

INTERACTIVE TEACHING MODEL:
A PROPOSAL TO INTEGRATE BASIC ARCHITECTURAL
DESIGN PEDAGOGY WITH DIGITAL MEDIA

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In Partial Fulfillment of the
Requirements for the Degree
Master of Science

By

Shivani Seshadri Gonavaram Bala Sai

Dr. Mohammed Saleh Uddin, Thesis Supervisor

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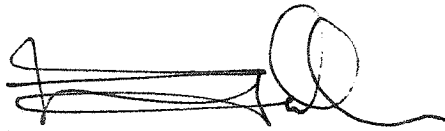
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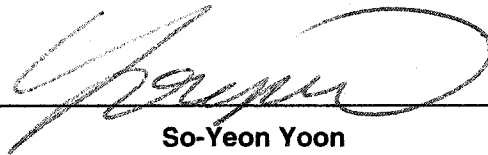
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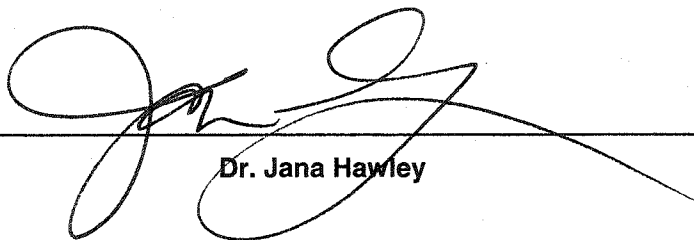
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ABSTRACT

In architecture as in life itself, science and art occupy positions of equal importance. In addition to the creative and imaginative skills that are expected from a design student, knowledge of some basic design elements and principles are necessary. These principles and elements are a collection of observations and hypotheses on the most permanent components of architecture. A clear understanding of the basic elements of architectural form and space helps to develop design concepts and realize the visual implications on the design solution.

Basic design pedagogy includes the realm of design communication where the student is introduced to a wide range of design ideas and concepts. Traditionally, a student engages in design inquiry where he organizes, analyzes and categorizes design ideas with sketches, perspective drawings and physical models.

In the recent past the face of the design studios has transformed dramatically with the advent of *Digital Media*. Digital software tools such as CAD, Photoshop, Form Z and 3d studio max are seamlessly integrated with studio assignments in most design schools. The tools are used to render design assignments which were traditionally done manually on drawing boards. Digital media is also being used extensively in the field of design teaching; beyond being just a tool for image manipulation and page layout. From online classes, to real time interactivity, web collaboration to virtual reality, digital media has revolutionized architectural education. An interesting development in design education is the use of virtual reality to review building

concepts using three dimensional visualization, interactive control and group discussion. Digital methods of teaching provide a vivid experience that could result in better understanding when compared to lectures or static images. This thesis is an attempt to create a digital model for basic design pedagogy. Students often have performance issues when they are introduced to alien concepts (design theory, concepts of design in buildings) and usually render assignments more as class exercises and fail to internalize important concepts. Especially reading intensive assignments based on theory of architecture fail to affect the later stages of design learning based on form making and form analysis. The proposal will attempt to tackle the problems of how to make text/reading based assignments more interesting to students and process of learning more interactive and fun in addition to establishing a connection between the theory and form making stages of design. In order to address at least some of the issues that the rudimentary methods of teaching cannot tackle, the thesis proposes to develop a digital learning tool where the learning would be more interactive and engaging.

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I would like to specially thank my parents Mr. Seshadri and Mrs. Vijaylakshmi for being my pillars of support throughout my academic endeavors. Finally I would like to thank all my friends and well wishers who have been the driving force behind my success.

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In architecture as in life itself, science and art occupy positions of equal importance. In addition to the creative and imaginative skills that are expected from a design student, knowledge of some basic design elements and principles are necessary. These principles and elements are a collection of observations and hypotheses on the most permanent components of architecture¹. A clear understanding of the basic elements of architectural form and space helps to develop design concepts and realize the visual implications on the design solution.

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In the recent past the face of the design studios has transformed dramatically with the advent of *Digital Media*. Digital software tools such as CAD, Photoshop, Form Z and 3d studio max are seamlessly integrated with studio assignments in most design schools. The tools are used to render design assignments which were traditionally done manually on drawing boards. Digital media is also being used extensively in the field of design teaching: and not just a tool for image manipulation and page layout. From online classes to real time interactivity and web collaboration to virtual reality, digital media has revolutionized architectural education. An interesting development in design education is the use of virtual reality to review building concepts using three dimensional visualization, interactive control and group discussion. Digital methods of teaching provide a vivid experience that could result in better understanding when compared to lectures or static images.

1. Though there are numerous definitions of elements and principles, this definition is taken from Elements of architecture, From form to place, Peirre Von Meiss, 2002, pg 11.



Students often have performance issues when they are introduced to alien concepts (design theory, concepts of design in buildings) and usually render assignments more as class exercises and fail to internalize important concepts². Especially reading intensive assignments based on theory of architecture fail to affect the later stages of design learning based on form making and form analysis. The proposed teaching tool will attempt to tackle the problems of how to make text/reading based assignments more interesting to students and process of learning more interactive and fun in addition to establishing a connection between the theory and form making stages of design. In order to address at least some of the issues that the rudimentary methods of teaching cannot tackle, the thesis proposes to develop a digital learning tool where the learning would be more interactive and engaging³. In order to create the learning tool, the thesis first overviews the different schools of thought in the areas of basic design elements and basic design teaching.

This chapter will examine the basic design teaching at the University of Missouri. Some of the innovative teaching tools such as games and interactive media used by the Ball State University, Adelaide University and the University of Oregon will also be discussed. The following discussion will overview basic architectural design concepts discussed in different books ranging from the simplistic *Elements of architecture, Pierre Von Meiss, 2002* to the analytical *Precedents in architecture, Robert H Clark, 1996*.

2. Woodbury. Robert F, Shannon. Susan J, Games in Early Design Education, CAAD Futures 2001, pg 202.

3. Cheng, Nancy Yen-Wen, Playing with Digital Media: Enlivening Computer Graphics Teaching, ACADIA' 99, pg. 102

1.1. Discussion on the elements of basic architectural design

Design cannot be taught, but design principles help in the process of learning design. "Architecture is normally conceived and realized in response to an existing set of conditions. The act of creating architecture is then a problem-solving, design process", that depends on the principles and elements of design. What are these principles and what is their significance? In the words of E L Boullée, That which constitutes perfectly the principles, upon which an art is founded, is when there is no means by which you can move away from these principles", *Elements of architecture, From Form to place, Pierre Von Meiss, 2002, pg 11-12.*

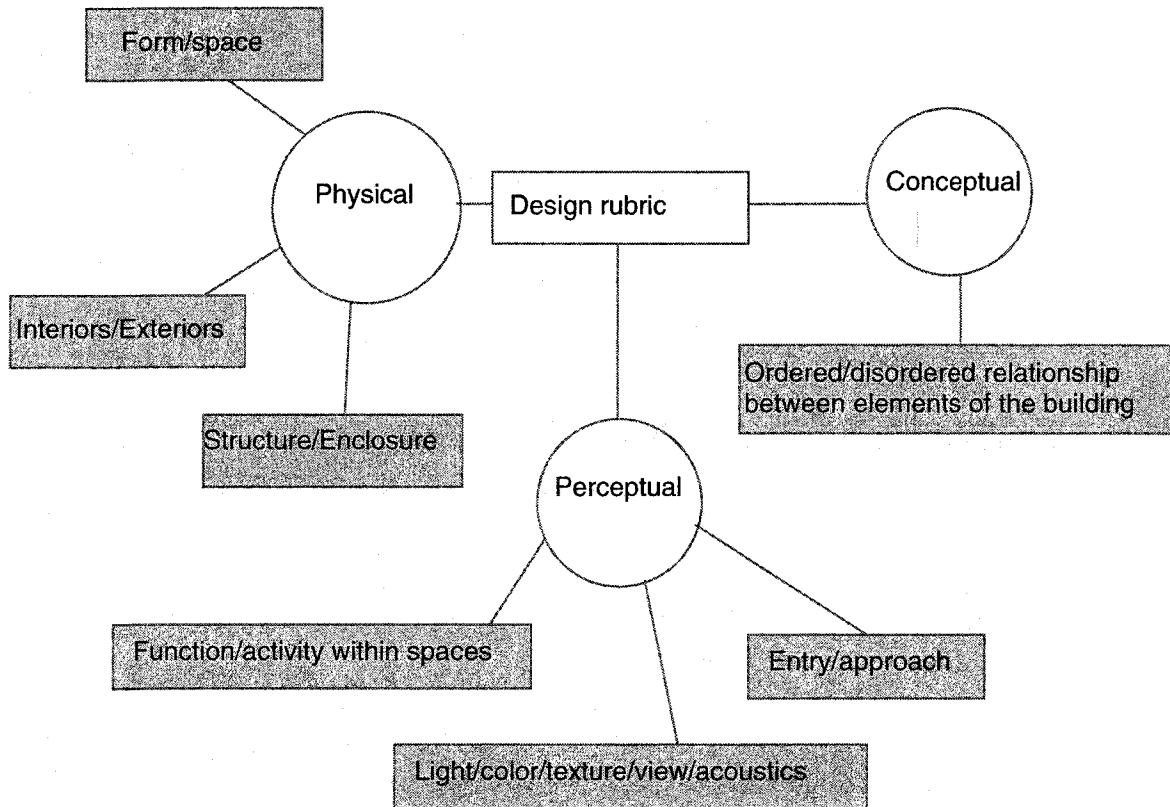


Fig.1 shows the classification of design elements into the three categories of physical conceptual and perceptual elements.

Fig.1 depicts classification of the elements into physical, conceptual and perceptual elements. Physical elements are most often visual in nature and can be perceived by observing and studying existing built forms. On the other hand perceptual and conceptual elements of design are experiential and can be perceived through analysis.

Architecture: Form, space and order, Francis D Ching, 1997, takes a theoretical and illustrative approach at defining design elements and principles. Following is a detailed analysis of how the book perceives design elements. Assuming that design is the process of form making the content of the book can be broadly categorized into two sections. While section one defines and categorizes form, section two deals with the elements of design that affect “form”. With the help of geometric drawings and simple illustrations of buildings, the book starts to define form from the basic point, line and plane leading to volumes as shown in fig.02.

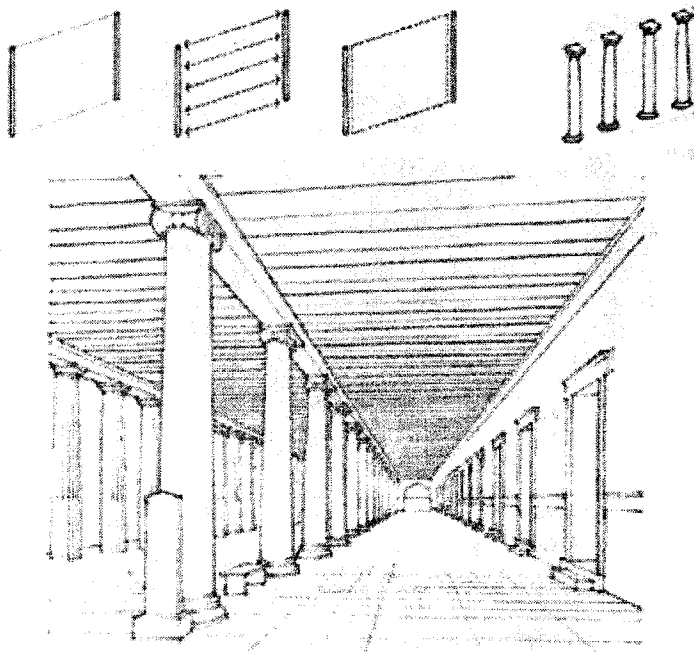


Fig.2 shows how planes are defined using simple geometric 3d drawings and are related to planes in buildings.




Fig.2 shows linear elements in buildings that are used to define a plane. Parallels are drawn between geometric elements and elements used in a building; points are shown as columns in the plan and these columns are seen as lines in elevation. The concept of forming a plane with lines is then depicted with the sketches of buildings. This kind of analysis is easy to comprehend because simple geometric drawings are used to explain concepts of design used in buildings.

The text also deals with different elements of design such as light, mass, volume, proportion and scale that affect the “form” making process. The aspects of light and mass which are very important to design are explained in a physical and simplistic manner. Mass is discussed in terms of regular or irregular and pure or transformed type of mass. The text also talks about different transformations and organizations of forms. Ordering principles or organization principles such as axis, symmetry, hierarchy, rhythm datum and transformation are elaborately discussed in the book. Illustrations with the design concepts in the text are simple and effective.

Precedents in architecture, Robert H Clark, 1996, takes a more analytical approach towards elements of design. The works of a wide range of architects such as Tadao Ando, Alvar Alto and Mario Botta are analyzed with the set of design parameters. The analysis of the buildings is then used to create a pattern in design consideration of various architects. These design considerations are then perceived as design elements or principles. Common ideas used in the design of all the structures are then compiled as formative ideas. Plan to section or elevation, unit to whole, additive and subtractive and geometry are some of the ideas of design discussed in detail in the text. This sort of analysis would help the learner identify the techniques of design problem description and solving. In order to understand the differences in how the two texts deal with the same concept, fig.3 compares the illustration of the elements of design in *Architecture: Form, space and order* and *Precedents in architecture*.

While Francis D Ching takes a simplistic and explanatory approach to mass, Robert H Clark deals with mass and form more as a tool to strengthen the ideas of unit to whole and the repetitive to unique relationships between different parts of the building, plan to section, geometry, additive and subtractive concepts of design and hierarchy. The text considers mass to be the three dimensional configuration of a building and not just the silhouette or the elevation of the building. Ching however deals with mass at a more basic level of relating to different types of massing and the various organization techniques that can create different kinds of mass.

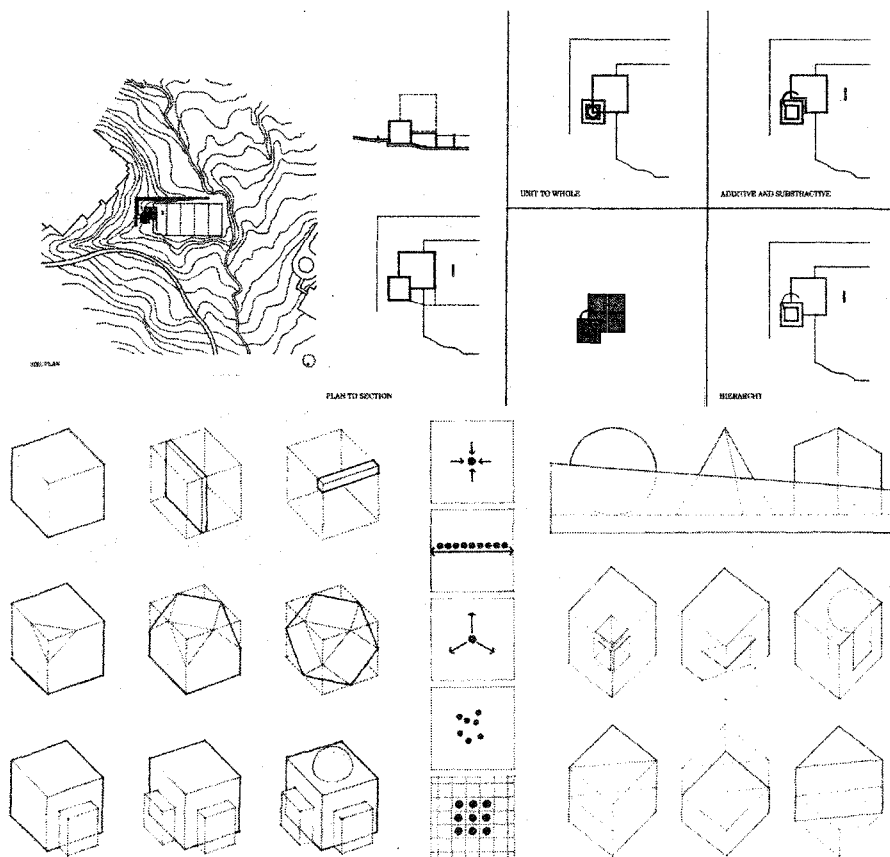



Fig.3 Shows a comparison between the analytical two dimensional approaches to illustrating design elements and the geometric/graphical three dimensional illustrations



As seen in the figure, *Precedents in architecture, 1996*, represents concepts with architectural drawings of a building to analyze the concept of mass. Concepts such as the unit to the whole – the relationship between the individual parts of the building, additive and subtractive – the dominant masses which are either added or subtracted and hierarchy of spaces is represented with the help of analytical sketches generated from the plan. On the other hand, *Form space and order, 1997*, provides a more graphical and geometric viewpoint of mass. Other texts on basic design such as *Elements of architecture, Pierre Von Meiss, 2002* and *Experiencing architecture, Steen Eiler Rasmussen, 2001*, take a more conceptual, broad and phenomenological view of design. While *Elements of architecture* takes a scientific approach to classifying and defining design elements, Rasmussen takes a visual and general view at the concepts that help in experiencing architecture. *Elements of architecture* is a collection of observations, research, experiences and ordered thoughts. Rasmussen classifies the design elements into elements that are common to architecture and other fields of design. More general and visual elements of design such as natural light, contrast and cavities are discussed in book by drawing parallels with other fields of design such as painting and photography. The illustration of the design elements is more text intensive in, *Experiencing architecture, 2002*.

When we analyze how the elements of design are presented by each of these texts, we can see that it is often more a difference of presentation than content. While some texts; “*Precedents in architecture*”, base the content on critical and in depth analysis of a few case studies, others think it preferable to tackle the subject by a comparative study of typical elements (the column, wall, door, square, street).

The figure below is a comparative analysis of how the four different texts discussed till now represent the elements of design. The bars are a representation of the percentage of the different types of representation ranging from geometric, theoretical, and analytical to conceptual.

Though there are wide ranges of design elements discussed till now, the thesis will specifically concentrate on the concepts of mass and light; since they are the most basic and important elements of design which can help students in their own process of form making.

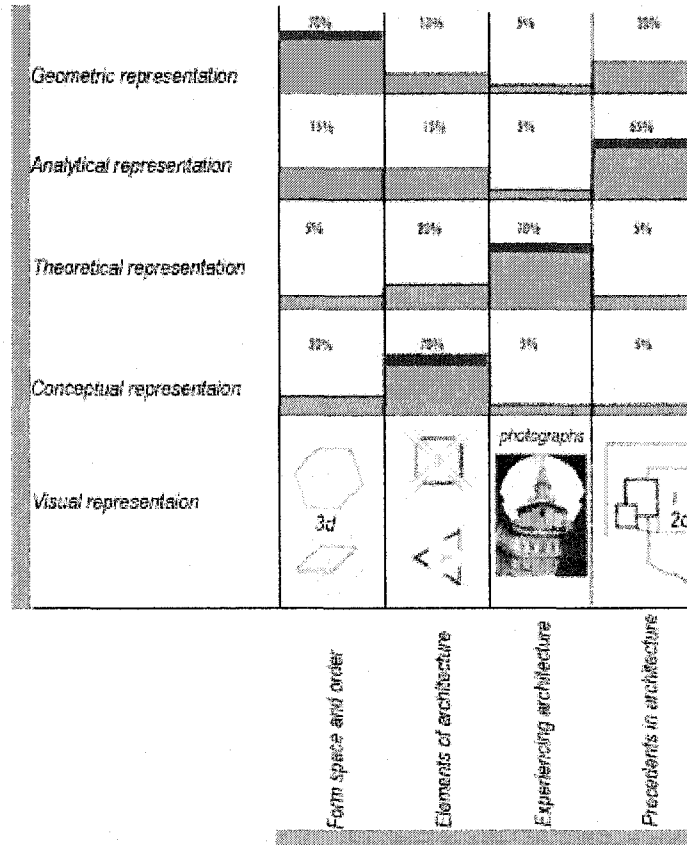


Fig.4 shows a comparative analysis of the typology used for illustrating the basic ideas and concepts of design in four different widely used texts on architectural design.

In conclusion, the techniques used maybe different but the elements discussed are the same. The thesis will compile a system of representation which integrates the methods used in the discussed texts. A teaching model which analyzes, and explains both theoretically and

conceptually the elements of design form the core of this thesis which will be discussed in detail in the third and final chapter of the thesis.

1.2. Overview of basic design teaching at the University of Missouri, Columbia

Basic design learning is usually associated with first understanding the concepts of design, analyzing case studies followed by exercises in 2d and 3d compositions using the concepts of design. As a part of the introductory class in the elements of architecture, students are given a series of writing assignments based on architectural theory and observation. Shown in fig.5, are some of the sample exercises that students worked on as part of a class in design communication, at the department of architectural studies with the University of Missouri. Clearly the attempt here is to help the student relate some of the organization concepts of design such as hierarchy, additive and subtractive or different types of organizations to the process of design. Students are also motivated to develop an eye to observe these elements of design by analyzing structures designed by known architects. Fig.6 shows a set of two dimensional compositions rendered by students examining different buildings. Such exercises are aimed at introducing students to the works of different architects and their varied approach to the use of design elements in their work.

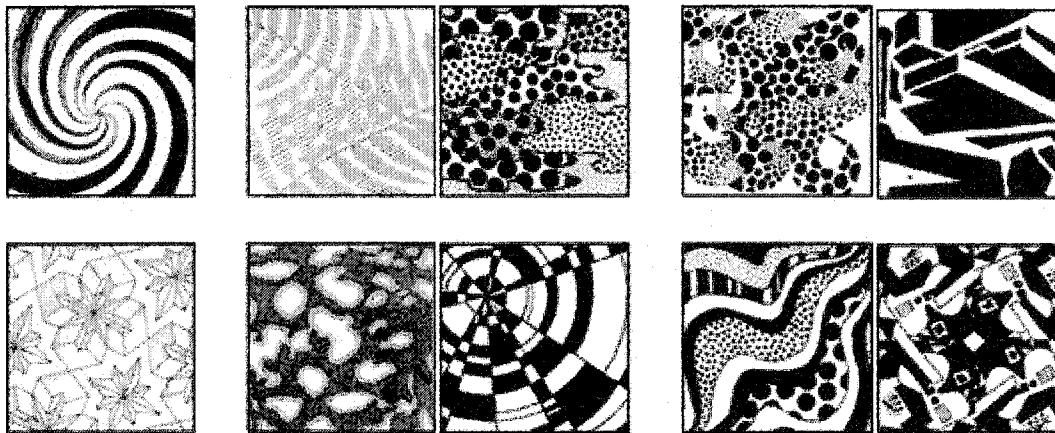


Fig.5 shows a collection of student works of 2d compositions highlighting the ideas of concentration and focus as part of the course in design communication.

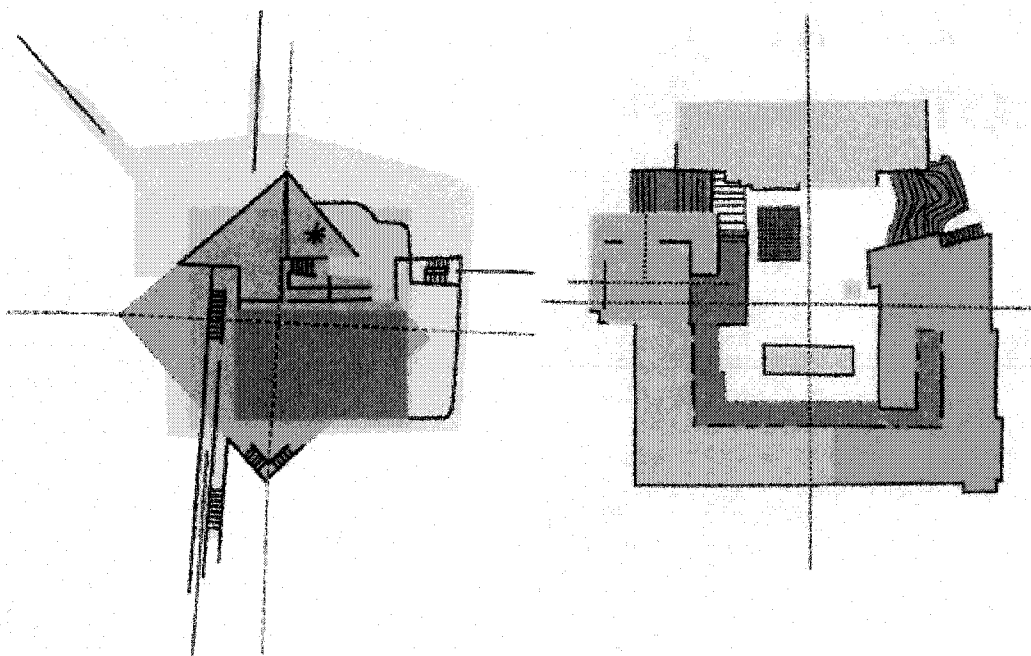


Fig.6 shows a set of analytical diagrams made by students of a course in architectural analysis, (University of Missouri) observing the concepts of hierarchy, scale, proportion,

1.3. Using digital media to transform architectural pedagogy.

Most of the design theory related to elements of design is usually represented in static media. By merely changing the media of representation from static to dynamic, the process of learning can be made more appealing. A chance to explore and interact can enhance learning in any field. Many schools of design are already working with creating interesting architectural games and innovative learning methods. Following is a brief overview of different models of integrating digital media in design studios⁴. The models are:

1. Computer augmented design studios aim to teach the principles of building design. Students use form making software in the production of their design representations, exclusively or in combination with traditional media. This includes image processing programs such as Photoshop, geometric (surface and solid) modeling and rendering programs such as Form Z and computer aided drafting program such as AutoCAD and an animation program such as 3d Studio to generate walk through movies.
2. Virtual and web design studio model explores the new ability of design partners who are geographically distributed to use internet and web technologies to exchange ideas, critiques and designs. Commercial tools for video conferencing, shared whiteboard drawing, and chat rooms as well as more experimented MUDs (multiple user domains) are being explored in virtual design studio projects.

At Ball state university, students were introduced to modeling software, Form-Z in their design communication course, which is run in conjunction with the design studio. The studio environment becomes the place of applying their new set of skills learned in the Form-Z introduction workshops.

4. Mark D Gross and Ellen Yi-Luen Do, Proc. ACSA National Conference '99 "Integrating Digital Media in Design Studios: Six Paradigms".

Therefore students are given an opportunity to use the computer as tool for inquiry. Schools are also experimenting with using “games” as student-centered teaching tools.

For example, the University of Oregon, worked with using games to teach design media projects.³ Students were given four different kinds of problems, increasing in difficulty discussed in the context of computer aided architectural design education: 1. Geometry play 2. Kit of parts 3. Dreams from childhood 4. Transformations. In the first section students were asked to create a few simple geometric two dimensional and three dimensional compositions using software tools. The section was aimed at combining design principles with software skills. The other sections involved a wide range of play modalities where students are motivated to learn the concepts of design. Fig.7 shows screenshots of the online library created as a part of the kit of parts exercise which was then used by students to create their own 3d compositions in space.

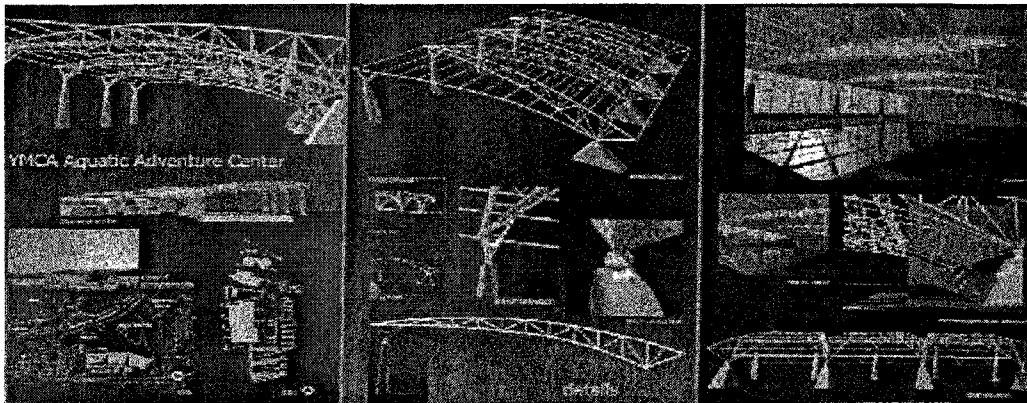


Fig.7 shows screenshots of the Kit of parts exercise used by students as part of studio at the University of Oregon.

Finally the exercise encouraged students to learn inter-actively by self-directed play in a low risk computer modeling environment.

Therefore the thesis will use a combination of games and interaction to teach the elements of design. Games that are generally used for educational purposes can be broadly classified into "skill and action games" and "strategy games". Skill and action games often involve the aspects of speed, motivation, anticipation and immediate validation. On the other hand strategy games demand more thinking and deeper participation from the player. This thesis will use a combination of both skill and action and strategy games to engage and entertain the learner. The thesis will aim to compile and integrate the interactive methods of learning and the most effective illustrations from the different texts discussed till now. The thesis proposes to build a model where students will be provided with 3d animations of case study buildings and games to learn some of the concepts of design such as mass and light.

This chapter will define in detail the two concepts of design that form the theoretical base for the thesis. We will start with the definition of mass/form and the different types of forms. Though there are different ways to define and classify form, the thesis will depend largely on *Francis D Ching, Architecture: Form space and order*. Form will be examined from the point of possible geometric shapes. Knowledge of geometry to discipline architecture is necessary to create compact, rational and structurally sound spaces. The following sections will first define mass and deal with the different transformations of mass from the subtractive to additive masses.

While mass is an element of design that is very visual and definitive in nature light is considered as a modifying element of design. Light is considered more perceptual. Architectural space evolves from a form or a mass when there is an illumination of the objects and the enclosing surfaces. Light is another important aspect of design which helps to define form. Light and its affect on mass will be studied with the help of the sun path diagram. The sun path diagram which studies the movement of the sun throughout the day can help in determining the light and shadow that the mass of a building creates both indoors and outdoors. The following pages will discuss in detail the sun path diagram and its significance.

2.1. Brief overview of the fundamentals of mass

Mass can be seen as a consequence of designing. When seen as a design idea massing may be considered relative to context, collection of units, single and multiple masses and primary and secondary elements. Massing has the potential to define and articulate exterior spaces, accommodate site, identify entrance and express circulation. The use of mass as the core design element can be seen in the works of the architects such as Mario Botta, Le Corbusier and Frank O Gehry. Mario Botta is known for his bold usage of pure geometric shapes in his buildings.

Botta's buildings exhibit a clear language of additive and subtractive masses. Corbusier on the other hand creates forms by combining amorphous forms defined by a regular Cartesian grid. Frank O Gehry however has a very dramatic approach to mass where he uses sculptural and highly intricate web of forms. Clearly all these architects consider mass to play an important role in their design process.

Mass in general helps in articulating the overall shape and volume of a structure. Mass that we see in buildings is mostly derived from three platonic shapes: the square, circle and the triangle. These forms appear either as regular or irregular. Most of the other forms are transformations of these basic platonic shapes.

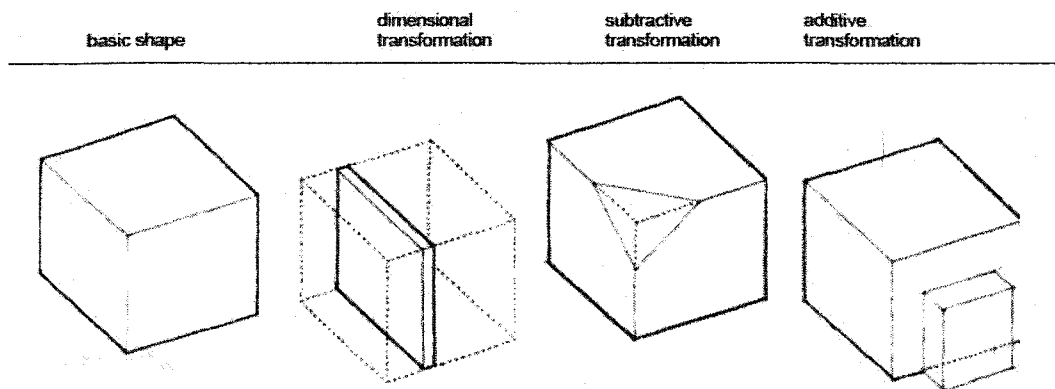


Fig.8 shows the different types of transformations that can be applied to a pure/platonic form such as a cube.

Dimensional, additive and subtractive transformations can be used to create new forms as shown in fig.8. Shown in the figure is a cube which is transformed first by changing the dimensions of the cube. Subtractive transformation is seen in the cube when one of its edges is deformed. Additive transformation can be achieved without changing the original cube and by adding new form to the original shape. How and where can the transformations be applied?

One can start with understanding the characteristics of basic geometric forms of a square, triangle and the circle. As seen in fig.9, each platonic form has a certain magnetic field around it. A clear understanding of the fields of radiance around a shape will help to better understand how to transform a shape to form an interesting mass. In the case of a triangle, the vertices hold the key to effective transformation; fields radiating from the vertices converge at the center and help in an effective subtractive transformation. Rectangular forms are more susceptible to any kind of transformation because they can be changed along the diagonals, edges or the vertices. Finally circular forms can be transformed along the perimeter or along the diameter.

Triangular forms have fields concentrated around the vertices

Rectangular forms have fields concentrated along the diagonals, edges and vertices.

Circular forms have fields at the center and around the perimeter

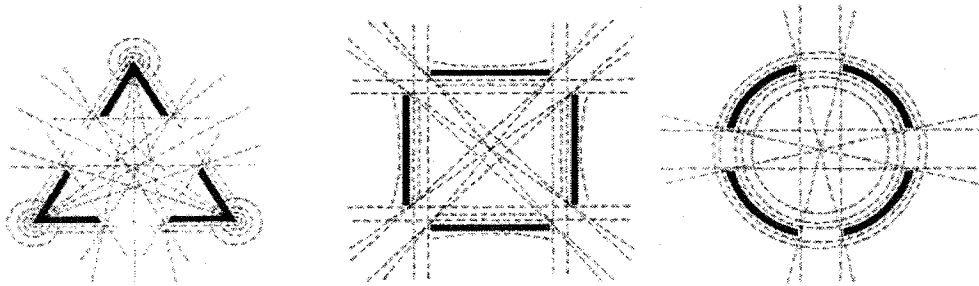


Fig.9 shows the different magnetic fields that support the basic shapes of a triangle, square and a circle.

2.1.1. Analysis and illustration of additive masses

The following section will discuss in detail the most commonly used types of masses; additive and subtractive masses. Additive forms of mass predominantly have perceptual dominant parts. An additive mass is produced by the addition of another form to its volume. This thesis uses the convention used in "Form space and order to classify the additive forms into 4 different categories. There are various possibilities of grouping additive forms together as shown in fig.10.

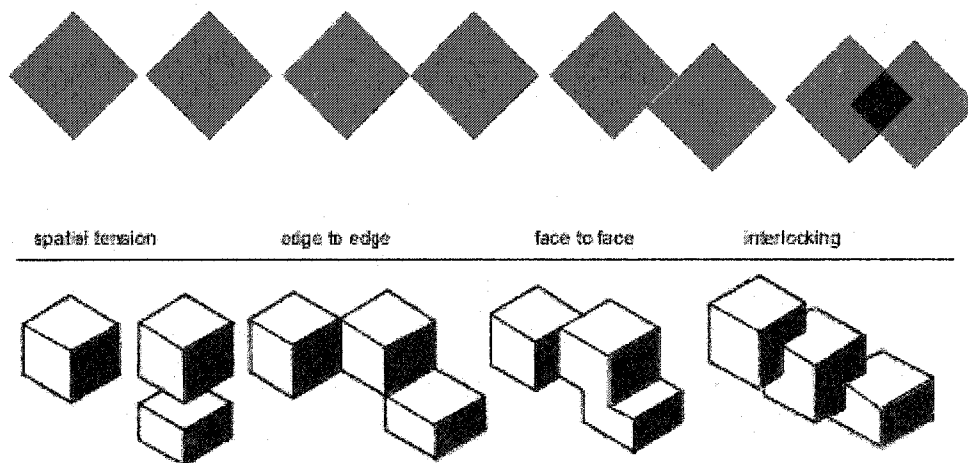


Fig. 10 shows the different types of additive transformations ranging from face to face to spatial tension

The figure shows a combination of cubes put together to form various additive transformations. In spatial tension, two forms of mass are placed relatively close to each other and share a common visual trait such as shape, material or color. In an edge to edge relationship, two forms of mass share a common edge and can pivot around this edge. Forms share a face to face relationship when they have flat, planar surfaces parallel to each other. Finally a mass is said to share an interlocking relationship with another mass when they penetrate into each other's space. The thesis will analyze Tadao Ando's Church on water, which exhibits all the different kinds of additive masses as a case study in the interactive section.

2.1.2. Analysis and illustration of subtractive masses.

The human always looks for regularity and continuity in a form. When a pure/platonic shape is partially hidden from the eye, one tends to complete the form. Similarly when parts of a regular form are removed from the whole, they still maintain their original identity. Such forms are known as subtractive forms. Subtractive forms have a predominant readable form from which different

parts can be removed. Hence they are forms which have perceptual wholes as seen in fig.11.

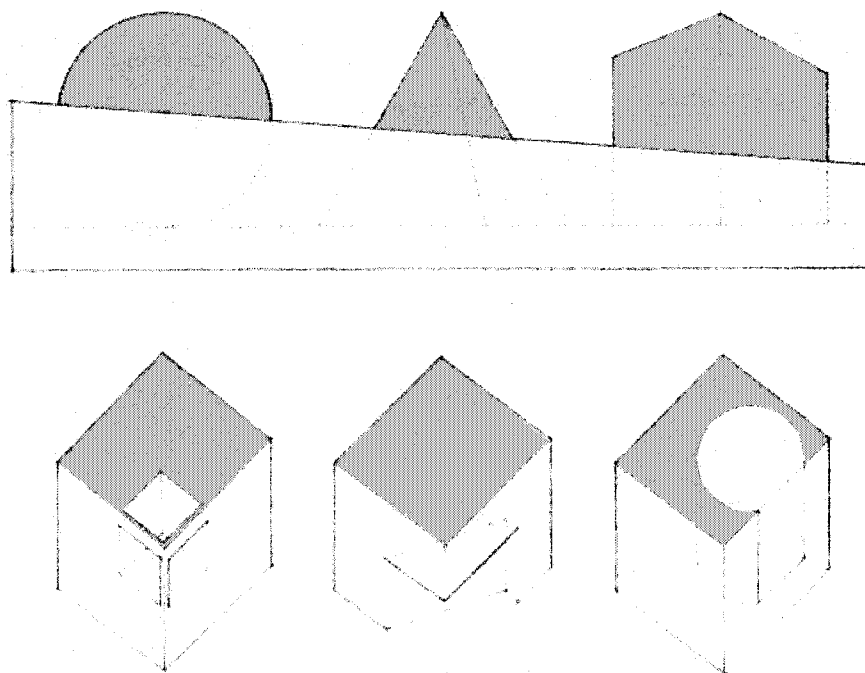


Fig.11 shows a set of subtractive transformations in the primary forms and particularly in cubes

Forms that are simple and geometrically regular such as the platonic forms adapt readily to subtractive treatment; these forms will retain their identity if portions of their volumes are removed without deteriorating their edges, corners and overall profile. Fig.11 shows a set of subtractive transformations on a cube. In each case the cube is deformed but the overall form remains recognizable.

2.2. Brief overview of the fundamentals of light

"Sunlight did not know what it was before it hit a wall", *Louis Kahn, Elements of architecture, 2002*. The effects of using daylight as a design element can be clearly seen in the works of well known architects such as Louis I Kahn, Le Corbusier and Tadao Ando.

Any discussion on light would refer to the quote *Silence and Light* a concept created and nurtured by Louis I Kahn. This concept dominates most of the architectural works of Kahn. Kahn uses the word *Silence* to define the immeasurable or that which has not yet come to be. According to him the immeasurable is the force that propels creative spirit towards the measurable, *Light*. One can often notice the subtleties of materiality coupled with an interesting play of light in buildings such as the Kimbell art Museum, the Exeter Library and other works of Kahn. Le Corbusier and Tadao Ando are also known for the usage of natural light as a major component of design in their works; such as the Ronchamp Chapel by Corbusier and Church of light by Ando.

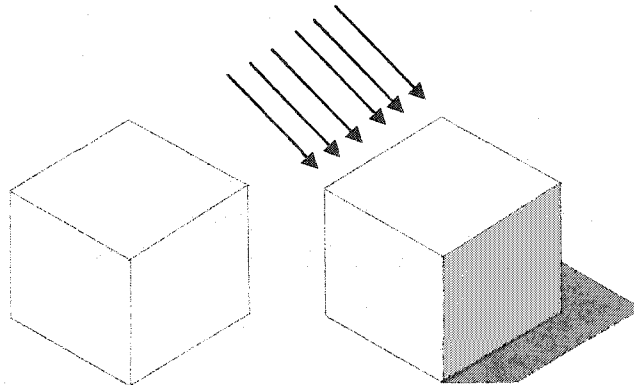



Fig.12 shows two cubes one without any light and the other defined by light and shadow

The thesis will discuss the aspect of light at a more basic and generic level. Also the thesis will specifically deal with natural light and does not include the study of artificial light. As seen in the figure above mass is better defined under the effect of light and shadow.



Therefore it is important to understand the quality and the quantity of light and analyze its effects on mass. Quantity and quality of light are discussed in detail in *Pierre Von Meiss, Elements of architecture*, where the emphasis is more on the aspect of the quality of light than the quantity as that aspect can be changed with artificial lighting.

A study of quantity and the quality of light will help in the better perception of mass and volume. Light also helps in reinforcing the structure, the texture and color of a mass. Shadow is light's counterpart and needs to be dealt with as equally as light. A study of parallel, directed lighting and uniform lighting helps to better understand the schematics of light. In order to understand the affect of light in the creation of an architectural space it is important to understand two basic factors. The first factor is the affect of the sun on a form in terms of surfaces which are lit and those which create a shadow. The second factor is the affect of openings in a mass which help study the patterns of light in the interiors.

The sun path diagram shown in fig.13 helps study the movement of the sun from east to the west. The figure also shows how the movement of the sun changes according to the month and the hemisphere. Knowledge of the longitude and the latitude of a place will further help calculate the precise position of the sun. With the clear understanding of the sun path diagram, it would be easy to determine the position of windows and also vegetation that would affect the effects of light and shadow indoors and outdoors.

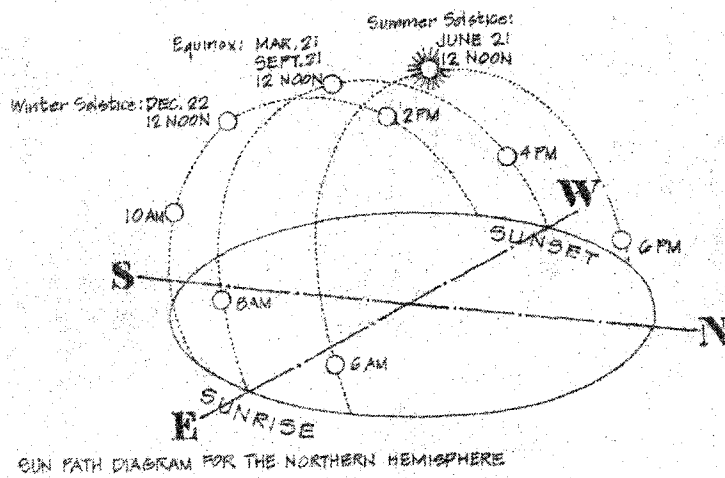


Fig.13 shows the sun path diagram for the northern hemisphere

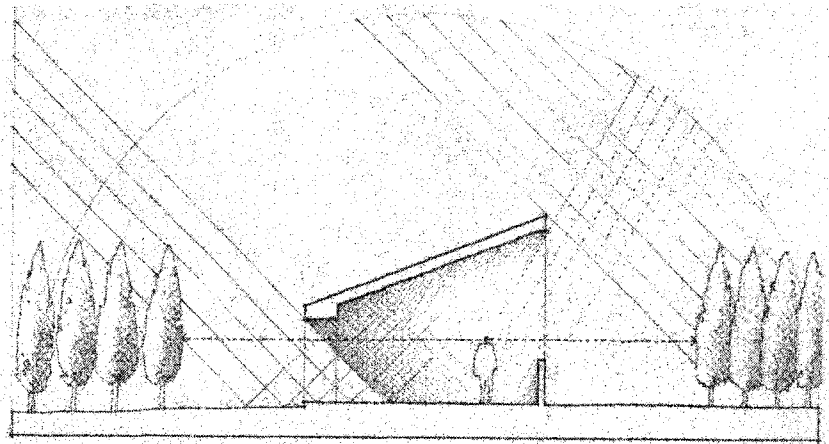



Fig.14 shows how the quality of light and shadow can be modified by the size and the position of the openings.



As seen in fig.14, the size and the position of a window or a skylight will affect the amount of daylight that a space receives. Therefore a study of the size, location and the orientation of a window can help determine the quality of day light. An opening can be oriented to receive direct sunlight during certain parts of the day. This sort of illumination creates sharp patterns of light and dark on the surfaces of the room. The openings can also be positioned in such a way that they allow diffused lighting in the room. Finally, having discussed the basic concepts of design, the next chapter will discuss the interactive teaching module which will basically present the material discussed on an interactive platform.

This chapter will discuss the proposed teaching model. It will also elaborate on how the aspects of mass and light, are presented on the interactive platform. Based on the patterns of learning followed by design schools, the model is structured to allow a process of studying, analyzing and implementing. The interface is divided into three sections: 1.Descriptive, 2.Analytical and 3.Geometrical/Graphical.

Descriptive animation:

The descriptive section consists of a three dimensional animation of a case study building. The building is selected such that it clearly shows the elements of design. This section aims to be an alternative to understanding the building with the traditional plan, section, elevation and view. However the animation of the building allows the viewer to see the building in a predetermined fashion.


Analytical animation:

The analytical section consists of an animation analyzing the case study building. The building is geometrically represented and animated to show the relationship between each part. The element of design is highlighted in the animation. Again the animation allows the student to view the analysis but does not allow him to interactively move the different parts of the building.

Geometric/Graphical game section:

The game section is designed such that it allows the student to review the case study. The game is used to test the student on making a connection between the design of the building and the elements of design used in the building.

Finally the three dimensional animations and the game are provided to the student on a platform built with the help of software called Macromedia Director.



This software was used to compile the entire presentation, because it can be made available to the student on a CD as a self running (Projector file) .exe file or on the web as part of an online learning process. Following is the description of the contents of the final director file.

3.1. Detailed description of interactive model for the element of mass

Section 1, Mass will begin with an animation introducing the student to basic concepts of mass. In this section, the student will be given a set of animations of the Villa Rotunda, Church on Water and Charles Gwathmey's house. The animations created in 3d Studio Max give a detailed description of the buildings. The description will basically inform the student about the site, basic layout and the overall design pattern of the structure. As opposed to using of architectural drawings, the animation will help the student visualize the building three dimensionally.

Section 2 will be another set of animations which will analyze the buildings, showing how the concepts of additive or subtractive masses are used in the buildings. The analysis is different in terms of being able to perceive the design elements three dimensionally. The different parts of the building will be represented geometrically and will show how they combine to give shape to the overall form of the building.

Finally Section 3 will review the concepts of design with the help of a game. The games are based on the buildings used as case studies and will help the student better relate the concepts to the design. In the following sections the thesis will discuss some of the examples

3.1.1. Description of the model for subtractive masses.

Mario Botta's Villa Rotunda is a very good example for a subtractive form. The building has a circular plan and is organized along the north-south axis. In correspondence to which a deep central cut descends from the skylight, to divide up the volume and give detail to the elevation. The stairway assumes the form of a circular column. The various residential functions are organized around the vertical space, which is developed over four floors. The mechanics and a recreation space are located in the basement. The second floor contains the living room with terrace to the south and the study and kitchen to the north. The bedrooms are on the third floor. Fig.15 shows a set of detailed views taken from the animation showing the building from various angles. The animation helps the student better understand the building.



Fig.15 shows a set screen shots taken from the descriptive animation of the structure of the Villa Rotunda.

The second part of the model is the animation analyzing the subtractive mass in Villa Rotunda. On analysis it can be seen that the whole structure is represented by a cylinder from which parts are subtracted still retaining the original form. The form of the cylinder is deformed by deemphasizing the center and the perimeter.

The subtractive form of the building is evident at all the levels of the building. On the ground floor the staircase and the entrance vestibule break the continuity of the cylindrical form along the axis connecting the front and the back of the building. Through analysis one can see the subtraction is more on the first floor to make way for the large window openings and the terrace. The effect of the incremental subtraction in the form of the cylinder can be seen at the rear of the structure. On the whole, the cylindrical form is established by reaffirming the shape on the top most level of the building. Fig.16 shows the screenshots taken from the animation analyzing the presence of subtractive mass in the structure of the Villa Rotunda.

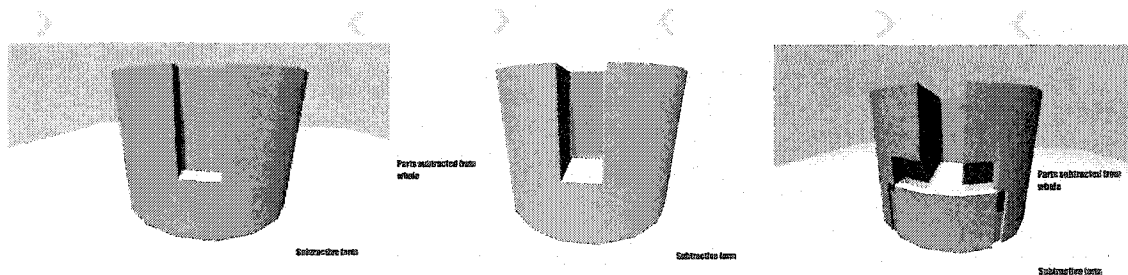


Fig.16 shows a set screen shots taken from the analytical animation of the structure of the Villa Rotunda.

Finally the student is introduced to the game based on the principles of design used in the design of the Villa Rotunda. The aim of the game is to not only to review the connection between the element of additive mass found in the building but to also to comprehend the design elements in plan, section/elevation and in a view. As seen in fig.17, the student is asked to assemble the different parts of the building (similar to assembling a jigsaw puzzle). One is asked to place the different components of the building such as the staircase, the openings, terraces, skylight and other elements which contribute to the overall massing of the building.

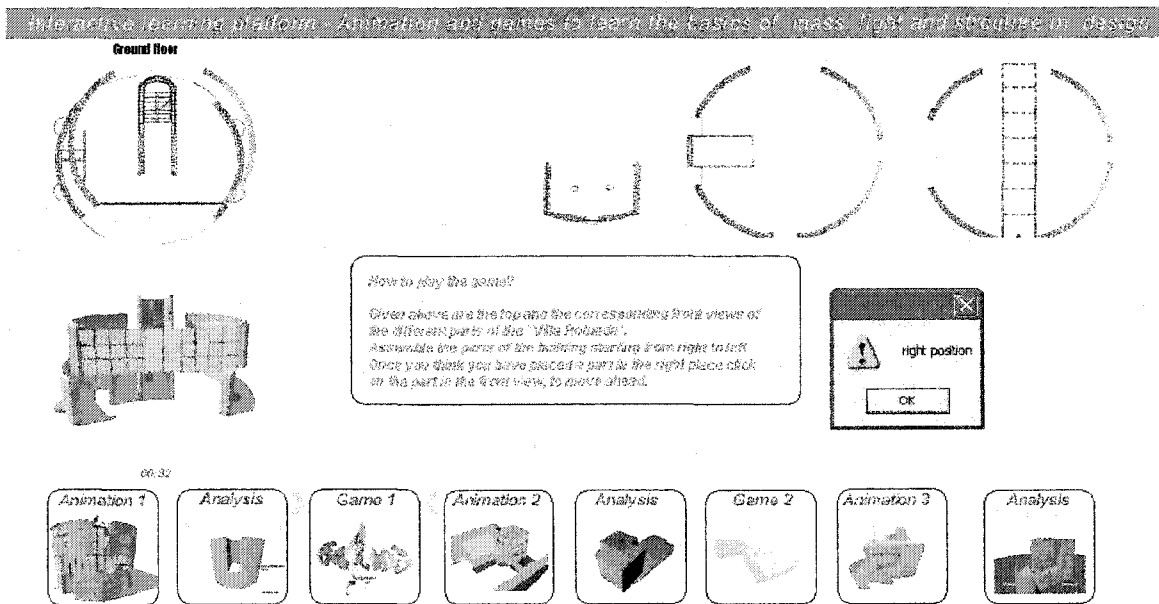


Fig.17 shows a screenshot of the game on Villa Rotunda

3.1.2. Description of the model for additive and subtractive masses.

Charles Gwathmey's house has an interesting form, which combines both additive and subtractive masses. It slowly builds from the base with a bedroom, bath, utility and study areas on the ground floor. The second level is interesting in terms of having a double height living room which overlooks a circular terrace. The bedroom on the third floor has an interesting sloping roof. A circular staircase at the rear connects the three levels of the house and also adds to the overall massing of the structure. As opposed to understanding these design elements with plans, sections and elevations, the design is presented with the help of an animation. Fig.18 shows the screen shots taken from the animation.

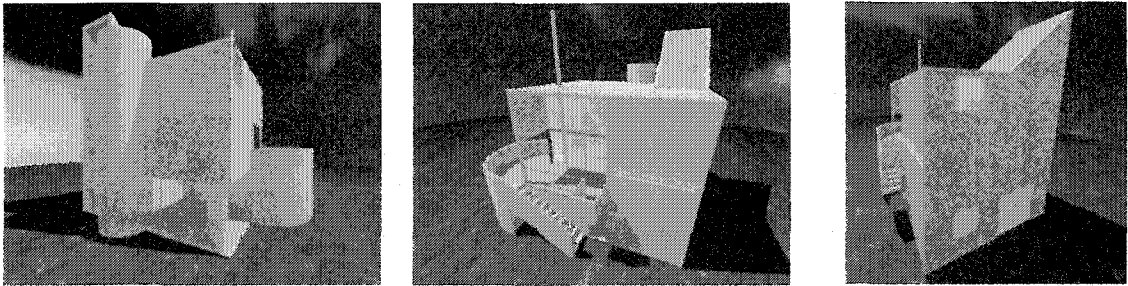


Fig.18 shows a set screen shots taken from the analytical animation of the structure of Gwathmey's house.

The house is a very good example of a mass which uses a combination of both subtractive and additive methods in conjunction. As seen in the analysis diagrams depicted in fig.18, at the core of the house is a cube that is transformed at various points still retaining the identity of the original form. The major subtractions that one can see in the mass are the recessed double height volume of the living room and the well defined rear entry into the house. The additive parts of the structure are the semi-circular terrace in the front which connects to the living room at the first floor and the circular staircase at the rear of the house connecting all the three levels. Fig.19 shows some of the screen shots taken from the animation analyzing the massing of the Gwathmey house.

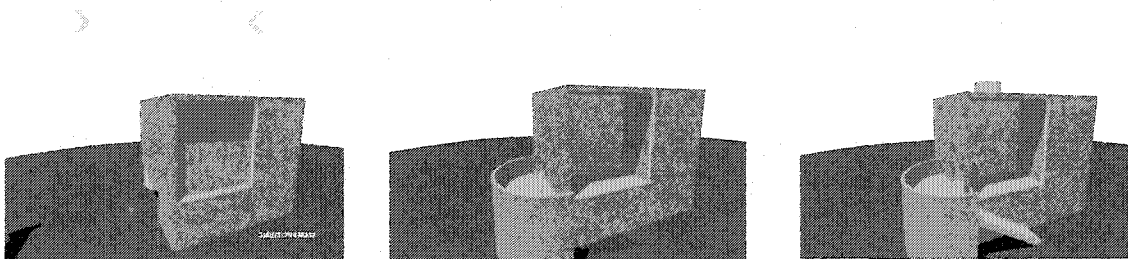


Fig.19 shows a set screen shots taken from the analytical animation of the structure of Charles Gwathmey's house.

3.1.3. Description of the model for additive masses.

In order to understand the concepts of additive forms we will look at Tadao Ando's Church on Water with the help of an animation as shown in fig.20. The form of the church is basically a combination of two squares, one serving as the entrance vestibule and the other serving as the chapel. The chapel is in the form of an elongated cube which faces the pool and is connected to the vertical cube by means of a semi-circular spiral stairway. Also the vertical cube has an elegant skylight framed in a glass cube. The church is fronted by a large reflection pool which steps down to the river below. Finally, a long, L-shaped wall runs alongside the south and east of the pond-building grouping.

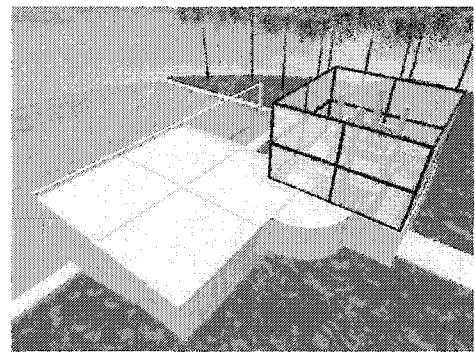
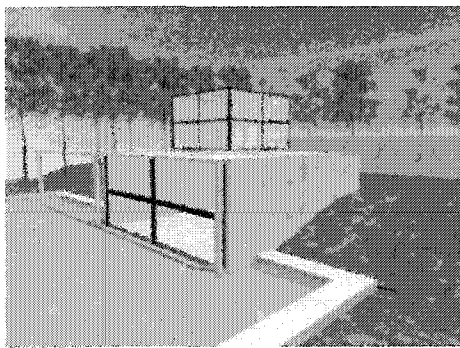


Fig.20 shows a set screen shots taken from the descriptive animation of Church on Water.

On analysis we see that the church exhibits different combinations of additive forms as shown in fig.21. The dominant parts that can be perceived are the two squares intersecting with each other. They share an interlocking relationship. The point of intersection of the two squares is well defined with a curvilinear form. Curvilinear form has a face to face contact with both the squares. A glass cube shares a spatial and face to face contact with one of the squares. Though simple, the effective use of materials and the right proportion of the form render a unique quality to the structure.

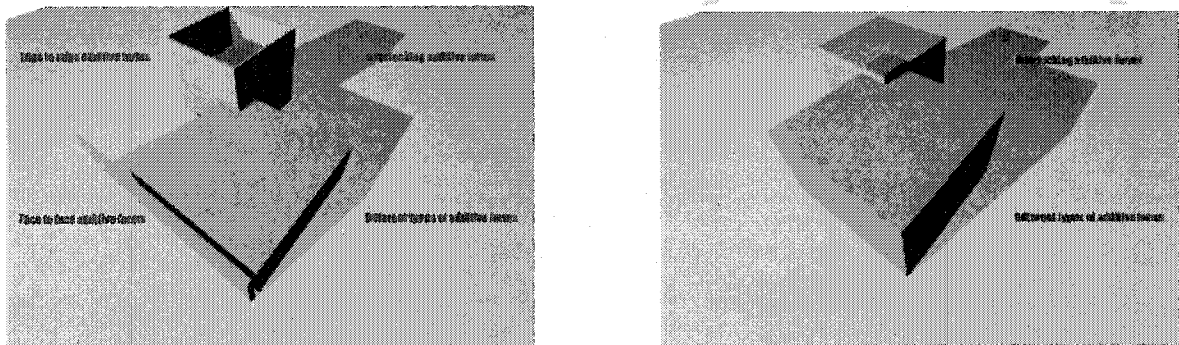


Fig.21 shows a set screen shots taken from the analytical animation of Church on Water

For the game section on additive forms, students are provided with the different parts of the building. They are then asked to identify the elements which share the different additive relationships such as face to face or intersected forms. The aim of this game is to motivate the students to understand the elements of additive masses and identify them in a structure. Fig.22 shows a screen shot of the game on additive masses, showing the message that would one would get on selecting the elements sharing a particular type of relationship with each other.

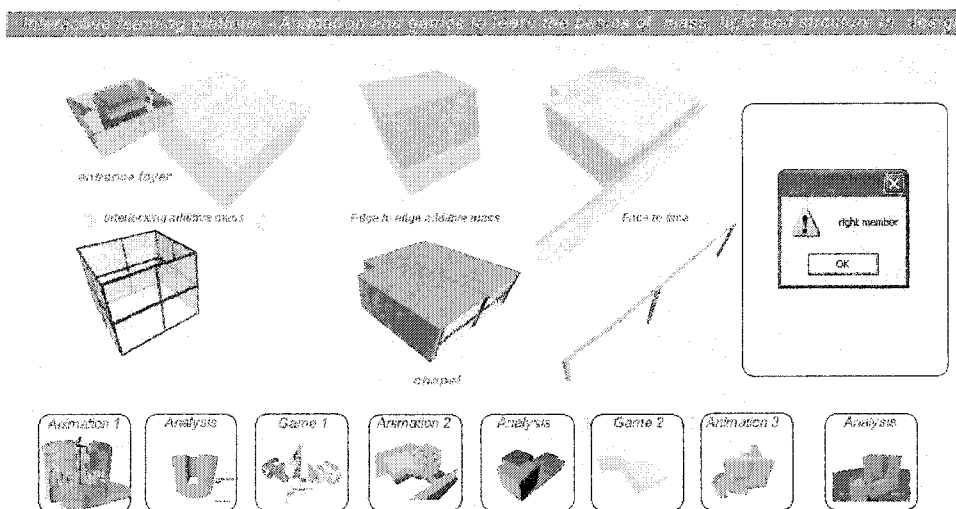


Fig.22 shows a screen shot of the game based on Church on Water

3.1.4. Description of the interactive model for the element of light

The model deals with the concept of light through a set of detailed animations studying the effect of the movement of the sun with respect to the form of the Villa rotunda. First one is provided with a set of exterior animations showing different viewpoints of the building and how the shadows change on the surface of the building as the sun progresses from the east to the west. Shown in fig.23 are some of the screen shots taken from the exterior animations. The viewer is also provided with a comparative movement of the shadows both internally and externally, as shown in the fig.24. This comparative depiction is aimed to help the learner observe how interior spaces are affected by the movement of the sun.

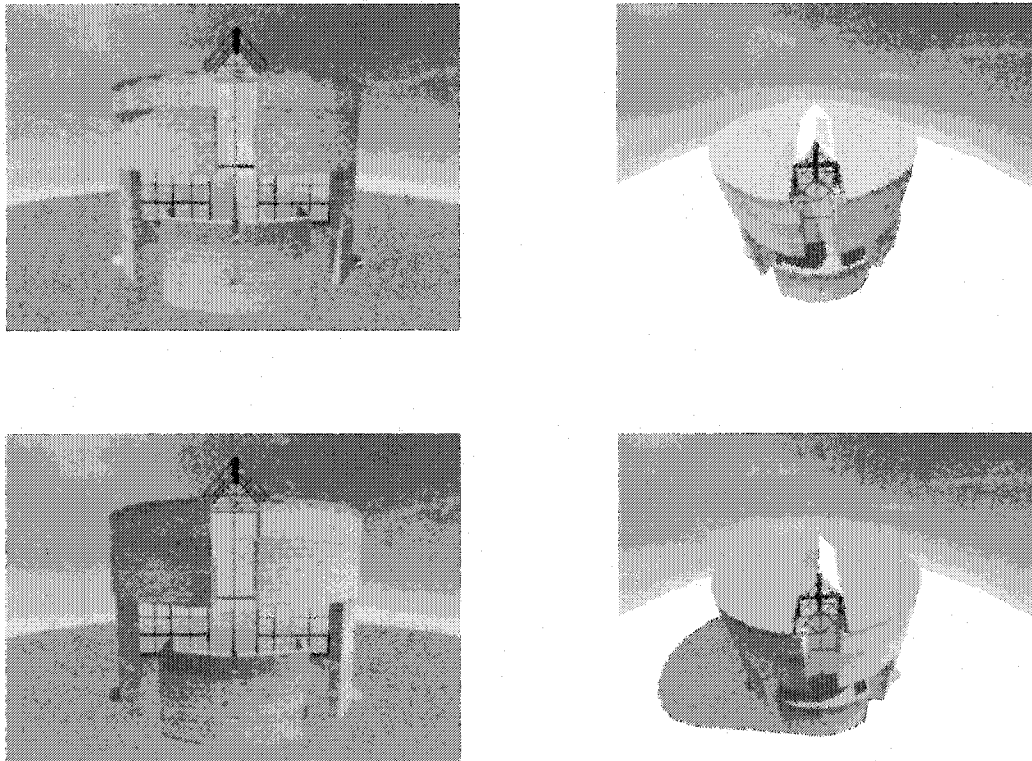


Fig. 23 showing screen shots of the two exterior animations showing the movement of the shadows with respect to the movement of the sun

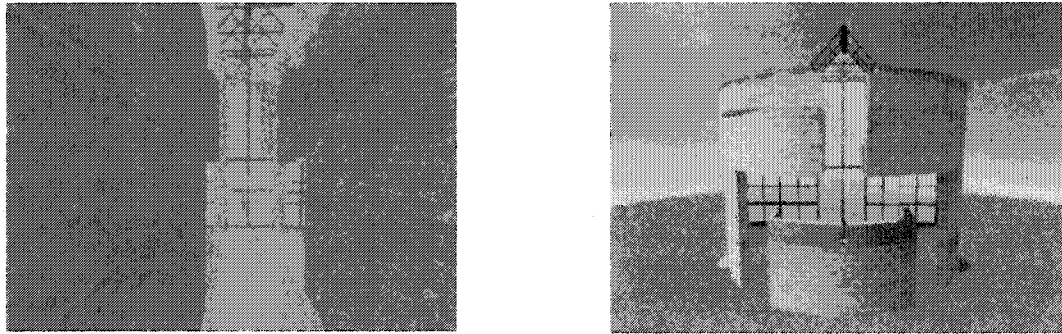



Fig.24 showing screen shots of the comparison between the interior and the exterior views depicting the movement of the shadows in Villa Rotunda

Interactive learning platform - Animation and games to learn the basics of space and light in design

How to play the game?
 Given below is the sun path diagram and the corresponding views of the shadows cast by the Villa Rotunda.
 Your task is to match the view with the position of the sun shown in the diagram below.

Fig.25 shows the screenshot taken from the model showing the game used to understand the sun path diagram and the relationship to the movement of shadows on the form.



Finally the student is provided with a game where one is asked to match the position of the sun with the position of the shadow cast by the form. Five different views each depicting the patterns of shadows at different times of the day are provided and the student is asked to match the views with the corresponding positions of the sun ranging from 8.00 am to 6.00 pm.

The concluding chapter will discuss some of the advantages, limitations and the learning benefits of this model.

This thesis created a model for an interactive learning platform which could be used to teach any element of design. Though the interactivity in the existing model is restricted to viewing animations of analysis and description of buildings, the aspect of allowing the viewer to walk through the building in real time can be experimented with, in the future. The animations of the buildings are aimed at providing a three dimensional option to understanding and analyzing a structure as opposed to plan, elevations and sections and two dimensional graphics as used in textual learning tools. In conclusion the learner would be able to learn some important elements of design and how they used in form making with the help of illustrations and games. Some of the advantages and the limitations of the proposed model of learning are:

Advantages:

The student is offered a more interesting platform to study and understand buildings.


The student has the freedom to set his pace of learning.

The concluding simplistic (no rules) game creates interest in the student and simultaneously tests him.

Limitations:

The model is only interactive in terms of allowing the student to select different animations and play a game. It could be made more interactive if the 3d models of the building were built in real time where the student could experience the building from different views and angles.

The model can be used for teaching only students who have a fair knowledge of design principles and are in the process of making the connection to the use of design elements in buildings.




Discussion:

This model can be used as a secondary or additional teaching tool in combination with lecture and assignment based design classes. Also if the model is found successful and if students seemed to have a better understanding of the elements discussed, the model can be used to experiment and represent other elements and principles of design. Also the basic designing of the model itself could be used as a design assignment for students in higher design classes. Students in higher classes could be asked to choose a building of their interest, and a design element that they want to represent and create a set of animations. They could also be asked to design a game which would help make a connection between the design and the design elements. In the process, the student will use his modeling, animation skills to generate interesting representations of built structures. Therefore towards the end of the project, the successful models could be compiled and provided to be used and played by students from lower design studios. Hence a link is created between the students from different levels of design studios.

Figure	Title	Source
01	Classification of design elements	Ching, Francis D., Architecture: Form space and order, Van Nostrand Reinhold, 1997.
02	Definition of planes	Ching, Francis D., Architecture: Form space and order, Van Nostrand Reinhold, 1997.
03	Comparative analysis of geometric and analytical illustrations	Clark, Robert H. and Pause, Michael. , Precedents in architecture, 1996
05	Student work from visual communication	http://missouri.edu/~yoons (accessed: July,2002)
06	Student works from Introduction to Architectural analysis	Student assignments from edn 361, Introduction to architectural analysis.
07	Screenshot of the student works from the University of Oregon	Cheng, Nancy Yen Wen. , "Playing with digital media: Enlivening computer graphics teaching", 1999, Proceedings of ACADIA '99
08	Different types of transformations on form	Ching, Francis D., Architecture: Form space and order, Van Nostrand Reinhold, 1997.
09	Magnetic fields around basic shapes	Meiss Pierre Von. , Elements of architecture, From form to place, Spon press, 2002.
10	Types of additive transformations	Ching, Francis D., Architecture: Form space and order, Van Nostrand Reinhold, 1997.

Figure	Title	Source
11	Subtractive transformation	Ching, Francis D., Architecture: Form space and order, Van Nostrand Reinhold, 1997.
13	Sun path Diagram	Ching, Francis D., Architecture: Form space and order, Van Nostrand Reinhold, 1997.
14	Effect of the position of openings on the quality of light	Ching, Francis D., Architecture: Form space and order, Van Nostrand Reinhold, 1997.
15	Screenshots from descriptive animation of Villa Rotunda	Director file (interactive teaching module)
16	Screenshots from analytical animation of Villa Rotunda	Director file (interactive teaching module)
17	Screenshots of the game on Villa Rotunda	Director file (interactive teaching module)
18	Screenshots from descriptive animation of Charles Gwathmeys' house	Director file (interactive teaching module)
19	Screenshots from analytical animation of Charles Gwathmeys' house	Director file (interactive teaching module)
20	Screenshots from descriptive animation of Church on water	Director file (interactive teaching module)

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13. Mark D Gross and Ellen Yi-Luen Do, Proc. ACSA National Conference '99 "Integrating Digital Media in Design Studios: Six Paradigms", University of Colorado, College of architecture and planning.