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Integrated visual approach to design building form in 3D

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Abstract— the design of the building in 3D requires many features that are based on mental techniques to achieve its functions and other techniques based on the perception of sensory for aesthetics. Achieving aesthetics to the building is complex. It does not merely depend on the formal principles, but it requires a set of spatial features may concern the surrounding environment, expressing the culture of the place or the contemporary social or political issues. These features play a major role in the exterior design of the building.
The main goal of this study is to reinforce visual architecture learning based on architecture visual language theory and the external forces influencing architecture form creation.
In its search for achieving the objectives, the research follows an analytical and descriptive approach. Through the research, different concepts and theories of creating the architecture form were introduced. Moreover, a list of the features of the building form in 3D was presented. This includes what is described and inspired by the real parts of the building.
An integrated framework for building form features was concluded where these features were organized into three architectural orders. This study in correspondence with these features presents the design principles that affect and add aesthetic features to the elements of building form.
In conclusion, the paper presents a role model for universal visual perception features of building form in.2D Matrix which consists of the features of the formation and the design principles. This tool will guide both the architecture students and practitioners to visualize and create an architectural form based on methodical thinking.
Moreover, this tool will support the visual experience in everyday life in perception the visual messages of the building form. It will also facilitate understanding the learning of architecture language and apply it methodology.

Keywords—Aesthetics, external forces, visual learning, visual perception, visual message.

1 INTRODUCTION

THE prior mission to students of architecture or to a beginner architect before starting the design of the building form is to browse and examine through books, magazines and the real buildings in searching for design ideas and vocabulary to use. In order to do this, they have to realize aesthetic and technical standards and basic principles that affect the components of the building to achieve the desired beauty of the building exterior form. They also have to understand external forces affecting the design of the building mass to achieve the creative visual message of the design in the architecture formation.

Creative thinking might be challenging aspect of the design process, it requires visual learning as well as a methodological approach; hence this study provides students with two skills namely the visual acuity [1] and the visual expression. The former is to grasp the different aesthetic and spatial characteristics of the building, and the latter depends on the ideas that are derived from the building or inspired by the vision.

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2 THE CREATION OF ARCHITECTURE FORM

The creative thinking is the second stage of visual learning. Architecture creativity is not merely a field of general creativity but it is the mother of all arts. Architecture is the first art made by man to characterize all his living activities and to become a mirror of society with all its values, customs, and traditions. The main objective of architecture creativity is to form the material and space from spatial systems to satisfy diverse psychological, social, artistic and intellectual tastes. [2]

It is difficult to identify one source or one theory of architectural forms. According to the creation of architectural form consists of five theories that have come from different cultures and generated many rich variety ideas. Five basic ideas, ranging from Pure creative imagination driven form of building up to the function and climate-driven form. [3]

Theory 1, An architectural form is shaped by its intended function. According to this view, the form of the good building is shaped by the various physical, social, psychological and symbolic functions it is expected to perform.

Theory 2, An architecture form is shaped by the creative invention. This theory states that the architecture form is inspired by the architect's personality.

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Theory 3, An architecture form is shaped by the prevailing spirit of the age. This theory states that every age is characterized by a unique spirit and common positions that cover all its cultural activities, thus creating a certain form of artistic creativity.
Theory 4, An architecture form is determined by prevailing social and economic conditions. This theory states that all individual efforts are affected by physical forces, thus the form reflects the social reality of the architect.
Theory 5, An architecture form is shaped by general principles. This theory suggests more universal, abstract, and applicable than types.

Creativity hence can be classified into three categories: [2]

1. Physical creativity involves space, environmental, psychological requirements, safety, security, and constructive requirements involve appropriate technology to achieve desired spaces, however, it lacks pleasure, sensitive and a cultural expression.
2. Artistic creativity involves visual and psychological influences. It also strengthens the sense of belonging and the appropriate awareness to the function of the building.
3. Intellectual creativity is intended for the goals of its era, whether ideological, social or political. It also creates the artistic and intellectual heritage for the future generations.

Finally, any kind of architectural creativity includes the former three components needs the architect to be fully informed and have the sense of human life and its necessities. This necessitates the architect to have a close eye, a careful ear, a keen sense, a creative thinking and to be a guide to his era. These elements together bring to humanity a remarkable architecture creativity.

3 RESEARCH METHODOLOGY

The research methodology analyzes and describes Correlations & Reciprocal Relations between two lists. List of the features for building form and list of artistic and aesthetic criteria. The first list acts as an integrated framework for the realization of the building in 3D. The latter affects the building features and adds an aesthetic touch to them. The two lists are utilized in making a model serve as an integrated visual analysis tool for the external building and it is applied to a variety of buildings in different time periods and different environments.

3.1. List of features of building three dimensional forms

This list resulted from previous readings and references and it is a group of features that reflect the actual part of the building we can see.

1.A form. A form is the purely visual aspect which defines a 3dimensional shape, mass, and space.
3dimentional Shape: refers to the configuration of surfaces and edges of the three-dimensional object; is the composition and complexity of the surface planes. We perceive shape by contour or silhouette.

Mass/ Size, A solid three-dimensional form. Mass refers to the size or physical bulk of a building and can be understood as the actual size, or size relative to context.

Solid /Void, Mass as solid (continuity of form and positive form), mass as void (subtraction and negative form). Voids and masses can be Referred to as Negative space / Positive space Negative form / Positive form, Volume / Solid or Space / Void. Design Space can be either full or empty. [4], [5]

Type of shape, (a form's outer contour) Regular and irregular shape:

Regular, A shape has regularized contours and mathematically similar in multiple directions. Geometrical form: Geometry is the fundamental science of forms and their order. Examples of regular forms: Simple: pure shape, the sphere, cylinder, cone, cube, and pyramid are prime. Complex: as a whole: a complexity of the surface plan with a transformation of the whole with dimension transformation, Additive, subtractive and division. As multiform: a complexity of the form relationships:
Separated, linked, attached, interrelated (interlocking and interpenetrating) forms.
Form organization: Linear, centralization, radial, clustered and grid.

Irregular forms, complex and highly different contours. They are generally asymmetrical and more dynamic. Freeform: outline curved, angular or a combination of both which uneven shape and random (shape without geometric characteristics) or organic shape.

Organic shape, like things which in nature. Abstract shapes are simplified or stylized versions of organic shapes. Think icons. [6].

- **2.Vocabulary.** Refer to the tangible external building elements that deal with building surface and its building envelope. It includes the components of the main block and a wide variety of function and decorative details. [7] (Exterior details) such as:

The treatment of edges, corners, and surface articulation. [5]

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Fenestration, window reveals, or similar elements to break up large expanses of uninterrupted building surfaces (blank walls) and doors.

Ornaments, columns, arcade structures, varying roof lines, Offsets or breaks in roof elevation, balconies, projections (e.g., overhangs, porches, or similar features),

Recess, (e.g., deck, patio, courtyard, entrance or similar feature)

Extension, (e.g., floor area, deck, patio, entrance, overhang, or similar feature).

Patterns, decorative patterns on exterior finish.

Wall system, horizontal, vertical planes, overhead plan.

3.Environment. Architecture informed by its context such as: **Site structure,** Geography: Strong visual: mountain (deferential structure), Weak visual: flat (strong structure).

Vegetation, provide appropriate design forms. Vertical tree forms: suggest to contrast with horizontal architecture massing and Tree massing: suggest to similarly scaled architecture mass.

Site-form relationships, natural environment- built environment. Natural features: (sincerity) such as the lines of rolling hills, the horizontal lines of cultivated fields and the angles of distant mountains. Man-made: vertical clustered of skyscrapers, the roof lines of houses.

Climate, extremely cold: a compact building of minimum exterior surface. Hot humid: open form to allow breezes to penetrate, rainy climate: slopes roofs, dry climate: flat roofs. [8].

4.Landmark. Refer to spatial tag and building identity of the place. Landmarks act as: [9].

Focal point, depends on form and size and reference points in mental spatial representations. Their function in mental representations is to locate other objects.

The uniqueness of the 3D object, physical structures as a tower, dome. For orientation and wayfinding, and for any spatial communication.

Aesthetical quality, and architecture icons as museums: for example, the Eiffel Tower, which is an icon of Paris, the Great Pyramid of Giza, Taj Mahal.

There are two type of landmarks. The one is a local landmark which is visible from restricted locations. The second type has city-wide relevance. It is a major point of reference shared by a large population.

It is often visible from long distances and describes external features to the individual that distinguished by their dominance and singularity of shape, color, size, height, location, visibility and finally, their sharp contrast with the background.: [10]:

Characteristics of good landmarks may be visual, semantic or structural attractions: They form anchors as a visual attraction with shape, color, and visibility.

5. Skyline. It is a very recent term which use of the word 'skyline' in relation to buildings did not appear until 1890. It describes as the profile of the building and the outline of the roof or a group of roofs seen against the sky. It is appreciated from a distance, for large-scale buildings and towers dominating an otherwise generally lower and visually monolithic roofline. The detailed roofline is that outline of buildings seen from the pavements in the city. It makes a certain characteristic form for its site as landmarks, and performs the main decorative and bring interest into the street scene. There are four types of the roofline. The first is the plain crisp edge of the much modernist building. The second is the product of the natural growth of towns in middle ages, the third is a product of the Renaissance and the fourth type is found in baroque building groups. [10]:

6.Materials. Each material has its own design language which expresses its composition and its texture and way of finishing it from other influential factors. [7]

The surface drives the use of materials in two profound ways. First, the visual characteristic of its external surface, ex. Texture and color. Second, the surface of the materials as planar.

Texture and color, Distinguish and reveal the forms.

Color, Specific hue determined by its wavelength to alter the perception of any form with three concepts, value, intensity /saturation, and temperature. All three concepts help to determine the legibility and psychological impact of a color. Value refers to the lightness or darkness of a color, Saturation defines the brilliance and intensity of a color and temperature to the perceived warmth or coolness of a color.

Texture, The visual or tactile quality of a form makes an element appear three-dimensional and give the appearance of mass and physical weight. Texture can increase the surface area of an object, add contrast, and enrich our understanding of the physical and conceptual qualities of any 3D object. Texture can enhance defy our understanding of a form. On a conceptual level, texture can add layers of meaning such as soft-hard, smooth-rough, light-heavy. (the human sense of touch.) Different textures can also be used as decorative elements to add more visual interest to the buildings

Planar, As a two-dimensional surface: exterior cladding that forms the building ex. stone, wood, and Aluminum. Planar forms have a variety of shapes may be suggested by means of outlines which classified from geometric (mathematically), organic(free curve),rectilinear(straight lines without mathematically), Irregular(straight and curved lines without mathematically), etc. [11]

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7.Context. Features to interact with place and the relationship to the surrounding to contribute to the sense of place. The relationship between places and human emotions. The sense of place is a comprehensive concept which in it men feels places, percept them and attached meaning to them. Attachment to places is one of the most important concepts in the relationship between place and people. In the recent years with the development of human societies and changes in their lifestyles, the attention of architects and designer and planners, has been increased and the role of design as a tool to shape the environment and respond to the human expectations has a greater importance for them. Local building forms and details contribute to the distinctive qualities of a place. Local character including Aspects of natural and built environment in particular geographic locations, streetscape , a network of green spaces including parks and public places. [12]

8.Gate, Entries and porches are strongly encouraged to be the primary element of each building on the street facade; they should be clearly identifiable and articulated. Every building entrance should be easy to locate and clearly distinguishable from the rest of the building to covey an attractive, welcoming appeal. The position of an entrance may be highlighted with architectural features such as a canopy, a door recess, size and scale of the entrance space a change in the surface texture of the pavement or forecourt may help to signal the location of an entrance, particularly for people with visual difficulties. A building's entrance fulfills an important role in providing the activity for the street and creating an identity for the building. While there may be more than one entrance, the main entrance into the building should be clearly distinguishable through its architectural design and treatment. These points should be visually and physically enhanced to convey a sense of pride. [13]

9.Style. Each building has a unique style which differentiates it from other buildings. In other words, each building has been shaped in a unique way and with special materials. Style hence can be described as the collection of components which were used repeatedly to build much building over one era. Thus, when this collection is repeatedly used it soon becomes a distinguishing characteristic for buildings of the particular era. Therefore, styles originally can be derived from old ones or can be a response to a certain style.

There is a difference between a building with belongs to a certain style and a building which has its unique style. Styles can influence each other and they change from its place to another. Although styles can be classified in a chronological order, they could mix and there could be more than one style in one era. Some styles, for example, are completely derivative and they freely copy other styles. Other styles like a revival style originally belong to a previous era.

On the other hand, a few styles such as the modern style is truly innovative as most modern styles are designed based on technology and new materials. Technology and new materials alone do not bring a new style but a true creative architect or a group of creative architects do create architecture forms based on technology and new materials. [7]

10. Expression. The expression defined as part of the communication process which consists of two complementary components, expression(transmitted information) and impression (received information).Expression in architecture implies a clear and authentic displaying of the character or personality of an individual (architect). [14]

Structure, a visible indication of building structure system where the shape of building element, column, capitals indicate a transfer of loads [7] such as High building: showing lateral Bracing. Long span: to shelter aircraft. Forms of curvature: shell structure. Qingdao Cultural Centre, China, Modern industrial building with a curved steel roof, Fire station using gasifies of steel arches.

Culture, New International Dictionary defines culture as "the complex of distinctive attainments, beliefs, traditions [which constitute] the background of a racial, religious, or social group. The form and relationships of buildings and spaces act as a kind of 'cultural marker', which can describe the way of life and social status of its inhabitants. The physical features of Architecture such as shape, size, decorations, and constructions style etc. are practiced through the cultural system of society. The expression of culture takes great skill to unite the past and present successfully and use of past style in architecture solve an emotional need.

Function, The building forms should express its function such as the repetitive pattern of the facade expressed repetitive activities of an office building. Interior flexibility suggests several similar modules. [8]

Meanings, Simple visual features (e.g. colors, shapes) can induce elementary implicit meanings such as dynamics, warmth, aggression, relaxation etc. These implicit meanings can be applied in art and architecture to create expressiveness. For instance, the use of vivid red color can emphasize passion, the use of diagonal lines can induce dynamics, the use of sharp angular lines can be associated with aggression, danger etc. [15]

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3.2. Conceptual Framework

The visual form features are organized in an integrated framework (Fig. 1) after they were displayed to realize the building in 3D. The framework is based on architectural orders requirements [4] .These requirements are physical, perceptual and conceptual orders, including clear and visible elements which describe the building block characteristics, the elevations and the building exterior appearance including; Forming, Vocabulary (exterior details), Environment.

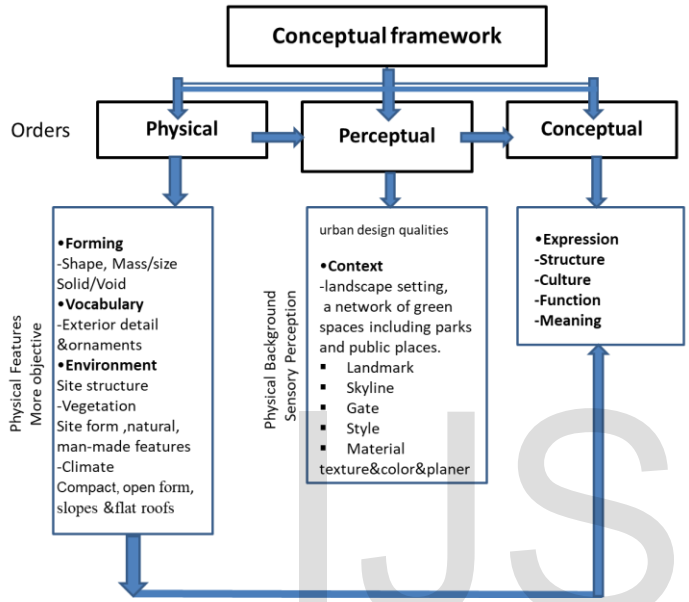

Fig. 1. Conceptual framework

Other elements act as a background and scenery for the building from inside and this includes the surroundings (context, landmark, Gate, skyline, and material. Other elements are inspired by seeing the building like visual expression.

3.3. List of Principles of 3Dimensional Design

The external building form analysis refers to its aesthetic aspects. Aesthetic is one of the important architectural principles that perceived by the students and professionals as a philosophy behind a pleasing appearance.

These principles are guidelines to fulfill aesthetic feelings in art & Architecture. Architecture uses them in creation effective forms, interesting volumes, surfaces, and masses. Artistic composition promoted by aesthetic principles such as; proportion and scale, unity, variety, balance, rhythm, emphasis and focal point, contrast and hierarchy which have the large impact on architectural design [7], [16]. It is necessary to develop a visual awareness and identify how those principles are used in design composition.

1.Balance. Means that the elements of art work is in equalization form. This is either Actual and Implied, Actual balance is a phenomenon of nature ruled by gravity, operating in real space. Implied balance is a virtual condition that involve the actual gravity and balance awareness (aesthetic factors of visual weigh). There are two kinds of balance: **symmetrical** (formal), when left and right sides are mirror images that correspondence across a divide. There is Radial symmetry which is around a center axis and spherical symmetry that around single point

Asymmetrical (informal), Dynamic Form asymmetry is based on different arrangements of parts. Where equilibrium is achieved by the balance differences in the art elements within a composition.

2.Unity/ Harmony. The unity achieved when the building as a whole is more important than its parts. To create harmony, Use a similar shape, lines, textures, and patterns. A unified design may be - A simple monolith or mass and Many forms or objects brought together to construct a coherent whole.

3.Variety. It is achieved through diversity and change. Using different line types, colors, textures, shapes.

4.Repetition. Three repetition methods: repetition, patterns, and rhythm. **Repetition** is the same element repeated that gives a composition of unity, continuity, stream and emphasis. Structural stability and visual unity is applied when there is a visual and Structural repetitive element in 3D form. **Pattern,** is the elements combination repetition as a decorative effect which uses lots of elements that compacted with each other.

Rhythm, is the visual beat by using repeated objects. Rhythm involves using intervals or spaces between elements for an impression of rhythm or movement. There are two kinds of rhythm:

Regular, Example, Rhythm in architecture relates to a regular occurrence (rhythmic) of similar and like effects. The same intervals over and over again.

Irregular, Repeating elements with no specific regular interval create random rhythms.

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5.Movement. Illusion of motion with shape to create a slow to fast action. It is a false perception. Characteristics of sleek forms designed to move without turbulence also allow these objects to look fast, even while standing still.

6.Proximity. organization based visually on things near to each other and excludes the more distant. Proximity can be a visual tool and/or a functional one.

7.Focus/Emphasis/Dominance. created by greater attention in art work or design by using certain areas or objects in numerous strategies for achieving emphasis such as Differences, or contrast, of color, texture, shape, and size or Isolation of elements and Relative placement of elements.

8.Proportion. the relationship of size between the certain part to the whole. It is a sense of size relationships that between objects to the context within the whole. Such as Intimate, Impressively and Monumental proportion and between one object to an outside measure such as the human body.

9.Gradation/Hierarchy. It is the combination of elements using chain gradual changes. Examples of gradation: gradually from small shapes to large shapes , gradually from a dark color to a light color and gradually from shadow to highlight.

3.4 A Role Model

This study will be established as a 2D matrix as a role model based on the previous two lists (features of the building form list and the principles design list) in 3D. This tool is applied on some buildings to make an integrated analysis its visual elements. It is a methodical learning method for the building form visual requirements.

The horizontal rows in the matrix is a list of building form features that determines some aspects to illustrate them. Then the matrix describes these aspects for the selected building. In the vertical column, there are varies design principles.

This matrix presents a way to describe and analyze the building features and to capture the connection between its each aspect and the design principles.

It works in four steps:

First: Determines the building that will be analyzed.

Second: illustrates the feature of building form list and described its aspects.

Third: highlights the interactions that affected by the design principles on the features aspects and illustrated it by sketches.

Fourth: concludes the specialized notes and illustrate the relationships in the matrix.

4 Case Study

In this part, the selected buildings (similar in function and size) will be analyzed according to the proposed role model in the twentieth century famous architect's era.

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TABLE 1.

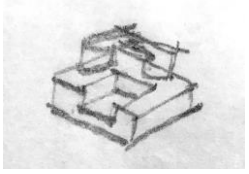
MATRIX ANALYSIS OF A MODEL IN THE EARLY 20TH CENTURY

General Data

Villa Savoye	
Architect	Le corbusier
Year	1931
City	Poissy - Paris
Style	Modernist Version of French country House

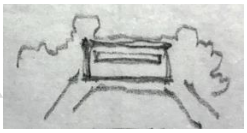
Features of building form in 3D \ Design Principles		Balance	Unity	Variety	Repetitio	Patterns	Rhythm	Movemen	Proximity	Emphasis	Proportio	Hierarchy
1- Forming												
Shape	Simple, formal shape, cubical form :symmetry	■										
Mass	added :curved structure											
Solid & Void	Subtract :the bottom and courtyard			■								
2-Vocabulary												
Fenestration:	Elongated window: harmony	■			■							
Ornaments:	Modular slender column				■		■					
Wall system:	Geometric and Curved wall			■				■				
3- Environment												
Site Structure:	Site flat, strong structure	■										
Vegetation	tree mass		■									
Site form	horizontal line of cultivated field	■										
Climate	open form for breezing .flat roof	■										
4- Landmark												
Local												
Icon												
5- Skyline												
Local Level	Flat by adding curved wall			■								
City Level												
6- Material												
Texture	Smooth	■										
Color:	White	■										
Planar	Light & transparent ,concrete and glass			■								
7- Context												
Land scape:	Grass plane, lawn grass	■										
Public spaces,	Seating landscape, Pedestrian corridors		■									
8-Gate												
highlight												
Icon												
9- Style												
Innovative	Modern style	■										
Derivative												
10-Expression												
Structure:	Modular column, frame structure											
Culture	logic, productivity and quantity (machine age)	■										
Function	Form follow function	■										
Idea	The house a floating effect.		■									

Sketch 1



Sketch 2

Sketch 3



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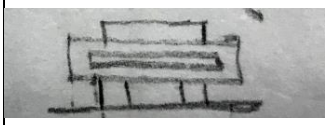

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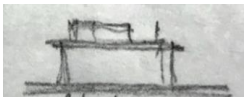

Sketch 6

Conclusion

The design was based on 7 features to achieve the simplicity, stability, and compatibility of the elements and crossed with nature. It achieves functional thought.

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TABLE 2.

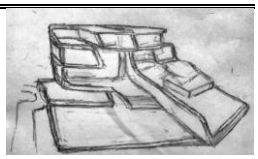
MATRIX ANALYSIS OF A MODEL IN THE EARLY 21TH CENTURY

General Data

Küsnacht Villa	
Architect	Zaha Hadid
Year	2006
City	Zurich, Switzerland
Style	a unique futuristic house,

Features of building form in 3D \ Design Principles		Balance	Unity	Variety	Repetition	Patterns	Rhythm	Movement	Proximity	Emphasis	Proportion	Hierarchy
1- Forming												
Shape	Organic shape, Asymmetry ,dynamic	■						■				
Mass	Formation ,overlapping ,clustered			■				■				
Solid & Void	Manipulate by sold and void			■								
2-Vocabulary												
Fenestration:	Opening from ceiling to floor			■	■							
Ornaments:	Terraces &other elements orotude irregular				■		■					
Wall system:	Fold Seamless and curvy wall			■		■		■				
3- Envionment												
Site Structure:	Strong visual with deferential structure			■				■				
Vegetation	Tree mass similarly scale the mass		■									
Site form	Natural rolling hill agricultural lands							■				
Climate	Clustered form							■				
4- Landmark												
Local												
Icon												
5- Skyline												
Local Level	Seamless transitions in roofline			■				■				
City Level												
6- Material												
Texture	Smooth surfaces											
Color:	One color ,white											
Planar	Light &transparent: concrete , glass			■								
7- Context												
Land scape:	Green land											
Public spaces,	Green land		■									
8-Gate												
highlight	Change of composition			■				■				
Icon												
9- Style												
Innovative	Deconstructure style							■				
Derivative												
10-Expression												
Structure:	Lightness &dynamism. steel frame ,R.Concrete							■				
Culture	Mixture between liberation and logic							■				
Function												
Idea	Strong relationship with site and landscape		■									

Sketch 1



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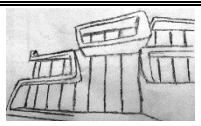

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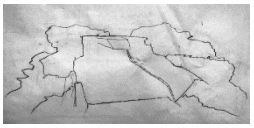

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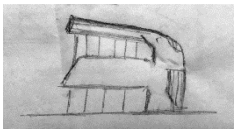
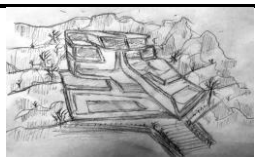


Sketch 5

Sketch 6



Conclusion

The design was based on 9 features to achieve the motion, variety and seamless transitions to give a feeling of liberation and simulation of nature.

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5 Discussion and Conclusion

The Matrix present the relation between the building features form in 3D and its design principles.
There are three features:

- Description of the Building block characteristics, such as form, vocabulary and environment.
- Clarification of the building background and what we are perceived from the scene including such as context, landmark, Gate, skyline, and material.
- and Inspiration of the different meaning of the building such as expressions.

This study is a theoretical research to develop the knowledge concept to the architectural students that improves the design process of the building block in 3D. It presents a methodological tool that acts as a model or guide for helping the fresh architects or architectural students to analyze an integrated building form elements in 3D. Also, it will support the visual educational process and help to create alternative designs with different aesthetic standards that improves the creativity in designing the building form. This tool will help architectural design teachers to enrich the student's mind with lots of vocabularies to find various methodological solutions based on creativity in problems solved.

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