon]	[Scalene Triangle - Quadrilateral - Octagon]	[Symmetry - Motif]	[Artwork - Beauty]	[Repeat - Pattern]	[Rhythm - Texture]

RESPONSE OF 35 ARCHITECTS

INDEX

ACADEMICS	CONSULTANT	PROPRIETOR	SERVICE

	Profile as Designer	Q 1. Relevance of Geometry in Design is w.r.t - [rank from 1-4 as per preference , 1 being highest] Only 1 rank per option , no rank to be repeated				Q 2. Geometry in Design is perceived with - [rank from 1- 4 as per preference, 1 being highest] Only 1 rank per option , no rank to be repeated				Q 3. Nature influences Geometry in Design through - [rank from 1- 4 as per preference, 1 being highest] Only 1 rank per option , no rank to be repeated				Q 4. Man-made objects reflect Geometry through - [rank from 1- 4 as per preference, 1 being highest] Only 1 rank per option , no rank to be repeated				Q 5. Geometry in Design is seen in the context of - [rank from 1- 4 as per preference , 1 being highest] Only 1 rank per option , no rank to be repeated				Q 6. Geometry in Design is necessary for - [rank from 1- 4 as per preference, 1 being highest] Only 1 rank per option , no rank to be repeated			
		[Construction - Measurement]	[Form - Purpose]	[Object - Aesthetics]	[Dimension - Component]	[Element - Component]	[Outline - Dimension]	[Technicality - Measurement]	[Scale - Proportion]	[Form - Element]	[Planes - Outlines]	[Balance - Proportion]	[Component - Composition]	[Component - Surface]	[Outline - Arrangement]	[Element - Composition]	[Dimension - Proportion]	[Square - Circle - Polygon]	[Right angled- Equilateral- Isosceles Triangle]	[Rhombus - Pentagon - Hexagon]	[Scalene Triangle - Quadrilateral - Octagon]	[Symmetry - Motif]	[Artwork - Beauty]	[Repeat - Pattern]	[Rhythm - Texture]
1	Academics	3	1	4	2	3	4	1	2	2	4	1	3	4	3	2	1	2	1	4	3	2	4	1	3
2	Academics	2	1	4	3	1	3	4	2	1	3	2	4	3	2	1	4	1	4	3	2	1	4	2	3
3	Academics	1	2	3	4	4	3	1	2	3	4	1	2	1	2	3	4	2	1	3	4	2	4	1	3
4	Academics	2	3	4	1	4	1	2	3	1	2	4	3	4	1	3	2	1	3	2	4	1	4	2	3
5	Academics	1	2	4	3	4	2	3	1	1	4	3	2	4	1	3	2	1	4	3	2	2	1	3	4
6	Academics	2	3	4	1	1	2	3	4	3	1	2	4	4	3	2	1	3	1	4	2	1	3	2	4
7	Academics	4	2	1	3	4	2	3	1	1	2	4	3	4	3	1	2	1	3	2	4	4	1	2	3
8	Academics	3	2	1	4	3	2	4	1	2	3	4	1	3	2	1	4	2	4	1	3	2	1	3	4
9	Academics	1	2	3	4	4	1	2	3	3	1	4	2	4	2	3	1	1	3	4	2	1	4	2	3
10	Academics	1	2	3	4	3	4	2	1	4	3	1	2	4	3	2	1	1	2	3	4	1	3	2	4
11	Academics	1	2	3	4	4	3	2	1	1	3	2	4	3	2	1	4	1	2	3	4	1	3	2	4
12	Academics	1	2	3	4	4	1	2	3	3	1	4	2	4	2	3	1	1	3	4	2	1	4	2	3
13	Consultant	3	4	2	1	1	2	4	3	3	1	2	4	4	1	3	2	3	1	4	2	1	3	2	4
14	Consultant	2	1	3	4	3	2	1	4	4	1	3	2	2	3	1	4	1	3	2	4	4	3	2	1
15	Consultant	1	2	4	3	3	2	4	1	1	2	3	4	4	3	2	1	1	3	2	4	1	4	2	3
16	Consultant	1	2	4	3	3	4	2	1	1	4	2	3	3	4	1	2	2	1	3	4	3	4	2	1
17	Consultant	4	2	3	1	2	4	1	3	1	4	3	2	2	4	3	1	2	3	1	4	1	4	2	3
18	Consultant	3	1	4	2	3	4	1	2	1	2	4	3	4	2	3	1	4	3	2	1	1	4	2	3
19	Entrepreneur	1	2	3	4	4	3	2	1	3	2	1	4	4	3	2	1	1	3	2	4	1	3	2	4
20	Entrepreneur	4	1	2	3	3	1	4	2	1	2	3	4	4	1	3	2	1	2	3	4	2	1	4	3
21	Entrepreneur	1	2	4	3	2	3	4	1	1	2	3	4	2	3	4	1	1	2	3	4	1	2	3	4
22	Entrepreneur	1	4	3	2	3	4	1	2	4	1	2	3	4	1	3	2	2	1	4	3	3	2	1	4
23	Entrepreneur	1	2	3	4	2	1	3	4	1	2	3	4	2	1	3	4	1	3	4	2	1	3	2	4
24	Entrepreneur	1	2	4	3	4	3	2	1	3	4	1	2	4	3	2	1	3	4	2	1	1	4	2	3
25	Entrepreneur	1	2	3	4	4	3	1	2	1	4	2	3	4	2	1	3	1	2	3	4	2	4	1	3
26	Entrepreneur	2	1	3	4	2	1	3	4	3	2	1	4	4	2	3	1	1	2	3	4	2	4	3	1
27	Entrepreneur	1	3	4	2	3	4	2	1	4	2	3	1	4	3	2	1	3	2	1	4	2	3	1	4
28	Service	2	1	3	4	2	4	3	1	2	4	1	3	4	3	2	1	1	2	3	4	1	3	2	4
29	Service	1	3	4	2	3	4	2	1	3	2	1	4	4	2	3	1	1	2	3	4	1	4	2	3
30	Service	2	1	3	4	3	4	1	2	1	4	3	2	4	1	2	3	1	2	4	3	1	3	2	4
31	Service	2	3	4	1	3	1	2	4	2	1	3	4	1	2	4	3	1	2	4	3	1	4	2	3
32	Service	1	2	4	3	3	4	2	1	1	4	3	2	4	3	2	1	1	2	3	4	4	1	3	2
33	Service	4	1	3	2	1	3	4	2	1	2	3	4	3	4	1	2	1	3	2	4	1	3	4	2
34	Service	2	3	4	1	4	2	3	1	2	4	1	3	4	2	3	1	2	1	4	3	1	4	2	3
35	Service	1	4	2	3	1	3	2	4	1	4	2	3	4	3	2	1	1	2	4	3	1	2	3	4

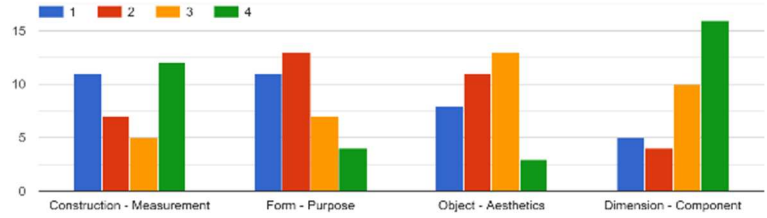
RESPONSE OF 35 DESIGNERS

INDEX

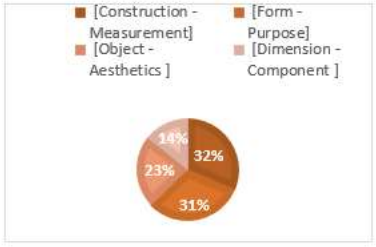
ACADEMICS	CONSULTANT	PROPRIETOR	SERVICE

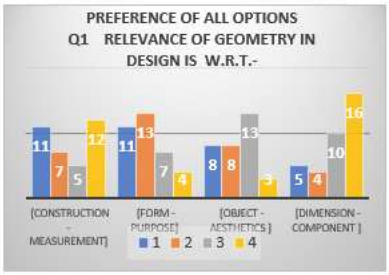
ANNEXURE 9 –
DATA ANALYSIS – EXPERT OPINION SURVEY

Q 1. Relevance of Geometry in Design is w.r.t - [rank from 1-4 as per preference, 1 being highest] Only 1 rank per option , no rank to be repeated



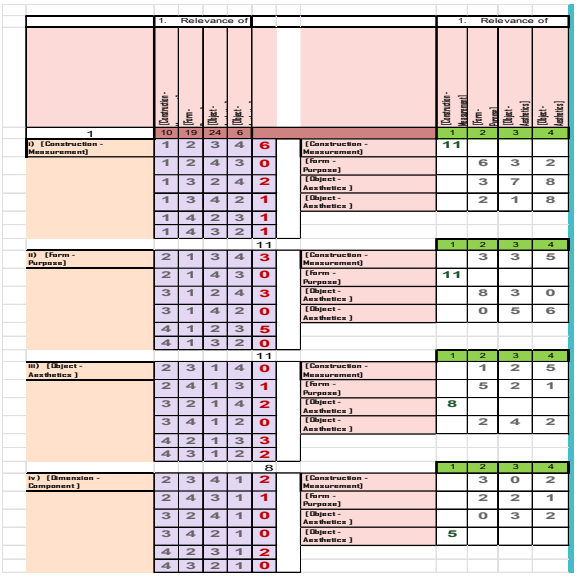
a) ILLUSTRATION # 1 : RESPONSE BASED CHARTS / QUESTION



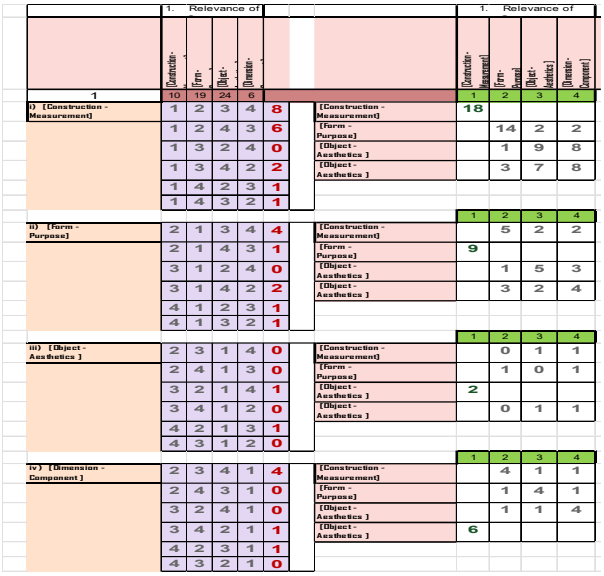


AS PER OPTION	1	2	3	4
Construction - Measurement	11	7	5	12
Form - Purpose	11	13	7	4
Object - Aesthetics	8	8	13	3
Dimension - Component	5	4	10	16

b) ILLUSTRATION # 2 : QUESTION BASED DERIVATIONS



RESPONSE OF ARCHITECTS



RESPONSE OF DESIGNERS

c) ILLUSTRATION # 3 : EXPERT RESPONSE / QUESTION

COMPARATIVE OPTIONS & RELATIVE RESPONSES – 6 QUESTION

d) RESPONSES OF ARCHITECTS - RESPONSES OF DESIGNERS

ANNEXURE 10–

[INCLUSION : REF ADVISE OF REVIEWER ON THESIS]

a. TABULATION OF INFERENCE FROM LITERATURE SURVEY

CATEGORIES	PARAMETERS	FOCUS AREAS	CONVERGENT AREAS	DIVERGENT AREAS	GAP AREAS
GEOMETRY W.R.T DESIGN	ELEMENTS	•Point, Shape, Line, Form, Space, texture, angle •Pattern, Motif, Tessellation, Repeats, •Measurements, Dimensions	1.Satisfy purpose w.r.t human body and movement 2.Exploration of space, volume 3.Symbolic of social practices and changes 4.Aesthetic pleasure	1.Materials and structure 2.Size and scale 3.Lifespan 4.Technology and effects	1.Interdependency of Architecture and Fashion 2.Overlap and Digression of Visualization 3. Geometry on Form Generation
	CHARACTERISTICS	•2d / 3d, Structure •Scale, Proportion •Sequence, rhythm, symmetry •Order, regularity, frequency			
	ATTRIBUTES	•Linearity, curvature •Viewpoints, projective, perspective •Aesthetics, perception •Symbolism			
VISUAL PERCEPTION	PHYSICAL ASPECTS	•Line, Shape, outline, contours, surfaces •Colour, texture •Materials, functionality •Contrast, symmetry, balance, orientation			
	VISUAL ASPECTS	•Stability, order, alignment, position, regularity •Form & space •Aesthetics, beauty, emotion •Organise, structure			
	COGNITIVE ASPECTS	•Sensory stimuli •Culture and symbol •Social practice & variance •Visual dynamics •Gestalt, response			
GEOMETRY IN DESIGN : ARCHITECTURE & FASHION	STRUCTURAL FORM	•Linearity, Curvature •Shape, contours, surfaces, textures, spirals •Human body and silhouette •rhythmic progression, tessellation, fractal Repeats,			
	FUNCTIONALITY OF PURPOSE	•Adaptability •Purpose and shape •Culture and use •Economics, materials, construction •Visual impact			
	AESTHETIC IDENTITY	•Emotions, •Cultural diversity •Symbolism, practices, •Elements and society •Identity through visual structure			
	PROPORTION & COGNITION	•Harmony, order, sequence •Evolution of form, organic growth •Scale and perception •Golden section, Fibonacci numbers Repeats,			

b. CASE STUDIES w.r.t. LITERATURE SURVEY

i) Case Study # 1 :

Geometry and form driven wearables – Future directions in Swimwear

[ref. Article presented at FTC Conference , IIT , Delhi, 2018]

1 Geometry

1.1 Geometry of Form

Natural elements evolve out of simple geometric patterns mapped within its molecular structure , which allows it to grow into beautiful forms . Its intrinsic property is in its dynamics which distinguishes it from the rigidity of static structures . Born out of nature , human body growth and dynamics are expressions of the natural movement of the body parts which are largely geometric structures . Man made objects are by and large static structures. Fluidity is infused by conforming to natural forms or movement . The basis of the creation is understanding of the geometry of the form or its dynamics . Geometry is thus the inherent principle on the basis of which all growths happen - in organic and man made forms . Every structure evolves from interconnected elements and shapes to build the form . It is this growth which determines how an object looks and performs. The geometry of the structure gives an optimum solution to the need . For natural elements the evolution is over a period of time , tested and reworked by nature with the purpose of adaptation . Man made structures are completely determined by the outline of the Form, or the function for which it is designed. Apart from artistic exercises , man made designs have to fulfill its functionality , thus justifying form following function.


Fig 1


Fig 2


Fig 3

Illustrations showing The human body structure and its geometry - appropriate sheathing with traditional knitting and 3D printing conforming to the basic geometry

1.2 Geometry in Design – Architecture and Fashion

Man made creations adopt geometry and aesthetics. Shelter and clothing are the two primary needs of the human species - both being sheaths to cover a volume or space. Function is the foremost determinant of both while aesthetics come second. Architecture and Fashion being the two domains respectively, to design and fulfill the functional and visual demand for realization of covering the space. Being man made exercises, both fields express the purpose through Geometric form generation. Wherein the micro components and their linkage determines the success of the design. The human body is equivalent to a 3D form and space. Mapping and understanding of this complex body form is essential to perfecting design of the garment , especially related to functional clothing. Fashion and Architecture go hand in hand to lead to the almost perfect design solution . Design demands functionality vis-a-vis aesthetics. The architectural structure of the human body adapts itself to the clothing needs and creates the visually appealing and functionally appropriate sheath as an expression of fashion.

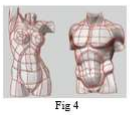


Fig 4

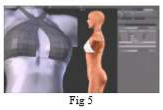


Fig 5

3D structure of human body as a solid form and designing appropriately

1.3 Dynamics of Geometry of the human body

The human body is a highly complex organic 3D form. It is continuously changing the surface details based on its muscle movements as well as metabolism of the body . Clothing has to constantly adapt to these movements and retain its physical and aesthetic character accommodating the expansions , contractions and bends etc . In each stage of such a movement the geometric structure of the form is a defined one which when considered in design allows the garment to stretch itself and recoil back to its original state. For functional clothing this is the primary need as performance of human body is dependant on its unhindered movement. Clothing which is flexibly adapting to body movements are best suited for functional efficiency and performance. The muscular actions leading to change in the body form and adaptive clothing understanding the geometric dynamics remains the primary consideration for an efficient functional wear. Mapping of the body , which varies from person to person , and a complete perception of the 3D form and its components and contours , is an absolute necessity for an optimum design.

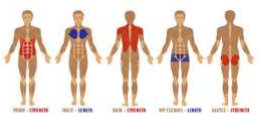


Fig 5


Fig 6

Muscular structure and movement of a human body for swimming

ii) Case Study # 2 :

Sustainable Transformation of a Vernacular Habitat through the Revival of Crafts: Naya Village in West Bengal, India.

[ref. ISVS e-journal, Vol. 6, no. 4, October, 2019*]*


Fig. 12. Children and their motifs the walls behind
Source: Banglanatak.com


Fig. 13. New generation of artist and contemporary designs and styles
Source: Banglanatak.com


Fig. 14. A child learns on to sing the Pater gaan
Source: Author

The vernacular aesthetics

The social identities are well defined in the traditional settlements in their built forms, decorations and lifestyle. (Patidat & Raghuwanshi, 2014). The cultural traditions, adapted over generations, express in the particular aesthetic. Elements of design in the composition, blends local resources with industrialized ones. Hence we come across industrial materials defining the art form in a newer manner. It also emphasizes variation in the themes and mode of artwork. (Mukherjee & Ghosh, 2019)


Fig. 15. Traditional building material
Source: Banglanatak.com


Fig. 16. Industrial material in building
Source: Author

The motifs and elements derived from the tradition that the village and the community grew on. Vernacular environments are very culture and place specific. The artwork befits the landscape, not to make a statement but harmonizing with nature. Use of scale is based on the visual relevance of the elements used vis-à-vis the built structure. (Cavalcanti, 1996)


Fig. 17. Surrounding landscape in design
Source: Author


Fig. 18. Elements from nature
Source: Banglanatak.com


Fig. 19. Scale of motif
Source: Author

The artwork on a building façade is a conscious choice of the artist and / or owner . In Naya, it manifests in a superb burst of creativity by merging building elements in the artwork or vice versa .


Fig. 20.
Innovative and creative integration of building components and the artwork
Source: Author


Fig. 21.

The built space all around is interspersed with daily objects becoming canvas for the artwork , as if to retain the ethos of the transition of the art from the building flowing into the surroundings spaces. In this way , they become elements in the visual composition , making it vibrant by the riot of colours and creating interesting aesthetics . (Ghosh M., Nag S., Roy S., 2015)


Fig. 22.
Daily objects become part of visual composition of the space
Source: Author


Fig. 23.
Source: Banglanatak.com

Creativity of the artist is manifested in their artwork. It generates a desire to be different from the neighbouring house and the façade remains a subjective choice of what the owners wish to illustrate and their sense of beauty, personal values and tradition of the community nurtured over generations. (Cavalcanti, 1996) It is unique in its own way, whether the built form is traditional or modern. Hence the designs vary from the traditional to contemporary styling of the design elements. It is interesting the way

iii) Case Study # 3 :

Perceiving Identity of Period Interiors Based on Visual characteristics: Comparing Aesthetics of Renaissance in England and France

[ref. e-ISSN: 2581-9984 Volume-5, Issue-2 (July-December, 2020), www.matjournals.com*]*

Figure 3(a): *Medieval France [14].*

Figure 3(b): *Renaissance France [15].*

Figure 4(a): *Medieval England [16].*

Figure 4(b): *Renaissance England [17].*

In the quest for revival of Classical styles, the art and architecture manifested the principles of design through quality, harmony, balance proportion and rationalism. In France, with the growth in business activities, a large number of rich private residences – **hotels' –** were constructed. Interior spaces were considerably refined in plan and compartmentalized into several units to accommodate private social activities. Hence private residences require the show of greater ingenuity in fitting necessary purpose into confined spaces. The shift in social practices called for intimate comfort in place of grandiose living .In England, houses were centralized in characteristics exhibiting asymmetry and informality. It showed increasing emphasis on privacy [6].

A significant aspect of the inception of Renaissance in France and England is the rise of Nationalism. France gaining control of its territories and expulsion of England in the Hundred **Years'** War, led to a strong Nationalist pride in both the nations [4].

All Renaissance Architecture is hybrid in its characteristic up to an extent as it is the resultant of an attempt to integrate the purpose of a later period with the code of forms and proportions derived from Classical Architecture of antiquity, more visible on the façade of the space. It is expressed as an assimilation of elements which vary in relation and often contrasts to the strong national style in practice. Although Renaissance stared in Italy, the variance is less visible as Italy hardly moved very far away from the Classical styles which remained its national style identity, but for a gradual evolution over time. The French and English Gothic, predecessor to their Renaissance, had evolved as a fierce expression over years for nations torn between unrest and war, impoverishment, moral and artistic decimation, symbolizing religious supremacy through ecclesiastical built structure. Whereas, the renaissance ushered in a national revival restoring order and prosperity, decline of the Church and its control, rise of intellectual professionals and manufacturers, almost as antitheses to the earlier era. It is but natural to generate a newer character of space and its elements at the fusion of two such diverse philosophy and aesthetic perception. Though Italy inspired France, while the latter influenced England, yet the overlap of mutual influences continued [7]. However, it is interesting to find how the Renaissance designs of space remarkably retain its individuality in France and England distinguishably. This study focuses on only the domestic interiors and the styles reflected as it is in these spaces the daily activities reflect the lives of the people, with purpose, unlike palaces and churches which often are symbols of affluence and show of might. It is in these spaces that the identity of the national style is visible based on the capacity and capability of the common people reflecting the style of a nation.

Study of the Interiors

The overall characteristic of the Renaissance periods is enlisted in the following chart. It goes to show the various characteristics and components composing the interior spaces [2].

THE GREAT DECORATIVE MOVEMENTS

DESCRIPTIVE SUMMARY

RENAISSANCE	BAROQUE	ROCOCO
Large (monumental).	Large.	Small.
Symmetrical.	Symmetrical.	Asymmetrical.
Straight lines.	Straight and curved lines.	Only curved lines.
Straight or turned legs, low heavy stretchers.	Cabriole legs. Ball and claw feet.	Cabriole legs. No stretchers. No angles.
Architectural motifs, acanthus, humans, animals.	Classic motifs, shells, lions, acanthus, etc.	Nature motifs, rock and shell, ribbons, Chinese.
Turning, carving, painting.	Carving, veneer, lacquer, ormulu.	Gilding, lacquer, caning, marquetry, ormulu.
Oak, walnut.	Walnut, mahogany, ebony, marble tops.	Walnut, mahogany, fruitwood, rosewood.
Velvets, brocades, damasks, cloth of gold. Tapestries.	Damasks, brocatelles, velvets, needlepoint, leather, Gobelin tapestries. Oriental and French rugs.	Damasks, brocades, satins, taffetas, moirés, Toiles de Jouy. French rugs.
Crimson, gold, green, blue.	Red, yellow, blue, green.	Soft, light colors.
Chests, cabinets, refectory tables, beds, chairs, stools.	Cabinets, tables, chairs, four-poster beds, clocks.	Commodes, desks, tables, consoles, beds, sofas, chairs.
Formal dignity, sincerity, strength, repose.	Massive grandeur, elegance, elaboration, variety.	Luxurious ease, intimacy, femininity, gaiety.

Figure 4(c): *Table of Renaissance elements [18].*

In France

The adaptation took place as application of decorative detail on basic Gothic designs, extending to overall symmetry and regularity. An elaborated staircase ceiling with curvature and similarly ornate wall and ceiling panel design, along with large carved chimneypieces mark this style. The stately spacious staircase was a befitting approach to the main rooms [8] In England, the new social structure brought in new directions of domestic building and decorations. A house with a great hall and a large number of rooms was not in need. traditional open timber roof and mullioned windows, followed by paneling and plasterwork, sculptured ornaments , caryatid figures , scrolls , pilasters , frescoe on walls, tapestries in velvet and damask , geometric pattern on ceilings , open wooden staircase and later marble staircase, well-proportioned rooms [9]. The general characteristics of French interiors in this period include decorative ceiling for staircases. The flat ceilings were coffered, colored, gilded in various geometrical forms. The staircases were stately and spacious, and also spiral. Decorations were in marble, plasterwork

iv) Case Study # 4 :

Visual perception-based design diversification of craft for sustenance - Classroom project: Study area - Kushmandi, West Bengal –

[ref. Article presented Paper presented at the 2nd International Conference in Crafts and Design held at IICD Jaipur , 2022, ISBN No. 978-93-5473-781-7]

APPRECIATING TRADITIONAL CRAFT-CASE STUDY : MASK MAKING AT KUSHMANDI , SOUTH DINAJPUR , WEST BENGAL

Figure 17.1: Location map – Kushmandi [marked with circle] <http://www.wbtrafficpolice.com/maps.php>.

Figure 17.2: Mukha craft

In 2016, as part of their curriculum, 26 students of Fashion and Lifestyle Accessory Design Department were required to execute a Craft Based Design Project and Prototyping. They were expected to conduct the activity over 20 days – 5 days of study preceding 10 days at the cluster, followed by 5 days at the Institute to summarise the activity.

For this particular study, the selected craft cluster was at Kushmandi located in Dakhshin (South) Dinajpur district of West Bengal. The primary craft being 'Mukha' – A wooden mask, used in a dance form called 'Gomira'. The masks are also made out of bamboo. Gomira, being predominantly a ritualistic dance form, as tradition, the masks related to it remain an object of worship. The activity was conducted in collaboration with the social enterprise Banglanatak.com, as part of their own initiative which was in collaboration with the MSME&T Department, Government of West of Bengal, through its Rural Craft and Cultural Hubs (RCCH) Project (MSME, 2017). UNESCO had launched its Global Alliance for Cultural Diversity in 2001 to study and revive the Intangible Cultural Heritage (ICH) of traditional settlements, in which India became a partner, and the RCCH project is an outcome of this initiative. Eventually, in 2017-18, the Wooden Masks of Kushmandi were bestowed with the G.I. tag bringing pride to the state (GI, 2018).

UNDERSTANDING THE TRADITIONAL CRAFT

A craft is relevant to its geographical and socio-cultural context. The students travelled from Kolkata, a mega city to Kushmandi, a backward rural area about 400 kms away- to understand the Mukha craft. Kaliyaganj, the nearest railway station, is 17 kms from Kushmandi.

The traditional wooden mask makers of Kushmandi block are mainly from the village of Mahishbathan, now under the Mahisbathan Gramin Hasta Shilpa Samabay Samiti Limited, an artisan's collective. In a nearby village of Ushaharan, Bamboo craft including masks are practiced. The students visited the cluster at the time of the annual festival – Mukha Mela – generally held in the month of October, which allowed them to mingle in the flavour of a rural fair and spirit of the society and exposed them to their various cultural practices. In the process, the students also learnt on the Bamboo craft and the jute mat 'Dhokra' weaving, which are parallel craft practices at Kushmandi (RCH, 2015).

Figure 17.3: Traditional puppetry at Mukha Mela

Figure 17.4: Masks in wood and bamboo

Craft cluster visit leads to understanding and learning about the history of the settlement, its geographic features, social practices and cultural characteristics of the community. The students can also learn about the origins and practice of the craft, sourcing of raw materials, tools and techniques and the market-oriented aspects of this traditional occupation. Living with the artisans opens up the perspective of the life of artisans, their joys and sorrows, under which the craft was born and survives as an integral part of their lives.

Initially, secondary research in the form of Literature survey was conducted before the students were led to the cluster. This allowed them to develop understanding of the locale as well as the craft and its innate details, thus arriving at the cluster with the basic understanding on the aspects of the craft as well as what to expect at the cluster. At the cluster, primary data was collected through survey and documentation which was assimilated before the next stage, wherein their analysis lead them in the direction of disseminating their learnings and thus providing future directions. Details on the Craftsperson profiles and their occupational details were created through this study (Saha, Saha, and Mondal, 2019).

LEARNING THE CRAFT PRACTICED

A craft is a manifestation of a human skills using specific materials, relevant tools and application of techniques. A cluster-based experience allows first hand exposure to the raw materials and indigenous tools at the hub of the craft activity. Students sat down and worked with the artisans to learn the mannerisms of handling the materials and tools, which helped them in developing basic prototypes as practiced traditionally.

Figure 17.5: Raw materials, tools and process of prototyping

This led to developing a common language of communication through close interaction, which allowed them to develop newer designs through the help of these craftsmen in the later part of the study. Working hand in hand with the masters of the craft, not only made one learn the nuances but also the ease or difficulty of developing the skills needed to practice the craft and the properties of the materials used-naturally. This induced a sense of respect and attraction in the students, for the craft after hands-on experience.

Survey Conducted and Assimilation of Data

The students were divided into groups and each group conducted survey of the artisans. It was primarily an ethnographic survey, with photo documentation at the field level. The primary survey included personal interviews of the artisans as illustrated.

Figure 17.6: Artisan profiles created by students

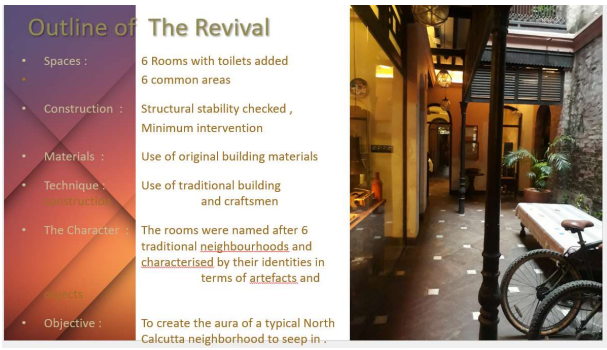
In this process, the students interviewed and subsequently worked with various artisans, which included leading names like Paresh Sarkar, Ananta Sarkar, Sankar Sarkar, Krishna Deb amongst others.

The data collected from the interviews was assimilated in various statistical modes to identify the demographics of the cluster. This level of the study was completed before design intervention.

v) Case Study # 5:

Antiquity within the urban modern –nuances of space design :– Case Study – Calcutta Bungalow , Kolkata

[ref. at the International Conference FASHION COLLOQUIA 2020, held at the Arch College of Design & Business, Jaipur, January 2020]



vi) Case Study # 6:

Traditional Crafts as Materials in Placemaking: Application and Sustainability in Aesthetic Transformation of Geometry of Urban Public [*Durga Puja Pandals, Kolkata*]

[ref. Encyclopaedia of Renewable and Sustainable Materials, vol. 4, pp. 259–291. Oxford: Elsevier.]

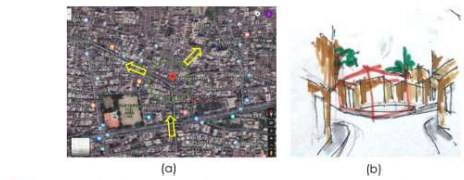


Fig. 41 (a) Location of Tridhara Sammilani (courtesy Google Maps). (b) Direction of geometric transformation. Courtesy Ms. Jayati Mukherjee, Assoc. Prof., NIFT.

Fig. 42 Tridhara Sammilani in (a) 2012 and (b) 2013. Courtesy Ms. Anwesha Mukherjee, Student, NIFT.

Fig. 43 (a) Location of Mudiali Club (courtesy Google Maps) (b) Direction of Geometric transformation. Courtesy Ms. Jayati Mukherjee, Assoc. Prof., NIFT.

Fig. 44 Mudiali Club in (a) 2010. (b) 2012. (c) 2013. (d) 2016. Courtesy Dr. Bishnupriya Basak, CU, Kolkata.

Fig. 45 (a) Location of Badamtala Ashar (courtesy Google Maps). (b) Direction of Geometric transformation (Courtesy Ms. Jayati Mukherjee, Assoc. Prof., NIFT).

Fig. 46 Badamtala Ashar in (a) 2010 (b) 2013. (c) 2014. Courtesy Ms. Anwesha Mukherjee, Mr. Dharanedharan, Mr. Gaurav Murmoo, Students, NIFT.

(3) *Application of Light* – Creative lighting leads to complete change in the visual perception of the space designed (Figs. 60 and 61).
(4) *Detailing of craft used* – Meticulously executed intricate detailing of the craft can recreate traditional spaces Fig. 62.

SWOT Analysis

Strength

Craft materials are largely sustainable and renewable in nature, Hence the materials and prototypes can be conveniently adapted to different uses when the present spatial arrangement undergoes change. e.g., a daily use metal Pot can easily become an element of the structure. Similarly, a craft object like a bell can be put to use in a lampshade.

Jayati Mukherjee 30/1/2026

Maingat Ghosh 30.1.26