# Graphic representation and processing techniques for form and space analysis

Uddin, M. Saleh [1]

Keywords: graphic analysis; design principles; representation

**Abstract** One of the most important aspects of architectural education and practice is to understand and learn the principles of design that relates to formation of three-dimensional built-form. Frank Lloyd Wright himself said, "*Do not try to teach design. Teach principles*."

One way of examining such principles would be to analyze a work of important architecture. Analyzing existing buildings is significantly important in architecture so that one becomes familiar with the organizational strategies of a design work. Both the process and product of an analysis can be a valuable learning experience. In this regard, a good learning tool would be to analyze architecturally distinguished buildings having significant merits.

Since there are no established methods of graphic analysis of architectural form and space thorough combination of manual and digital representation, this paper investigates the possible representational techniques ranging from sketches, axonometric drawings, tactile diagram models, 3D digital models and animations. In one hand the paper demonstrates the strength of simplified axonometric drawings and cardboard diagram models in formulation and representation of precedent analysis, on the other hand the paper highlights the power of 3D-computer animation that takes into account of parametric changes (in terms of its position, orientation, scale, shape, and rendering characteristics) to help enhance representation of analytical components and overall understanding.

1. Department of Architecture, Southern Polytechnic State University, Georgia, United States of America

## 1. Architectural Analysis and Design Principles

In architecture, the primary goal of a design analysis and its representation is to expose the underlying concept, organizational pattern, design characteristics, and 'tectonics through simplified diagrams. Analysis for a built physical building will inherently lead to the reconstruction of the underlying design principles as a predicted hypothesis. Both the process and product of an analysis can be a valuable learning experience in architectural education.

Often, an analysis is an attempt to reduce the written discussion of theories involved, and to emphasize more clearly the design characteristics and 'architectonics' used through simplified graphic diagrams and sketches.

Howard Robertson in the preface of his book '*The Principles of Architectural Composition'* mentions: "*In attempting to formulate some of the guiding principles of architectural design, I have been actuated by the desire to demonstrate that composition in architecture is susceptible of an analysis, through which can be isolated certain main factors which assist in, or militate against, the production of successful design."*

Throughout history, the notion of 'precedent' has always provided conceptual models to serve the quest for appropriate architectural forms. Since the end product of architecture is a built outcome, the most basic theoretical stance must be supported in turn by a few fundamental grammars. Such was the case with Le Corbusier's '*Five Points of the New Architecture'* published in 1926. The design and construction of Villa Savoye by Le Corbusier (1928-31) gave an equally seductive physical expression to the 'five points' idea. In turn it provided a collective iconic precedent. Conversely, when analyzed, the built work of Villa Savoye was clearly able to demonstrate the principles of 'five points' and also supported the theoretical model.

Although the result of a design analysis can take the form of a written text, recent developments in drawing techniques and computer simulation suggest that incorporating multi-dimensional graphic means along with text description and tactile model will enhance the understanding of the analysis equally to a professional architect and to a beginning student.

All analyses have two basic components: a) Formulation or Conception of Analysis, and b) Representation of Analysis

## 2. Components of Analysis

Although graphic analyses of precedents are approached differently by various authors, there are significant overlaps among the issues undertaken for analysis. Some issues are categorized sometimes as element, other times as a system, elsewhere as relationships. For example 'Circulation' is categorized as an element by Clark and Pause, whereas Ching illustrates this same issue as a system. Simon Unwin defines it as an element doing more than one thing.

Reviewing the above examples, it can be said that it is possible to express and examine a design vocabulary in a work through three main divisions:

a. *Components/Elements of Design:*
- Basic or Conceptual Elements (Line, Plane, Volume, Mass, etc.);
- Defining Elements (Entry, Path, Place, Opening, etc.);
- Modifying Elements (Light, Color, Texture, Temperature, Sound, Ventilation, etc.).

b. *Relationships between Design Elements:* Building to Context, Circulation to Use, Plan to Section, Unit to Whole, Inside to Outside, Repetitive to Unique.

c. *Principles of Design*: Axis, Symmetry, Hierarchy, Rhythm, Repetition, Datum, Transformation.

Similarly, it is possible to express analytical components or issues in a design work into following four basic categories (excluding Perceptual Components), each having sub-issues within it:

a. *Contextual Components:* Location, Site and Context, Site Forces, Approach, Movement, Climate, Socio-political.
b. *Organizational Components:* Proportions in plan-section-elevation, Geometric Order, Light-color-shade and shadow, Transformation: functional-formal-spatial and elemental, Axes, Core, Datum, Regulating lines, Equilibrium/Hierarchy, Thematic modulation.
c. *Thematic Components:* Theme and meaning, Design principles, Parti diagram, Zones, Figure/Ground, Circulation sequence-space-exit.
d. *Visible Components:* Massing, Cluster of units, Containment, Form and space, Geometric adaptation, Unit to Whole, Repetitive to unique, Solid to void, Core system, Structure, Layers, Interlock, Frame to mass, Plane to mass, Membrane to mass, Envelope to core, 3D solid-void, Addition-subtraction, Enclosure to non-enclosure.

Although a general guideline can be drawn from reviewing various authors work, it seems that each building may have certain qualities that are unique to that building and an analysis not having fixed issues can effectively bring out some new issues.

## 3. Graphic Representation Means of Analysis

Analysis can be presented through text, verbal narration, two- and three-dimensional graphics using architectural drawing conventions, video, computer animation, and interactive navigated graphics. Although live video and realistic animation can provide a near experiential quality of being in a building, without understanding conventional drawings of that building, analysis will remain incomplete. Plan, elevation, section, and 3D drawings are abstract representations of a building that provide a holistic view of the building without being distracted by the details of materials used, treatment of facade, and such other details.

Although the result of a design analysis can take the form of a written text, recent developments in drawing techniques and computer simulation suggest that incorporating multi-dimensional graphic means along with text description will enhance the understanding of the analysis equally to a professional architect and to a beginning student. Below are the basic categories of representational media for graphic analysis.

### Drawing Conventions

Each analysis may demand its own method of drawing. Some analyses may be very effective with two-dimensional plan, others may need three-dimensional exploded axonometric. Drawings are an abstract representation of reality. All technical drawings are constructed on the basis of common systems of projection. The projection is the relationship between a point in space and its representation on a selected plane. Depending on the nature of the projections, all drawings may be divided into two basic categories:

1. Multi-view drawings (two-dimensional plan, elevation, and section), and
2. Single-view drawings (three-dimensional axonometric and perspective).

Plan, elevation, and section drawings are multi-view drawings where several coordinated images are necessary to communicate the complete visualization of the object. Single-view drawings are three-dimensional projections where one drawing illustrates several surfaces of the object, facilitating the understanding of the overall form of the object. The possibility of combining various conventions into one drawing to show more information has always been an experimental approach by avant-garde architects. However, parallel projection and central projection are the two systems that are capable of portraying the three-dimensional nature of an object.

Axonometric drawings particularly may become very useful in such an analysis because of their diagrammatic but three-dimensional nature in communicating the main idea in a straightforward manner.

It is important to choose an effective view point of a drawing that will illustrate an analytical issue clearly. Following are some of the options that may be used for construction of a paraline or a perspective drawing to suit specific purposes. Examples shown in Fig. 1 are axonometric drawings, a common projection convention favored by architects for the simple reason that such drawings can be generated from existing floor plans.

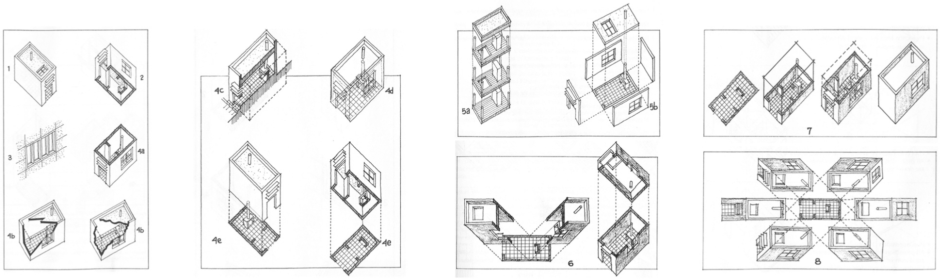

Fig. 1 Axonometric drawing exploration to represent various possibilities of 3D form and space analysis

**Tactile Hand Models**

Primarily, for analysis the common trend is to use drawings and images, ignoring the fact that the tactile hand model can provide the unprecedented understanding of tectonic and spatial composition of built-forms. This is particularly important in education. Architectural models are representation of buildings in a smaller scale using materials that are symbolic to real materials. They fit to three basic genres: a) presentation model, b) design process model, and c) analytical diagram model.

Understanding the spatial composition in 3D is the most essential prerequisite for creation and construction of diagram models for analysis. Simplifying the construction to create the diagram model along with proper material to emphasize and de-emphasize various aspects is the key to having a successful analytical model. Similar to drawings, tactile models can also construct and represent 3D spaces in wireframe, layers, solid-void, and exploded formats. Since the overall form and space is important in such diagram models, more than the precision of scale the use of material and proper proportion is critical. Fig. 2 below shows examples of diagram models that use various motifs of axonometric drawings through use of material and improvised methods of model-making.

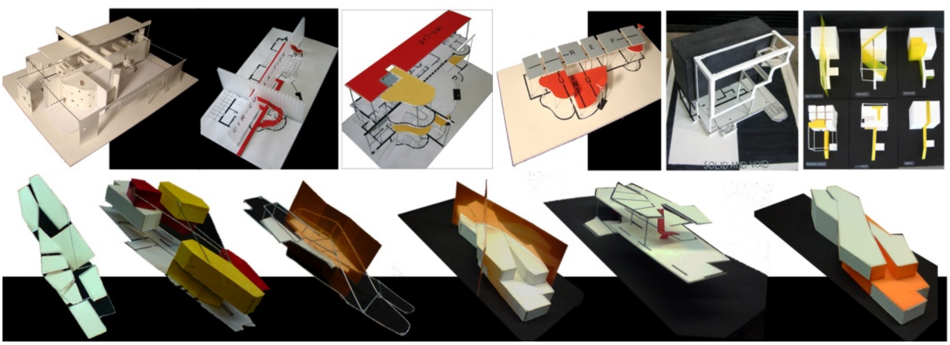

Fig. 2 Diagram models in cardboard offers best possible understanding of spatial and tectonic composition of built-forms for beginning design students

**Digital Modeling and Animation**

Without getting involved into technical details, it could be simply described that, there are three basic factors that together determine what an object in 3D computer model will look like. The first factor is the model construction mode, which tells the model how accurately an object should be constructed, and how much surface detail to display. Secondly every object is assigned a surface, which gives the object color and texture. The third factor is the lighting, which provides shading and depth to the model. Although these and their combination can provide a wide range of rendering options, by examining precedents of analytical diagrams drawn by various authors it can be stated that the basic features of hand drawn analytical diagrams are not readily available in computer 3D applications. Most of these are unique improvised features and not commonly encountered in 3D applications.

However, on the other hand, computer animations, which are generated from 3D models, have an unparalleled capability to demonstrate spatial experience. Animations can also manipulate the constitute components of the spatial structure, thus illustrating analytically the composition of a building or object. Since animated models can be built initially from a plan, it is possible to show both plan and three-dimensional structures in order to illustrate the sequential reading of the three-dimensional space. A 3D computer animation can respond to a variety of changes within the components of created models in a defined timeline where each event is recognized and changed in terms of its position, orientation, scale, shape, and rendering characteristics. Usually every event that has happened to every object is tracked, and a final animation is created incorporating changes of all objects.

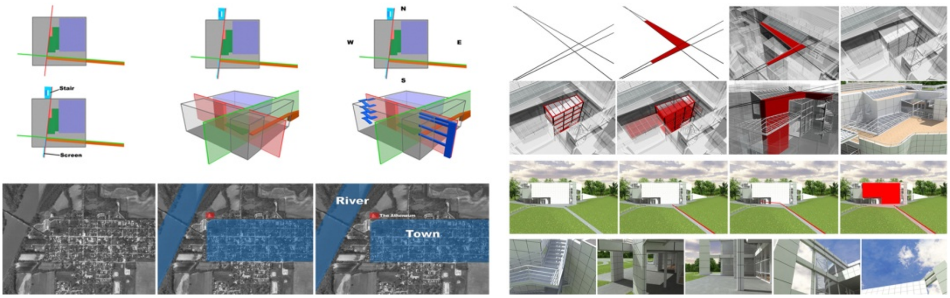


Fig. 3 3D-computer animation capable of revealing information through parametric changes of elements in position, orientation, scale, shape, and rendering characteristics. Various modes and combination of wireframe and rendering techniques in the modelling environment can be animated as needed

**4. Processing Techniques in Drawings and Models**

The most important aspect of any graphic analysis is the process of transforming concepts of analysis into visual graphics. Bringing out specific issues of analysis such as the basic form composition, structural system, relationships between elements, can be achieved by:

1. Reworking on an existing drawing,
2. Drawing a new drawing or 3D model,
3. Creating a new drawing or model only emphasizing specific issues.

Undertaking such executions will involve the processing of drawings. It could be processing of an existing drawing or graphics to highlight a certain part, or processing a new drawing with emphasis, addition, reduction, change of scale, and so forth. A processed drawing here means some type of modification from typical conventions. Combination of conventions such as combining a section in its axonometric projection, or a sequential rotation of an axonometric will fall into this category. For the purpose of analysis all drawings may be processed in following categories:

*Reduction:* Reduction is the most basic technique of representation. A commonly used technique in design analysis, reduction consists essentially of omitting all irrelevant data from a design drawing so that only information essential to the study remains. The effectiveness in making such an analytical drawing is in deciding what is to be shown and what is to be left out. In an analysis, it is quite common to have a series of drawings with limited quantities of data, each highlighting specific issues, rather than one drawing containing a great deal of information.

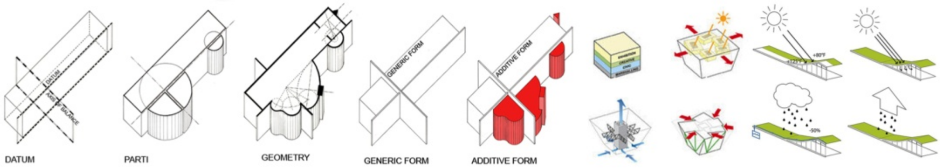


Fig. 4 Drawings illustrate process of reduction by omitting all irrelevant data deduced from detailed plan and 3D drawings

*Addition:* It may become essential for an analytical drawing to introduce information that is either non-visual or non-architectural. It may be information about functional use, or about the underlying geometrical system, such as axes and zones. Addition of lines, planes and volumetric enclosures can help greatly to understand the morphological deduction or transformation of the final form/s from its original platonic form/s and volume/s. Lines of vision, vertical and horizontal circulation of movement, lines of force between objects, implied grids, are important non-physical elements that need to be included in an analysis and can be achieved by adding such information. The use of graphics need to be chosen carefully so that it does not read as building element or conflict with existing drawing.

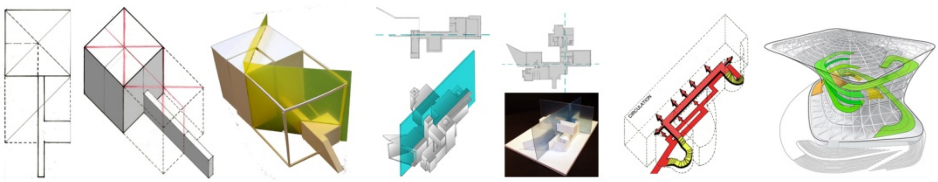

Fig. 5 Diagrams both in drawing and cardboard model illustrate use of additional elements to represent non-physical concepts of design, such as geometric relationships, axis, circulation, etc.

*Explosion:* An effective way to examine the relation between various aspects, systems, elements, layers, and surrounding context is to use exploded drawing techniques. Three-dimensional exploded views offer limitless possibilities of showing the manipulation of drawing elements to show more information which is almost impossible in a single plan or elevation. Exploded axonometric or perspective drawings usually combine both plan and three-dimensional views in a single drawing to give cross reference between each other. By the technique of disassembly this drawing type provides insight into the build-up of the spatial structure of the building under scrutiny. Juxtaposing or superimposing drawings giving complementary information can be very helpful when examining the relationship between different aspects of design. Similarly, taking apart of elements that obstruct information can also be useful.

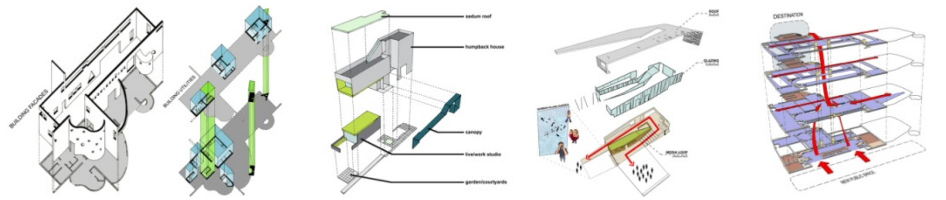


Fig. 6 Technique of explosion in both drawing and model can be an effective method to illustrate relationships between various aspects, systems, elements, and layers in analysis

*Simplification:* Constructing drawings that remove all things not important to the analysis makes that particular issue more visible. The simplification process may take account of both reduction and addition within the same drawing. Additional lines, symbols, or text may be included to enhance communication.

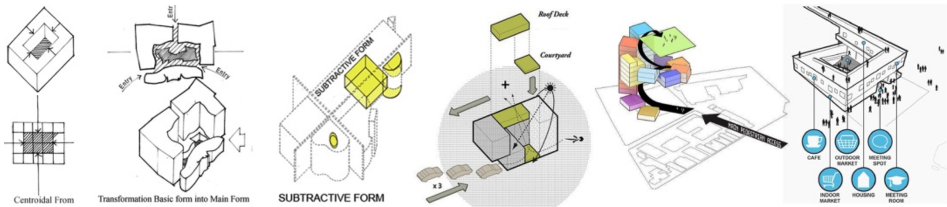


Fig. 7 Diagrams illustrating process of simplification by removing unnecessary details that are not relevant to the particular concept of analysis

*Emphasis:* Through emphasis, a part can be highlighted within the context of the whole. This can be done by varying line thickness, line types, and shading. Through a contrast shade of graphics, a drawing may easily identify and differentiate the issue of concern. Emphasis can be created by bringing contrast and hierarchy in graphics.

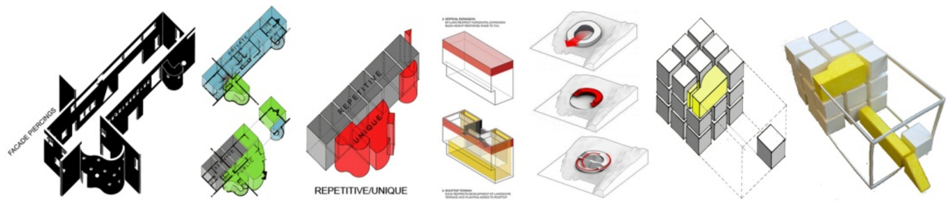


Fig. 8 The process of emphasis in an analytical drawing or model can be achieved by adding contrast and highlight through line, shade, color, contrast, etc.

## 5. Conclusion

Although a general guideline can be drawn from reviewing various authors work, it seems that each building may have certain qualities that are unique to that building and an analysis not having fixed issues can effectively bring out relevant as well as some new issues. In that context, Geoffrey Baker's approach may seem to be more suitable to adapt for a building where three-dimensional sketches gets priority in representing various concepts of analysis.

In regards to representation, some analyses may be very effective with two-dimensional plan-elevation-section, while others may need three-dimensional exploded axonometric. In an academic environment cardboard diagram models are the best possible ways to understand a building's analytical components by beginning design students.

Although use of Photoshop to highlight relevant portions of hand drawings is effective, 3D computer modeling seems to be lacking features that are important for diagrams. 3D-computer animation is capable of revealing information through parametric changes of elements in position, orientation, scale, shape, and rendering characteristics to highlight specific concepts of analysis. Software applications may soon need to incorporate features of various line thickness options along with dashed lines, dotted lines, lines with various arrows, combination of wire frame and hidden line, etc. to make applications friendly for 3D analytical diagram models. That day may not be far when 3D modeling programs would have the power to create improvised diagrams reflecting users' particular preferences of representation options.

This author's own finding in teaching analysis in sophomore design studio suggests that combination of 2D plans/elevations/sections and 3D axonometric along with cardboard diagram models are the most effective method of learning and representation of analysis in built-forms.

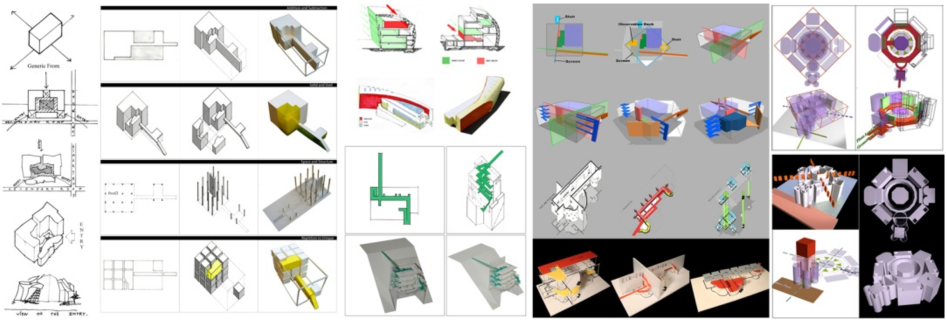

Fig. 9 Formulation and representation of analysis by 2nd year architecture students using 2D drawings, 3D diagrams and analytical cardboard models. Image illustrates manual drawings, tactile cardboard diagram models, and digital models in formulation and representation of analytical components

## References


Baker, G.H. (1996). *Le Corbusier: An Analysis of Form,* Van Nostrand Reinhold, New York, 1997, Chapman & Hall, London, Van Nostrand Reinhold, New York, 1984, 1989, 1996.

Barker, J., Tucker, R.N. (1990). *The Interactive Learning Revolution: Multimedia in Education and Training,* Kogan Page, London / Nichols Publishing, New York.

Clark, R., Pause, M. (1985). *Precedents In Architecture.* New York: Van Nostrand Reinhold.

Cotton, B., Oliver, R. (1994). *Understanding Hypermedia.* London: Phaidon Press Ltd.

Falk, D. R., Carlson, H. L. (1995). *Multimedia in Higher Education: A Practical Guide to New Tools for Interactive Teaching and Learnin.* New Jersey: Learned Information, Inc.

Leupen, B., Grafe, C., Kornig, N., Lampe, M., Zeeuw, P. (1997). *Design and Analysis.* New York: Van Nostrand Reinhold.

Mitchell, W.J., McCullough, M. (1996). *Digital Design Media: A Handbook for Architects & Design Professionals.* New York: Van Nostrand Reinhold.

Robertson, H. (1924). *The Principles of Architectural Composition.* London: The Architectural Press.

Southerland, M. (1999). *Modelmaking: A Basic Guide.* New York: W. W. Norton & Company, Inc.

Uddin, M.S. (1999). *Digital Architecture.* New York: McGarw-Hill.

Unwin, S. (1997). *Analysing Architecture.* London, New York: Routledge.