Vesna Dragojlov

Paper : **Application of the art and architecture principles in the design of spatial models**

Topic: Architecture

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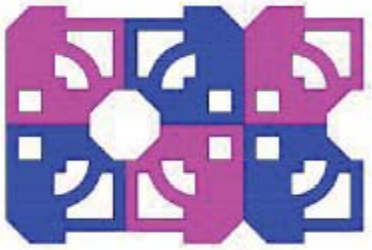
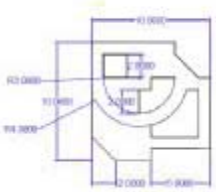
Abstract
In the field of architecture and art the design of any spatial models should adopt important principles in the creation of an integrated model: one or more principles can used to generate the same shape or an object , and many objects can be created employing architecture and arts principles. The color and texture give a model a sense of form and the possibility of recognizing it from the more scientific perspective: as an example, students from the first year of the College of Engineering have used several different models of art and architecture; these models have been analyzed using geometrical methods to find the strategies for creating those models. After geometrical analysis had been completed, the results showed that models used more than one principle to generate them. The principles have been used on two levels: at the first level the macro composition was created; the second level included a micro composition to create one unit. This unit has formal relationships that linked to the other unit. In addition to using a selection of color (homogeneity and contrast) , this paper provides an insight into the principles of installation form such as adjacency and proportionality at the first level, and at the second level, the principles of private relations as well as structural design have been used, such as the gradient balance. The focus has been on exploring shape and design alternatives, where producing many shapes from different colors and different relations depends on the principles of art and architecture, which, in turn, provide the basis for the formation of design models.





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Application of the art and architecture principles in the design of spatial models

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Abstract

In the field of architecture and art the design of any spatial models should adopt important principles in the creation of an integrated model: one or more principles can used to generate the same shape or an object, and many objects can be created employing architecture and arts principles. The color and texture give a model a sense of form and a possibility of studying it from a more scientific perspective: as an example, students from the first year of the College of Engineering have used several different models of art and architecture that they have analyzed using geometrical methods to explore the strategies for creating those models. After geometrical analysis had been completed, the results showed that models used more than one principle to generate them. The principles have been used on two levels: at the first level the macro composition was created; the second level included a micro composition to create one unit. This unit has formal relationships that linked it to the other unit. In addition to using a selection of color (homogeneity and contrast) , this paper provides an insight into the principles employed to create forms such as adjacency and proportionality at the first level, and at the second level, the principles of private relations, as well as structural design have been used, such as the gradient balance. The focus has been on exploring shape and design alternatives, where producing many shapes from different colors and different relations depends on the principles of art and architecture, which, in turn, provide the basis for the formation of design models.

1. Introduction

The principles of arts and architecture are considered to be of scientific basis, on which the students of arts, architecture and the artistic-architectural design rely at the first stages of learning design as well as the geometrical and spatial formations. Students focus on one or more than one principles related to color, shape and the

formal relations according to the instructions of their professors. A sample of students' designs was studied: they designed spatial shapes using the shape unit and finding the most frequently-used principle in designing them. The structure of the research was adopted to accomplish the objective of the research as in (fig. 1).

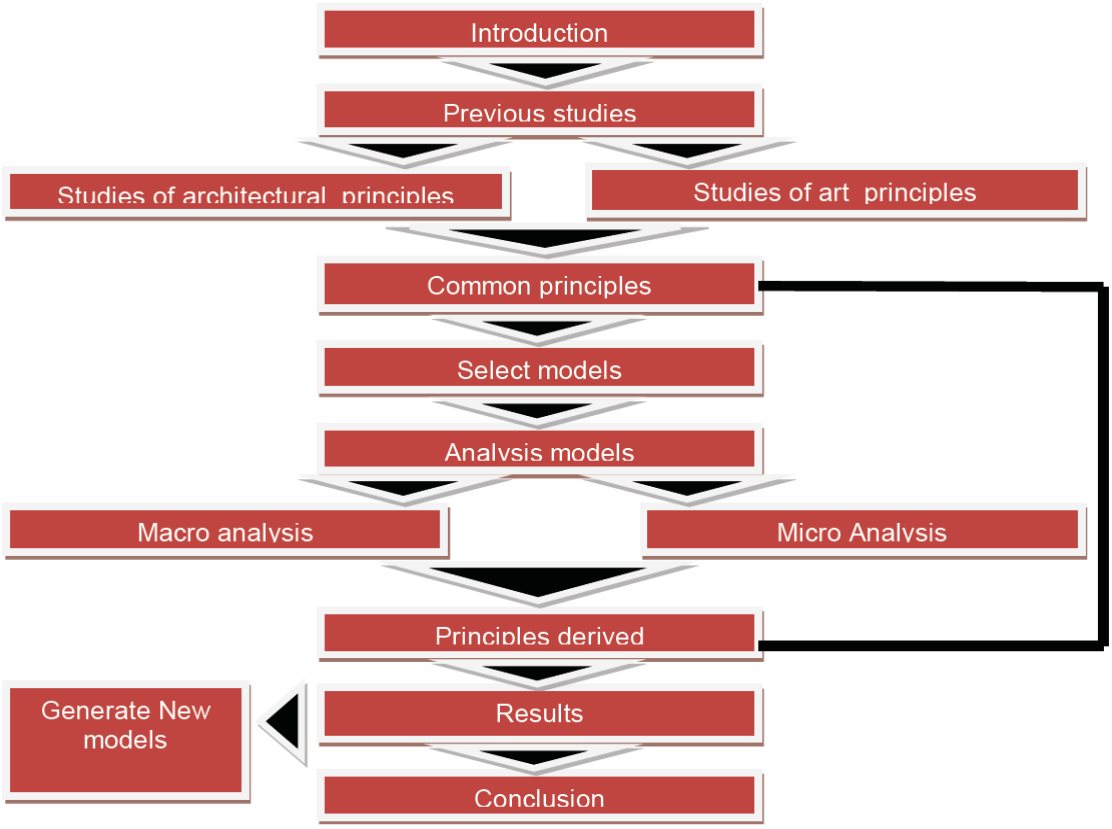


Figure (1) the structure study.

2. Previous Studies

There are many studies that deal with the principle of arts and architecture and their applications. Some of these studies separate the principles used in the architectural design and the principles used in the artistic design[6]. The following are the studies that analyze the principles of arts and architecture not based entirely on science, or on one of the disciplines, but rather as two integrated parts:

Study [1] focused on the principles which apply to a shape and its construction. The study indicates that three basic stages were used in this process. The first stage is an abstract proposed shape, i.e. any basic shape or basic unit. The second stage connects this basic unit with another unit to form the part which, in turn, forms the final design or the resulting shape. More than one basic unit or one basic shape can be used in order to construct the spatial models, [1] and the difference of the relations strategy in these three stages is what produces different and various alternatives for the same basic units. (fig. 2).

(figure -2) three stage to create the compact shapes.[1]

From this study, it can be concluded that there are three stages which determine the kind and the value of the product. In addition to the repetition, the principle of a copy of the unit or the basic shape was also noted. Furthermore, copy and repetition taking a certain direction is connected to the mirror principle to formulate the main parts of the whole shape.

Study [2] emphasized the part and the whole principle in arts and architecture. The part cannot represent the whole in most of the cases because a part or any artistic work can be formed from a part or an element, but the product is something else which diverged from the basic element [2]. An example for that is using a cube for a pyramid formation. And through this study we can conclude that there is one main element that is a part of the whole in the design process (fig. 3).

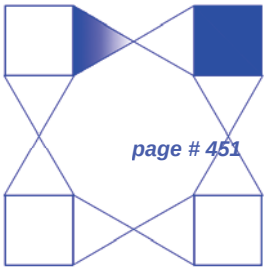
(figure-3) the partial object and the concept.[2]

Study [3] discusses the formation of a shape using multiple shapes or elements and these elements can be have different dimensions and colors in accordance with the designer view [3]. And from this study we can conclude that shape can be formed in two ways, as follows:

a. Single shapes.

(figure-4) Using single shape to design compact shape.[3]

b. Multiple shapes. (fig. 5).



(Figure-5) using many shapes to create multi-compact shape.[3]

Study [4] is part of the studies which investigate the main shape or the basic element. This study relies on the subtraction and addition principles to formulate the shape in arts and architecture and this process should be planned well, i. e. cannot be random. There are many kinds of subtraction and addition for the shape including the following:

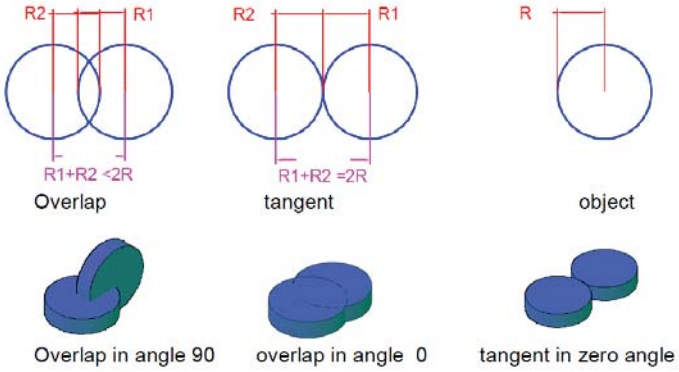
a- Subtraction or addition of a part with the same shape of the original part and with different proportion.

b- Subtraction or addition of a part which is different from the original shape part and with a scale that is connected to the original part.

c- Subtraction or addition of different parts; some of which are similar to the part and some are different and with a scale and a proportion that is connected with the original part [4].

d- Random addition and subtraction.

Study [5] focuses on the importance of the formal relations amongst the elements and parts. There are several relations that we can make use of in this study, and the focus is on the overlapping relations horizontally and vertically (angle = 0) for the horizontal and (angle > 0) for the vertical (fig. 6)



(Figure-6-) variable of overlapping [5].

3. Conclusion from the previous studies

The previous studies indicated the importance of the basic shape and the three stages of designing in addition to the formal relations and the mechanism of copy and repetition. Moreover, focus was on the part and the whole as well as on the principles of subtraction and addition. The studies have not shown the mechanism of using these principles in the formation of several models out of one or more than one basic element that a student can count on to form the spatial shapes or to accomplish any other design which involves an artistic aspect. Therefore, the problem of the research was identified based on the level of clarity of the adopted mechanism for designing the spatial or the imaginary models which are dependent of the principles of arts and architecture. To solve this problem the following hypothesis was adopted: there are design strategies for using the principles of arts and

architecture the students and the instructor can implement to complete the design of the product. Also, the objective of the study was established, which is to identify the strategies to use the principles of arts and architecture in the artistic and architectural design for the first year students. To accomplish the objective of the research certain spatial models will be selected and analyzed relying on the items that will be extracted from the previous studies.

4. The items of the theoretical framework

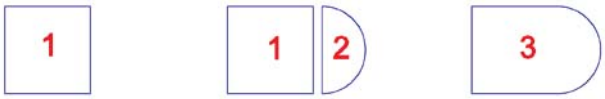
Through reviewing the previous studies, it became clear that there are two fundamental points in the process of forming the imaginary spatial shapes as follows:

4-1 The level of individual parts:

It stands for the principles used in forming the part (the basic units), and this variable involves secondary variables such as:

4-1-1 The shape of the part: The formation might involve one or more than one shape and as follows:

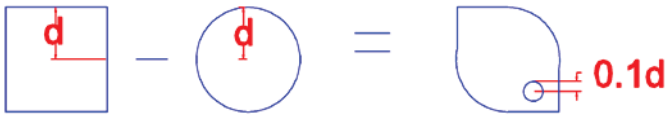
A- One shape . B- Several shapes (fig. 7).



(figure-7) one shape with another shape to create multi-shape .

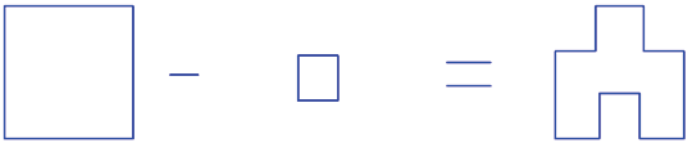
4-1-2 Subtraction: This includes three items, as illustrated below:

A- Subtraction of a new shape with proportions that are related to the proportions of the basic shape. (fig. 8)



(figure-8) using new shape to subtract from main shape

B- Subtraction of a shape with the same shape of the basic part with proportions that are related to the proportions of the basic shape (fig.9)



(Figure-9)using same shape in deferent scale in subtraction process

C- Subtraction of several shapes (includes the two above cases) (fig. 10)

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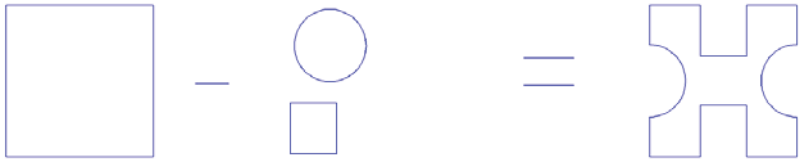


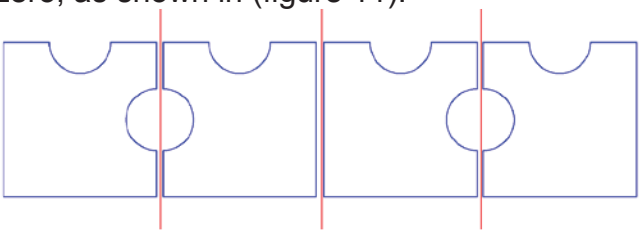
(figure-10) deferent shape are used subtraction process

4-2 The level of the whole:

The changes related to this level are centered around the relation between the parts and the whole, and this relation can be found through studying the following variables and measuring them in accordance with the models, as follows:

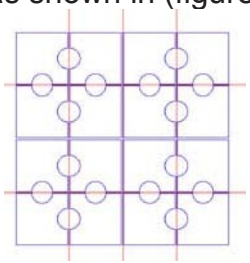
4-2-1 Mirror: It is the process of the repetition and copy in a certain way and in a certain direction:

A- One directional: The axis of the repeated shapes is in a parallel direction and the angle equals zero, as shown in (figure 11).



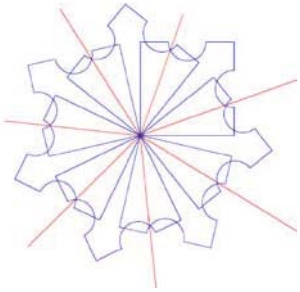
(figure-11) parallel Axis .

B- Vertical or in two directions and the angle between the axes of the repeated shapes is bigger than a zero, as shown in (figure 12).



(figure-12) the angle between the axes of the repeated shapes is bigger than a zero

C- Radial: When the axes of the repeated shapes meet in one point, as shown in (figure 13).



(figure-13) radian axes with overlapping objects.

4-2-2 Overlapping relations: These involve two axes which are:

A- Contact: It includes two variables:

- Horizontal, where the angle between the front faces of the two shapes equals zero, as shown in (fig. 6).
- Vertical: where the angle between the front faces of the two shapes is bigger than zero, as shown in (fig. 6).

B- Overlapping: in this variable, the shape should be restored to its original shape before addition or subtraction and then measuring it , (fig. 6).

- Horizontal, where the angle between the front faces of the two shapes equals zero, as shown in (fig. 6).
- Vertical: where the angle between the front faces of the two shapes is bigger than zero, as shown in (fig. 6).

4-2-3 Color relations: The colors are measured depending on the lever of colors and it involves three variables and as follows[6][7]: (fig. 14).

(Figure-14) color variables (harmony , tone ,contrast).

After identifying the main components of this study a measuring model was formulated to measure the study cases as shown in table (1).

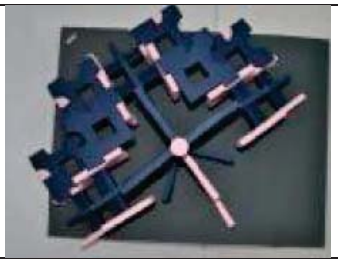
(Table -1) variables to measure the samples.

Sample No.1					
Micro level	Basic shape		clear		
			Not clear		
	Subtract		New shape in different proportion		
			Same shape in different proportion		
			New and same shape in different proportion		
Macro level	Mirror		one direction		
			Multi- direction		
			Radial		
	Overlapping relations	Face to face	vertically		
			Horizontally		
			both		
		Intersect	vertically		
			Horizontally		
			both		
	Colour relation		Contrast		
			Tone		
			Harmony		

5. The empirical study

In this part of the research models of the Department of Architecture first year students' works were selected; they were supervised by the subject matter experts, professors well-experienced in dealing with the students at this level. The focus was on developing the process of thinking in forming the shapes by adopting the determinants for the design process. The basic shape (the unit) for all students was selected, which serves the purpose of a unified shape. Then the subtraction, addition and shapes correlations were implemented to formulate spatial shapes that, at the same time, have the artistic and the geometrical characteristics. 20 models (with artistic and the geometrical aspects) were selected to be analyzed using the geometrical method and some geometrical programs available, to measure the items and the variables of the theoretical framework as shown in table (1).

(Note: the measure of one model was chosen due to the great number of the analysis results; for further information please contact the researchers for providing the rest of the models).

Sample No.1					
Micro level	Basic shape		clear	*	
			Not clear		
	Subtract		New shape in different proportion		
			Same shape in different proportion		
			New and same shape in different proportion	*	
Macro level	Mirror		one direction		
			Multi- direction	*	
			Radial		
	Overlapping relations	Face to face	vertically	*	
			Horizontally		
			both		
		Intersect	vertically	*	
			Horizontally		
			both		
	Color relation		Contrast	*	
			Tone		
			Harmony		

(figure-15) image for one real modes which is measured in table above.

6. Results of the practical study:

Through the application of the practical study to the models, it was shown that 100% of the results used the principle of subtraction from the basic shape. Furthermore, the principle of subtraction from the main element and with different shapes from the original shape represented 50%, 40% for the subtraction as original same shape and 10% for the subtraction of a new shape. Therefore, the ratio on a clarity scale for the main shape was 65% not clear and 35% clear. For the principle of mirror repetition and the directional copy, the greater percentage was in the variable with multiple directions (horizontal and vertical) and that percentage was 70%. The percentage of the radial repetition was 25%, while for a single direction was 5%. For the variable of overlapping, the results were close to each other somehow because most of the models have correlation and contact face to face. The difference was in the secondary variables; the variable of the face-to-face horizontal direction and with zero angle was 50% and for the vertical (angle bigger than zero) 10% and 40% for both variables.
For the principle of overlapping, the ratios were close to each other between the horizontal and vertical overlapping. Results concerning the colors relations showed that 60% represented the contrast in colors, 15% the tone and 20% the harmony. Moreover, the results showed that the models with high percentage were with normal shapes which lacked the artistic and geometrical innovation when evaluated against the models that used the principles with less percentage.

7. Conclusion:

The design process depends greatly on several geometrical, artistic and aesthetical principles and norms, but in this research, principles were relied upon as they are the basis of the design success. The results of the practical study indicate that changing the original shape by means of subtraction or addition is an important principle that is more frequently used in the first phase of the design process. The clarity of the original shape is vital therefore, the designs in which the original shape is changed lose the original form and this will make the design less valuable artistically and architecturally. The comparison between the designs showed that implementing the most commonly used principles to show the design creates a good configuration, however, it may be better to use the less common principles. For instance, the employment of subtraction principle, adjacency relations, color relations and the way in which we repeat and copy is a simple fraction of architecture principles. If these principles were employed with a planned mechanism, then the

design will have more value and will be more efficient. Three methods were established for the use of these principles that the professor and the students of art and architecture can rely on with the potentiality of selecting other principles such as balance, hierarchy among many others. These methods are illustrated in the following table:

Line one

Contrast	Horizontal correlation	Horizontal face-to-face overlapping.	Two-directional repetition	Different kinds of subtraction	Clear

Line two

Harmony	Horizontal and vertical correlation	Horizontal face-to-face overlapping.	Radial repetition	Subtraction in the same shape	Clear

Line two

Tone	Horizontal and vertical correlation	vertical face-to-face overlapping.	Radial repetition	Subtraction in the same shape	Clear

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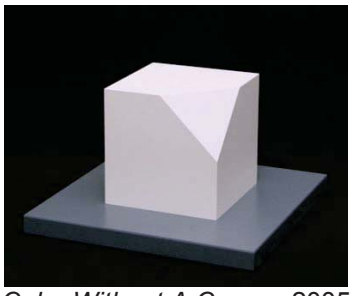
ART PERSPECTIVE:

Following the adopted structure of the research which analyzes architecture principles of color, repetition, and different transformations of a single shape (on a micro level) to create a complex shape or spatial forms (on a macro level), it is instructive to note that the architecture principles applied in this study are equally relevant for the design of art, process-based art that relies on sets of precise instructions explaining how to do something. They can generate infinitely original outcomes. A good example of this is the work by the artist, Sol LeWitt, who has worked both with 2D shapes and spatial forms, writing instructions for his artwork, sets of rules, which, when applied, can generate many results, and thus open up the doors to interpretation, ambiguity and contradictions. The following illustrations do not necessarily follow the same rules, however, they provide good examples of what can

be done with the introductions of the variables: here he explores geometry and repetition:

Sol LeWitt:


Cube Without A Corner, 2005


Octagon on a Cube, 2005

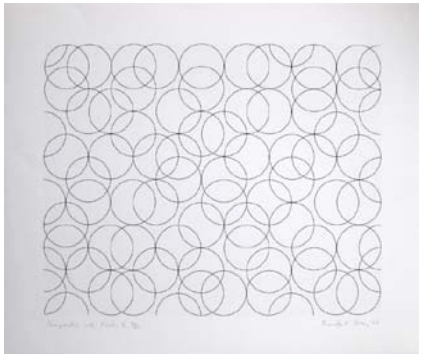

Progression #2, 2005

Similarly, Manfred Mohr, an algorithmic artist, creates simple shapes based on his sets of rules to create interesting variations which, when compared, have relationships to other versions, but they are also different, depending on the number of parameters used and the range of values; in this case, the work is based on the 11-d hyper-cube; the algorithm the artist wrote selects a subset of cubes from 42240 cubes inherent to the 11-d hyper-cube and decides which sides shall be black or white; the whole structure rotates in front of the green background:


Manfred Mohr: Subset Series

Common Principles in details:

Repetition:
In previous studies in architecture principles, the principle of repetition proved to be a simple, yet powerful principle to create a variety of complex shapes using simple shapes, as illustrated in Figure 2. It is simple and at the same time complex as it opens up an incredibly rich space for experimentation in both architecture and art. With the power of computers it continues to be a field of limitless variations. From weaving patterns that offer orderly outcomes, carefully planned and executed, to generative art forms employing variables with infinitely varied results, repetition has a powerful effect on human psyche. Dynamic visual patterns (such as in the work of op art movement artists from the 1960s– Bridget Riley) can appear to “vibrate physically” (1); they can ‘encourage our eyes to dance’ (2) as they have a very strong sense of depth and motion, as illustrated below:



Bridget Riley: Composition with Circles

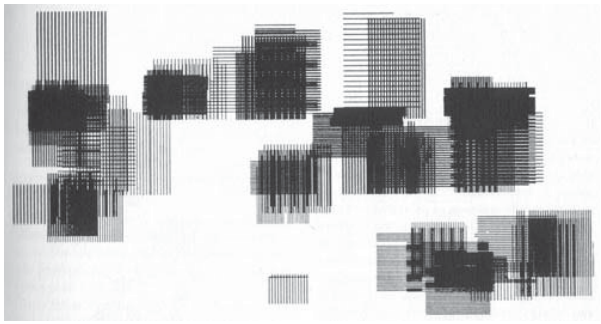
Similarly, the work of Elena Manferdini and her “Ricami Stool” , 2008, with its intricate pattern cut in metal plays with our perception as it appears to be very delicate compared to its actual strength as a piece of furniture.
By using the process of recursion as part of the orderly and planned repetition principles, similar to repetitive patterns described above, shapes become repeated in a self-similar way. A good example of that would be a fern leaf that contains a series of smaller and smaller leaves. The patterns found in nature provide a rich field of study as in exploring fractals by Mandelbrot, which is a good example of recursive patterns; the following is an example from the work of University of Advancing Technology student, Garrett Savo, where he uses a simple fractals program to generate his fractal artwork.

Garrett Savo: Arts and Technology class; University of Advancing Technology, 2011

In the world of architectural design, the Japanese architect, Toyo Ito, has designed a pavilion in Serpentine Gallery. London, where he uses a recursive repetition principle of rotated concentric squares to create a complex structure that is simple in its implementation of a simple process of repetition using simple elemental shapes to create a building that occupies the space of controlled chaos, architecturally innovative and sound:

Toyo Ito, Serpentine Gallery, London

Implementing repetition principle by varying values creates limitless possibilities: Frieder Nake modulates random values by applying space-division algorithms, as in his work, Rectangular Hatchings (1965):



Frieder Nake: Rectangular Hatchings (1965):

The random elements employed here are total number of rectangles, position of rectangles, size of rectangles, direction of lines and selection of drawing pen.

Modularity, as part of the repetition principle, uses one or more shapes to produce a complex form. However, here the elements of the shape are not transformed, they are only repositioned.
The product, Coat Hook, by MOS Architects that is created using the modularity principle explores a design space to place simple shapes as being repositioned to create a new product:

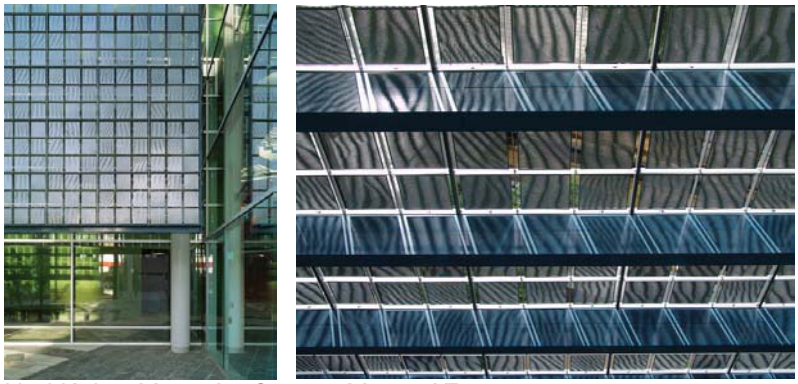
MOS Architects: Coat Hook

In this research I am particularly interested, as an artist, in the process of **parameterization,** which indentifies and describes the variable elements, and discussed in the book, Form+Code by Casey Reas. Parameters in this context are defined as values (for instance, color and size, and proportions, which have been heavily explored in the architecture part of this paper) which have an effect on the output of a process. This process opens up a space for further research in the field of both art and its implications on the architectural forms.
It also ties in the two principles that provide the foundation of this study, that of repetition and transformation (in this case here, subtraction, addition and overlapping). Repetition, as already explained, provides outcomes of some possible

designs which are also valuable with good configuration. The transformation principles explore the effect of the parameters on the whole, on the outcome of the complex shape. “Fractal Dice” by the artist, Keith Tyson, uses a very simple set of rules, “a dice-based system, to achieve complex results. The initial state of each piece originates from a cube, and the method by which the piece evolves to its final state is by a cube, or more specifically, the roll of a die. Fourteen aluminum and plastic works will be on view in Fractal Dice. “(3):

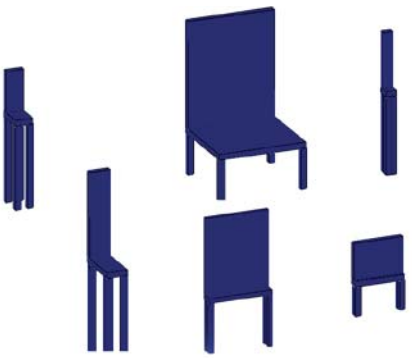
Keith Tyson: Fractal Dice

In a parameterized system, where there are constants and variables, random values are used to evoke unpredictable results of the physical qualities.
In the public art work by the artist, Ned Kahn, in any set of rules there is always room for variations. For Mesa Arts Center in Mesa, AZ, he created a wall of simple, identical moving squares which are repeated in a patterned way. However, with the introduction of unpredictable interaction from nature, such as wind, in this case, the outcome of this complex spatial shape becomes randomized and always original, based on the forces of the wind:



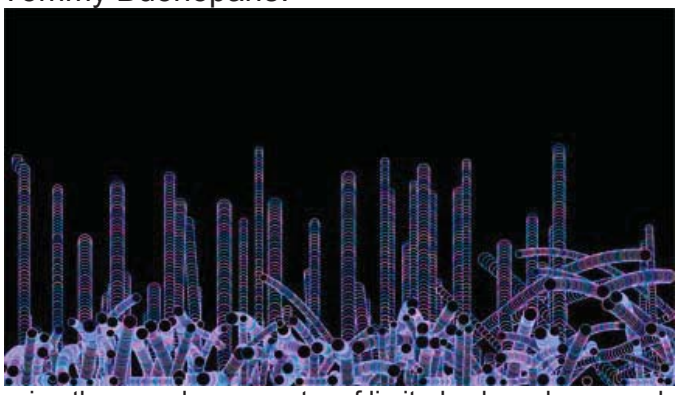
Ned Kahn: Mesa Art Center, Mesa, AZ

Using simple geometric programs, such as open source Processing, parameterized design becomes an open-ended, exploratory field.
A good example is the code that Casey Reas wrote for the parameterizing the chair, where he decomposes the object into its simple parts: seat, back, legs and applies variables to each simple component, choosing values at random, to generate always unique designs of the chair when the code runs:



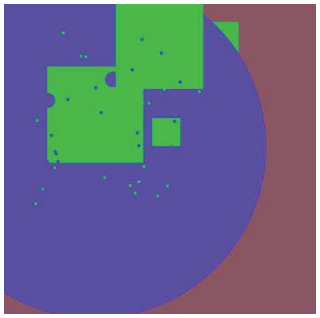
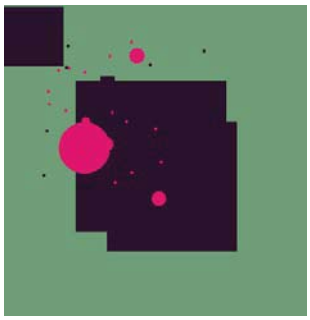
The following are some examples of the work of University of Advancing Technology students that employ simple set of rules with constants and parameters, using Processing, to create original, chance based outcomes:

Tommy Buonopane:



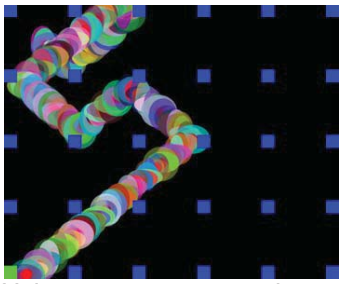
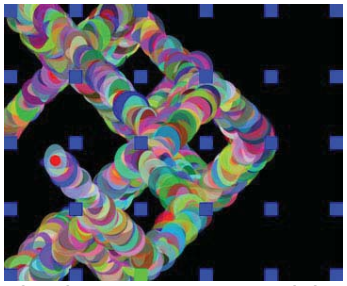
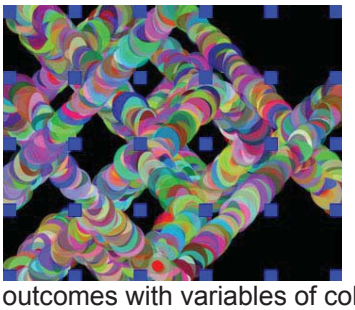
using the sample parameter of limited color scheme and one simple shape (circle);

Dan Parish:

Using only two shapes: circle and square as constants to create original art implementing variables for color and the scale of the shapes

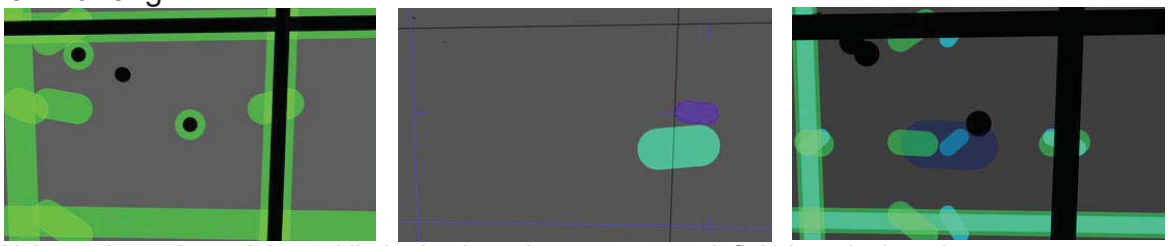
Dennis Pishik:

Using one constant and constrained space to create original outcomes with variables of color and

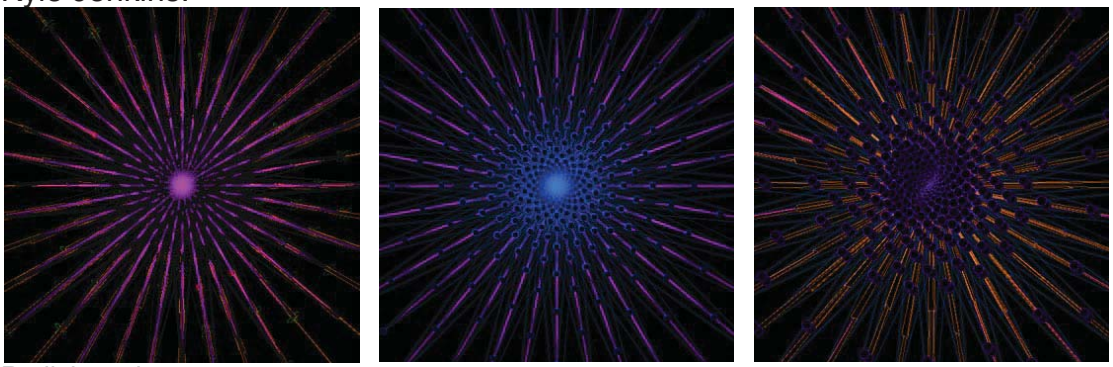
velocity.

Ian Furlong:



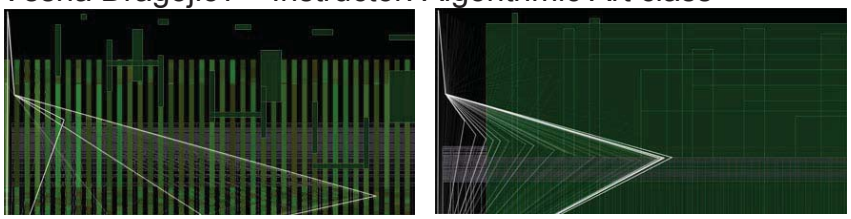
Using only stroke weight and limited color scheme to create infinitely redesigned space.

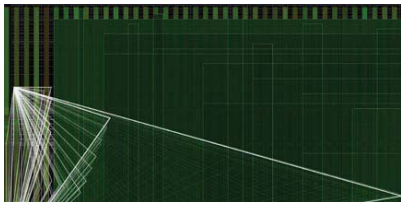
Kyle Jenkins:



Radial overlaps

Vesna Dragojlov – Instructor: Algorithmic Art class





Using simple shapes, line and squares, with limited color scheme.

CONCLUSION:

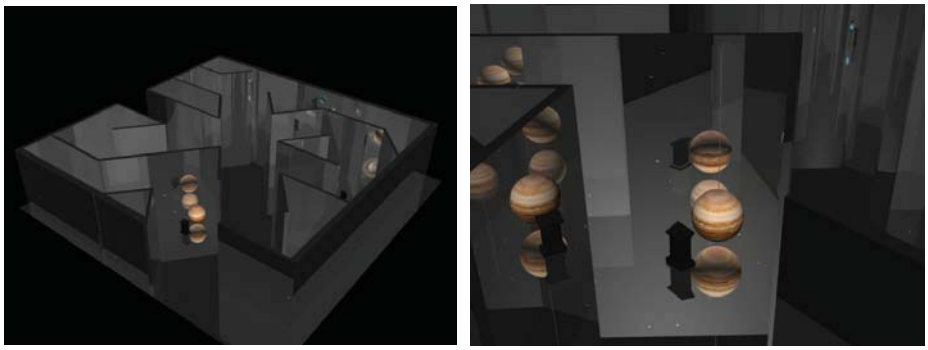
From the art perspective it is valuable to look into the main principles discussed here and the multitude of the possibilities for generating complex forms using very simple geometric elements. The limitations are necessary to identify for sound architectural structures, however, looking more deeply into the various techniques of repetition, as an example, may result in the creation of quite innovative spatial shapes. The quality of controlled chaos that can be created using variables with constraints may lead to further exploration of the redesign of the space.

As the French architect, Francois Blanciak asks himself,

“What would happen, if architects liberated their minds from the constraints of site, program and budget”? (4)

The answer is his book, “Siteless”, 1001 building forms

For further research into the design of the space, it is recommended that the element of light as an interesting design element is explored as it can lead to the creation of dynamic, constantly redefined spaces based on the interaction of light source and the spatial shapes within it, and the projection of light as an immaterial element onto the physical spaces, creating an interplay of augmented and physical environment, as in the example of the work by University of Advancing Technology student, Josh Hemmy. He places spatial forms in a maze of mirrored rooms that, by projecting them onto the mirrored walls, infinitely redesigns that space:



Josh Hemmy, student at the University of Advancing Technology, 2011

Footnotes:

(1) Casey Reas: Code+Form, pp.49
(2) Casey Reas: Code+Form, pp.49
(3) http://oneartworld.com/The+Pace+Gallery/Fractal+Dice.html
(4) Francois Blanchiak, Siteless, MIT, 2001

References:

1. Form +Code, Casey Reas, Princeton Architectural Press, 2010
2. Interaction of Color, Josef Albers, Yale University Press, 1965
3. Francois Blanchiak, Siteless, MIT, 2001
4. Design Basics, David A. Lauer and Stephen Pentak, Thompson, 2007
5. http://oneartworld.com/The+Pace+Gallery/Fractal+Dice.html
6. http://www.beflix.com/reichardt.php
7. http://formandcode.com/code-examples/parameterize-chair
8. http://www.bonluxat.com/a/elena-manferdini-ricami-stool.html
9. http://www.barbarakrakowgallery.com/sol-lewitt
10. http://www.emohr.com/